THE TEACHING OF GENETICS IN SELECTED SECONDARY SCHOOLS IN KITWE DISTRICT, ZAMBIA

by

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A dissertation submitted to the University of Zambia in fulfilment for the Requirements of the Degree of Master of Education in Science Education

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DECLARATION

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

Signed.....Date.....
..

APPROVAL

This dissertation by Justina Chifwa is approved as fulfilment of the requirement for the award of the Degree of Master of Education in Science Education by the University of Zambia.

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ABSTRACT

This study investigated the teaching of genetics in selected secondary schools of Kitwe District in order to determine causes of poor performance in genetics questions in the biology examinations held at the end of senior secondary education. This study was guided by the following questions: Who teach genetics in secondary schools in Kitwe District? How is genetics taught in secondary schools in Kitwe District? What challenges do teachers and learners face when teaching and learning genetics respectively? How could the teaching of genetics be improved?

The research design used was cross sectional survey. The target population was all teachers of biology in Kitwe District. Data was collected from 18 teachers of biology and three heads natural sciences department who were purposively sampled. Data was also collected from 180 randomly sampled grade 12 pupils. Three participating secondary schools were purposively sampled. The research mainly used the qualitative research methodology. Qualitative data was collected by using lesson observations, open ended interview guides and questionnaires. The data collected was analysed using qualitative content analysis approach.

The study revealed that most of the teachers (14; 78%), who taught genetics in Kitwe District were holders of secondary teachers' diploma. Seven (7; 39%) of the teachers of biology who participated in the study, had more than ten years experience in teaching biology in general and genetics in particular. The majority (13; 72%) of the teachers used lecture method to teach genetics while some teachers (5; 28%) used group work.

All the teachers observed used question and answer technique at some point during the lessons but asked low order questions. They did not use teaching aids or practical work when teaching genetics. Further, they did not give homework to the learners. Some teachers (50%) did not write lesson plans and those who wrote did not write clear objectives. The challenges teachers faced when teaching genetics were; learners' lack of background knowledge, lack of teaching and learning aids, negative attitude of learners towards genetics, the abstract nature of genetics, the bulkiness of this topic and the teaching of genetics in the third term of grade 12 just before final examinations. The learners complained that the teachers taught genetics very fast using similar and confusing terminology. The implications of these findings are that learners found it difficult to construct their own knowledge about genetics. This study concluded that the use of low order questions and the *lack of*; lesson planning by some teachers, homework, teaching aids and variety in teaching strategies was the cause of poor performance in genetics in Kitwe District.

Among the major recommendations were that regular short in-service courses for teachers of biology should be conducted in order to increase content and skills in teaching genetics. It was also recommended that internal monitoring of lessons by school administrators should be intensified to ensure that teachers prepare for lessons adequately in order to present effective learner centred lessons. It was further recommended that genetics be taught in term one of grade 12 in order to give learners time to understand the concepts.

DEDICATION

This work is dedicated to my husband Rev. Patrick Siame, our children Mwamba, Justina and Patrick.

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ACRONYMS

AIEMS	Action to Improve English, Mathematics and Science
CDC	Curriculum Development Centre
DEBS	District Education Board Secretary
ECZ	Examinations Council of Zambia
HOD	Head of Department
MESVTEE	Ministry of Education, Science, Vocational Training and Early Education
MoE	Ministry of Education
SCORE	Science Community Representing Education
ZASE	Zambia Association for Science Education
U.S.A.	United States of America
MEGA	Multiplayer Educational Gaming Application
DNA	Deoxyribonucleic Acid
CTS	Creative and Technology Studies
U.K.	United Kingdom

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter presents the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, theoretical framework, operational definitions, delimitation of the study and the organisation of the study.

1.1 Background to the Study

Currently, Zambia's formal education system consists of two years of early childhood education, seven years of primary education (grade one to seven), two years of junior secondary education (grade eight to nine), three years of senior secondary education (grade ten to twelve) and two to seven years of tertiary education (Education Act, 2011; Ministry of Education, Science, Vocational Training and Early Education [MESVTEE], 2013). Transition from primary to secondary and tertiary levels, is determined by national competitive examinations set by Examinations Council of Zambia (ECZ) at the end of grades seven, nine and twelve (Ministry of Education [MoE], 1996).

Early childhood care, development and education refers to both non-formal and formal service provision. Early childhood education caters for two broad levels which are: Day-Care or Crèche and early childhood education. Furthermore, the early childhood

education has two levels which are nursery and reception. The crèche stands in for the parents as it provides care, affection and love to the young children. The aim of nursery education is to promote social interaction of young children from different social backgrounds through play. The reception level prepares learners aged five to six years for entry into grade one. Therefore, the teaching and learning at this level is largely informal through guided and unguided play with formal teaching taking about 40 percent of the programme. The academic component prepares them for smooth transition to formal education at grade one.The curriculum for early childhood education is dominated by play and pre-learning activities based on the following learning areas: social studies, integrated science, pre-mathematics, literacy and language and expressive arts (MESVTEE, 2013). The teachers who teach at this level possess pre-school teachers' certificate (MoE, 1996).

The curriculum for lower primary education (grade one to four) in Zambia consists of the following learning areas: literacy and language or sign language or braille, integrated science, social studies, mathematics, creative and technology studies (CTS). Learning areas at upper primary (grade five to seven) are: literacy and language or sign language or braille, integrated science, social studies, mathematics, expressive arts, technology studies and home economics. The primary curriculum forms the foundation for the junior secondary school education (MESVTEE, 2013). The main focus of the education offered at grade one is to provide the first competence level necessary for the learner to assimilate the learning in grade two. As such the teaching and learning at grade one starts with imparting pre-learning skills in all learning areas. At grade two the

emphasis is to develop and consolidate the levels of literacy and basic mathematical skills achieved earlier. Primary curriculum forms the foundation for the junior secondary school education.

These learners are taught by teachers with Zambia primary course certificate or Zambia primary diploma who teach them all the subjects (MESVTEE, 2013).

At junior secondary school level there are two pathways that learners choose to pursue. They can choose either academic education or pursue pre-vocational and life skills. Junior secondary schools offer the following compulsory academic subjects: English language, business studies, computer studies, integrated science, social studies, mathematics, religious education, zambian languages and one optional subject; french, chinese or portuguese (MESVTEE, 2013). The vocational career pathway offers five options. Learners choose one of the following options according to their aspirations and ambitions: agriculture, technology, performing arts and creative arts, physical education and sports and home economics and hospitality. They take a maximum of seven subjects. They take six compulsory subjects namely, computer studies, English language, mathematics, integrated science, social studies and business studies. At each secondary school learners choose one vocational pathway from the two they are given to choose from. The vocational pathway options at junior secondary level are shown in Table 1.

Table 1. The Options for Vocational Career Pathway at Junior Secondary Level.

Pathway	Option
Agriculture	Agriculture Science (Entrepreneurship Integrated)
Technology	Design and Technology (Entrepreneurship Integrated)

Performing Arts and Creative Arts	Art and Design and Music Education (Entrepreneurship Integrated)
Physical Education and Sports	Physical Education (Entrepreneurship Integrated)
Home Economics and Hospitality	Home Economics (Entrepreneurship Integrated)

Source: MESVTEE, 2013

Junior secondary school level is the basis for acquiring knowledge, skills and values needed for learning at senior secondary level. The curriculum at this level also equips learners with knowledge and skills to either continue with the academic education or pursue pre-vocational and life skills (MESVTEE, 2013). The teachers qualified to teach at this level are holders of secondary teachers' diploma. Teachers received specialised training from colleges of education to teach particular subjects at this level (MoE, 1996).

The senior secondary school curriculum prepares learners for tertiary education and the world of work. They may choose to follow either the academic or the vocational pathway. However, each Senior Secondary School is restricted to offering two options under academic and two options under vocational career pathways. The academic career pathway at this level consists of the following options: Social Sciences, Business Studies and Natural Sciences (MESVTEE, 2013). The subjects in each pathway option are shown in Table 2.

Table 2. Options for Academic Pathway at Senior Secondary School Level

Pathway	Compulsory Subjects	Optional subjects: at least one subject from these subjects
Social Sciences	i. Mathematics ii. English Language iii. Science iv. Biology v. Geography /History vi. Civic Education vii. Literature in English	i. Zambian Languages ii. Religious Education iii. Foreign Languages
Business Studies	i. Mathematics ii. English Language iii. Science iv. Biology v. Civic Education vi. Principles of Accounts vii. Commerce	i. Zambian Languages ii. Religious Education iii. Foreign Languages iv. Literature in English
Natural Sciences	i. Mathematics ii. English Language iii. Biology iv. Chemistry v. Physics vi. Civic Education vii. Additional Mathematics	i. Zambian Languages ii. Religious Education iii.Geography/History

Source: MESVTEE, 2013

The vocational and technical career pathway offers the same options as those offered at junior secondary, the following are options: agriculture, technology, home economics and hospitality, performing and creative arts and physical education and sports.

Table 3. Options for Vocational Pathway at Senior Secondary School Level

Pathway	Compulsory Subjects	Optional Subjects
Agriculture	i. Agriculture Science ii. English Language iii. Mathematics iv. Science v. Civic Education	i. Religious Education/ Zambian Languages ii. Geography/History
Technology	i. Design and Technology/ Computer Studies ii. English Language iii. Mathematics iv. Science v. Biology	i. Religious Education/ Zambian Languages ii. Geography/History iii. Civic Education
Performing and Creative Arts	i. Art and Design/ Music Education ii. English Language iii. Mathematics iv. Civic Education v. Literature in English	i. Religious Education/ Zambian Languages ii. Geography/History
Physical Education and Sports	i. Physical Education ii. English Language iii. Mathematics iv. Civic Education v. Biology	i. Zambian Language ii. Religious Education/ Geography/ History
Home Economics and Hospitality	i. Fashion and Fabrics/ Food and Nutrition/ Home Management ii. English Language iii. Mathematics iv. Science v. Biology	i. Zambian Languages ii. Religious Education/ Civic Education iii. Geography/History

Source: MESVTEE, 2013.

Science subjects offered at senior secondary school level are: biology, chemistry, physics, science (physics and chemistry) and agricultural science. Pupils are required to

take at least two science subjects. At this level teachers with bachelor's degree qualify to teach a particular subject they trained to teach (MoE, 1996).

Of all the science subjects given above, biology is taken by the largest number of pupils compared to other science subjects (MoE, 1996). For example, in 2012 a total of 98,622 candidates sat for biology, 98,441 candidates sat for science, 3,786 candidates sat for chemistry and 3,789 candidates sat for physics in the school certificate examinations (ECZ, 2012). It is also offered by most secondary schools in Zambia (MoE, 1996; ECZ, 2012).

The Zambian senior secondary biology syllabus comprises 13 units namely; Living organisms, nutrition in plants and animals, transport in plants and animals, respiration, growth and development, homeostasis, excretion, responses, locomotion, reproduction, health, ecology and genetics (CDC, 2000). Genetics is the study of how characteristics are inherited and how variations occur within a species (Kilgour, 1987). It covers the following aspects: variations, mitosis and meiosis, monohybrid crosses, sex determination, sex linked characteristics, co-dominance and mutation (CDC, 2000). Genetics has been part of the Zambian biology syllabus since 1973 (Haambokoma, 2007). Genetics is an important topic to learn in these days and age where its applications are relevant to everyday life (Knippels, Waarlo and Boersma, 2005).

In addition, Venville, Gribble and Donovan (2005) stated that in our modern biotechnological world an understanding of the basic genetics is critical for effective

scientific literacy for future citizens. Its application in health, agriculture, crime investigation and heredity require a better understanding through biology education (Zulu, 2011). In health, genetics helps to predict what disorders a person is likely to develop or how a person will respond to certain treatment. (Finegold, 2015). In agriculture, genetics is used to boost crop productivity by using agricultural chemicals such as weed killers to protect crops and enhance plant growth. This leads to food sufficiency (Dendekar and Gutterson, 2000). Furthermore, genetics is used in crime investigations to identify, confirm or eliminate a suspect. Deoxyribonucleic Acid (DNA) is used to solve crimes by getting a sample of a suspect's DNA and comparing it with evidence from the crime scene. If a suspect is not identified, biological evidence from the crime scene can be analysed and compared to offender profiles in DNA data bases to help identify the culprit (William, Johnson and Martin, 2004). Genetics also helps to solve paternity wrangles (Dlamini, 1999).

In Zambia the performance of candidates in biology school certificate examinations held at the end of senior secondary has not been good. Table 4 shows the performance of candidates in the grade 12 biology examination for a period of eight years (that is from 2005 to 2012).

Table 4. National Performance of Grade 12 Candidates in Biology School Certificate Examinations (2005 - 2012).

Number of candidates who scored a particular examination grade						
Year	Distinction (1 and 2)	Merit (3 and 4)	Credit (5 and 6)	Pass (7 and 8)	Fail (9)	Total No. Sat.
2005	788 (1%)	3,002 (5%)	5,819 (9%)	21,997(32%)	38,986(53%)	70,592
2006	1,358 (1%)	4,551 (5%)	7,614 (9%)	28,946(37%)	34,700(48%)	77,169

2007	2,138 (3%)	6,342 (7%)	11,940(14%)	34,608(40%)	32,073(37%)	87,101
2008	2,514 (3%)	6,843 (8%)	11,563(13%)	35,380(40%)	32,214 (4%)	88,514
2009	1,208 (1%)	5,808 (7%)	15,730(17%)	30,928(35%)	36,039(40%)	89,713
2010	2,375(2%)	9,640 (9%)	20,062(19%)	37,510(36%)	33,664(33%)	103,251
2011	3,474 (3 %)	12,128(10%)	22,290(19%)	41,221(36%)	35,857(31%)	114,970
2012	4,036 (3%)	12,504(10%)	26,320(20%)	47,285(36%)	42,129(32%)	132,274
Total	17,891	60,818	121,338	277,875	285,662	763,584
Average	2,236(2.3%)	7,602(8%)	15,167(16%)	34,734(36%)	35,708(37%)	95,448

Source: ECZ Data Base (2013).

Table 4 shows that during the period 2005 to 2012, of the candidates who sat for the examinations on average 34,734 (36%) merely passed while 35, 708 (37%) failed completely. This means that very few candidates become eligible to enter biological sciences related fields such as medicine, nursing and biology teaching. These results also show that the teaching of biology in general and genetics in particular is not effective.

Table 5 shows the performance of candidates in Kitwe District in the grade 12 biology examination for a period of six years (that is, from 2005 to 2010).

Table 5. Kitwe District Performance of Grade 12 Candidates in Biology School Certificate Examinations (2006-2010).

Number of candidates who scored a particular examination grade						
Year	Distinction (1 and 2)	Merit (3 and 4)	Credit (5 and 6)	Pass (7 and 8)	Fail (9)	Total No. Sat.
2005	26 (1%)	128 (5%)	245 (9%)	903 (35%)	1,125 (50%)	2,427
2006	79 (3%)	510 (16%)	825 (26%)	1,193 (38%)	523 (17%)	3,130
2007	119(4%)	381(14%)	779 (28%)	1,302 (47%)	189 (7%)	2,770
2008	76 (2%)	399 (13%)	672 (22%)	1,546 (50%)	396 (13%)	3,089
2009	27 (1%)	178 (6%)	613(19%)	1,365 (43%)	982 (31%)	3,165
2010	77 (2%)	384 (9%)	922(21%)	1,920(43%)	1,180 (25%)	4,483
Total	404	1,980	4,056	8,229	4,395	19,064
Average	67 (2%)	330 (10%)	676 (21%)	1,371(43%)	733 (23%)	3,177

Source: ECZ Data Base (2013).

As can be seen from Table 5, for a period of six years on average 1,371 (43%) merely passed while 733 (23%) completely failed the examination. There are many factors which contribute to this poor performance. One of the reasons why candidates get poor grades or fail in biology could be the poor scores in genetics questions which appear every year. The structured question on genetics is in the compulsory section A of Biology Paper 2. There are also questions in the multiple choice paper and sometimes in the practical paper. The total marks for the multiple choice paper, theory paper and practical biology papers are 160 marks. For example, in 2013 the questions on genetics contributed 23 marks (15%) of the total marks.

Chief examiners reports for biology theory paper 2 from ECZ revealed that grade 12 pupils did not respond well to questions on genetics in the final school certificate examination (ECZ; 2007, 2008, 2009, 2010, and 2011). It is reported that, the question on genetics is attempted by very few candidates. Furthermore, most of those who attempt give wrong responses. For example, in 2007, the question on genetics was testing candidates to describe the events during meiosis which cause each ovum to be genetically different from another. Most candidates failed to answer the question. Another part of the same question, candidates were asked to draw a genetic diagram to show the inheritance of sickle cell anaemia in a family. Most candidates failed to answer the question but drew incorrect genetic diagrams that were not labelled (ECZ, 2007).

Similarly, in 2008, the question on genetics was about how sex linked haemophilia was inherited in a given family. The candidates were asked to state the genotype of the mother on a given pedigree diagram. Most candidates failed to state the correct genotype of the mother. Some wrong responses given by candidates were homozygous, heterozygous; X Y and X X. Part 'b' of the same question asked the candidates about the causes of haemophilia. The common wrong responses candidates gave were: mutation, recessive gene h, lack of calcium and inheritance. In part 'c' of the same question, the candidates were asked why males were more likely to suffer from haemophilia. The most common wrong response to this question was, 'because males had only one X chromosome' (ECZ, 2008).

The question on genetics in 2009 was the most poorly answered question in that paper. Most candidates failed to distinguish between a characteristic and a gene. Most wrong responses included; the occurrence of an X chromosome, because the trait is only determined by one gene, it is a characteristic carried by either X or Y chromosome and that it is a characteristic found on the X chromosome. When asked why males are more likely to suffer from sex-linked diseases, most of the candidates gave wrong responses. Most common responses were; because the Y chromosome in males is short, males do not go for menstruation period and males have only one X chromosome (ECZ, 2009).

A baseline study conducted by Haambokoma, Nkhata, Kostyuk, Chabalengula, Mbewe, Tabakamulamu and Ndhlovu (2002) revealed that teachers and learners found a number

of topics in biology difficult to teach and learn respectively. Genetics was considered to be one of the most difficult topics by teachers and learners to teach and learn respectively. It could therefore be argued that difficulties in genetics experienced by candidates contribute, to some extent to poor performance in biology.

The researcher developed the interest in this issue when she was marking grade 12 biology paper 2 final examinations answer scripts. It was noticed that the candidates were not responding well to questions on genetics and were scoring poorly. The researcher wanted to find out why most of the candidates did not respond well to questions on genetics. Genetics is an important topic to be learnt as it is relevant to everyday life. Thus, it was decided that the teachers teaching this topic be investigated in a more systematic way. Hence the genesis of this research idea.

1.2 Statement of the problem

Although the performance of learners in genetics has been poor in secondary schools, no study has been done in Kitwe District to determine the causes of this poor performance. Investigations that have been done so far have only identified genetics as a difficult topic to teach and learn (AIEMS, 1994; Haambokoma *et al,* 2002; Haambokoma, 2007). This is a knowledge gap which needs to be addressed.

1.3 Purpose of the study

The purpose of this study was to determine the characteristics of teachers who teach genetics and to investigate how genetics was taught in selected secondary schools in

Kitwe District. This study was conducted in order to provide explanations for poor performance as well as to propose viable solutions. The study also explored the challenges faced by the teachers and pupils when teaching and learning genetics respectively.

1.4 Objectives of the study

The objectives of the study were:

a. To determine who teaches genetics in selected secondary schools in Kitwe District.
b. To establish how genetics is taught in selected Secondary Schools in Kitwe District.
c. To explore the challenges faced by the teachers and pupils when teaching and learning genetics respectively.
d. To come up with ideas and suggestions on how to improve the teaching of genetics.

1.5 Research Questions

The study was guided by the following questions:

a. Who teaches genetics in secondary schools in Kitwe District?
b. How is genetics taught in secondary schools in Kitwe District?
c. What challenges do teachers and learners face when teaching and learning genetics respectively?
d. How could the teaching of genetics be improved?

1.6 Significance of the study

It was anticipated that the findings from this study would generate knowledge which could minimise the existing knowledge gap about how genetics was taught in selected secondary schools in Kitwe District. It was also anticipated that the information generated by this study could be used by teachers of biology, school administrators, heads of departments (HOD's) for natural sciences, teacher educators, senior education standards officers (natural sciences) and in-service training providers, textbook writers, Zambia Association for Science Education (ZASE) and curriculum development officers to improve teaching and pupils learning of genetics in secondary schools in Kitwe District. Data generated could also be useful to other researchers.

1.7 Theoretical Framework

This study is guided by the constructivism theory of learning based on the idea that learners construct and build their own knowledge of the world around them through experience (Piaget, 1970; Vygosky, 1978; Driver, 1988). Constructivists believe that the construction of new understanding is a combination of prior knowledge and new information. Active learners construct their knowledge with teachers acting as facilitators (Ratanaroutal and Yutakom, 2006). A distinction can be made between cognitive constructivism about how the individual learner understands things in terms of developmental stages and learning styles, and social constructivism, which emphasises on how meanings and understandings grow out of social encounters. Social

constructivism views each learner as a unique individual with unique needs and background (Creswell, 2003).

Social constructivists encourage the learner to arrive at his or her own version of the truth, influenced by his or her background and culture. Social constructivists take into account the background and the culture of the learner throughout the learning process. The learner's background helps to shape the knowledge and truth that the learner creates, discovers and attains in the learning process (Creswell, 2003). The learner has a responsibility for his or her learning (Petty, 2009).

Teachers who are constructivists are aware of the role of prior knowledge in students' learning, recognising that students are not blank slates or empty vessels waiting to be filled with knowledge. Instead, they believe that students bring with them a lot of prior experiences, knowledge, and beliefs that they use in constructing new understandings (Jones, 2002). This influences the pedagogical skills they employ to teach problematic topics such as genetics. These skills include group work, discussions, practical work, role play, work sheets, work cards, games and songs. These strategies engage the learners to construct knowledge by themselves.

Student preconceptions have been shown to be very resistant to change. Preconceptions are based on a child's early experiences, intuitions and form a filter for later learning. In order for understanding to take place, teachers must elicit students' prior concepts and build on these concepts during instruction. The teacher must provide educational experiences that will confront prior conceptions or provide a cognitive conflict in order

to promote conceptual development. The use of a cognitive conflict involves placing a student in a position in which the application of his or her own understanding of a problem leads to cognitive difficulties which the student must then resolve (Jones, 2002).

In addition, Jones (2002) stated that constructivism offers teachers instructional approaches that are in line with current research on learning. By viewing learning as an active process, taking students prior knowledge into consideration, building on preconceptions, eliciting cognitive conflict, teachers can design instruction such as group work, role play, practical work, problem solving, computer simulation, videos, case studies, brain storming and debate that goes beyond rote learning to meaningful learning that is more likely to lead to deeper, longer lasting understanding. Constructivist teaching fosters critical thinking and creates motivated and independent learners.

According to Mohan (2010), social constructivism emphasises the importance of the learner being actively involved in the learning process. Jones (2002) and Creswell (2003) agree that learners do not simply mirror and reflect what they read but they construct their own understanding. Social constructivist scholars view learning as an active process where learners learn to discover principles, concepts and facts for themselves. Learners are also active in the construction rather than passively receiving information. Social constructivists believe that reality is constructed by our own

activities and people as members of a society, invent the properties of the world. Knowledge is a product of human beings and is socially and culturally constructed.

In the classroom constructivist teachers usually encourage learners to use active learning techniques such as practical work, pairing, group discussions, brainstorming, role play, video games, simulations, slides and real life problem solving to create knowledge by reflecting on what they are doing and talking about what they are doing. The teacher ensures he or she understands the learners' prior knowledge and guides the activity to address the prior knowledge. Since learning occurs through learners' experiences, it is important that the teacher must prepare class activities that engage the learners in the lesson. The learners must be given opportunities to work independently this can be done by giving exercises that they can do individually or in pairs or in groups such as summarising the main points of a lesson. They must also be given minds-on activities such as discussions, problem solving and case studies that promote analysis, synthesis and evaluation of what has been learnt. In addition, hands-on activities such as practical work and project work must be given to the learners so as to enable them to verify the scientific laws and principles. The teacher should use a variety of learner centred methods of teaching in order to help them to retain what has been learnt.

1.8 Delimitation

The research was undertaken in three selected secondary schools in Kitwe District, on the Copperbelt Province.

1.9 Operational Definitions

Constructivism: Refers to the theory of learning which states that learners construct their own knowledge of the around them through experiencing things.

Active Learning refers to anything that students do in a classroom other than merely passively listening to an instructor's lecture.

Collaborative or Cooperative Learning refers to instructional approaches in which students work together in small groups to accomplish a common learning goal.

Critical Thinking is a collection of mental activities that include the ability to intuit, clarify, reflect, connect, infer and judge. It brings these activities together and enables the student to question what knowledge exists.

Learners refer to individuals receiving instruction. In this study this term is used inter-changeably with pupil or student.

Learner Centred Lesson: This refers to the type of lesson where the student did most of the activities in a lesson. The student assumes the responsibility for learning while the instructor is responsible for facilitating the learning. Thus, the power in the classroom shifts to the student.

Teacher Centred Lesson: This refers to the type of lesson where the teacher did most of the talking and activities while learners passively received information.

Teaching Strategy refers to the procedures and methods by which objectives of a lesson are realised in the class.

1.10 Organisation of the Study

This study was organised as follows: chapter one presented the background to the study, statement of the problem, purpose of the study, objectives of the study, research

questions, significance of the study, theoretical framework, operational definitions and delimitation of the study.

In chapter two, related literature is reviewed. This chapter is structured as follows: Teaching, lesson planning and preparation, lesson presentation, international and local literature on genetics education and Examinations Council of Zambia Chief Examiner's Reports on performance of candidates in genetics questions.

Chapter three outlines the research methodology as follows: research design, research sites, target population, sample and sampling procedures, research instruments, data collection procedures, data analysis, ethical issues and limitations of the study.

In chapter four the findings of this study are presented according to research questions. The discussions of the findings are presented in chapter five. In chapter six, conclusions are drawn from the results and recommendations are given. In addition to the main text, there are appendices.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents review of literature related to genetics education. It is structured as follows: Teaching; lesson planning and preparation, lesson presentation, studies on genetics education done outside Africa, studies on genetics education done in Africa, studies on genetics education done in Zambia and Examinations Council of Zambia Chief Examiner's Reports on performance of candidates in genetics questions. These aspects of literature depict the problems teachers encounter while teaching as well as the learners' problems on learning genetics and how the problems could be solved.

2.1 Teaching

This section starts by defining what teaching and particularly what effective teaching is. It highlights the factors that contribute to effective teaching. Mohan (2010) defines teaching as a process of assisting learners acquire new knowledge and skills. It consists

of showing and guiding the learners in performance of tasks and then measuring their results. Das (2007) on the other hand defines teaching as the creation of a situation which facilitates learning. He observes that it is an interactive process between the teacher and the pupil.

Onyekuru and Ibegbunam (2013) defined teaching effectiveness as a measure of the extent of realisation of instructional objectives. They stated that there are four main factors that enhance effective teaching and learning; teacher variables, family variables, school variables and learner variables. They defined teacher-variables as aspects of teacher characteristics such as qualification, experience, motivation and dedication. Family variables include social cultural background of pupils, level and type of education of parents or guardians and personal relationships among family members. School variables, on the other hand are seen as teaching effectiveness which include quality and quantity of teaching staff, facilities such as well equipped libraries and laboratories, instructional materials and learner variables which include motivation and previous knowledge. Of these factors, the teacher-variables are the ones that exert the most influence on learning outcome because the teacher is the implementer of the curriculum. One of the teacher variables which contribute greatly to improve pupil academic achievement is teacher qualifications. Edu, Edu and Kalu (2012) and Onyekuru and Ibegbunam (2013) reported that teaching experience and teachers' qualification had an influence on teaching effectiveness of secondary school teachers while gender had no influence. Teaching and learning are interrelated. Well trained

teachers, highly qualified teachers and teachers who perform their duties responsibly have a bearing on the effectiveness of teaching (Onyekuru and Ibegbunam, 2013).

2.1.1 Qualified and Experienced Teachers

Qualified teachers are teachers who received relevant training in education for their teaching subject up to a minimum level (Onyekuru and Ibegbunam, 2013). In Zambia, University bachelor's degree holders are the teachers qualified to teach senior secondary classes and diploma holders are qualified to teach junior secondary school classes (MoE, 1996). The experience of a teacher is based on the number of years of service (Rice, 2010). Onyekuru and Ibegbunam (2013) reported that the more years a teacher spends in teaching service, the more experience the teacher gets and becomes more knowledgeable in all it takes to improve the achievement of learners. In addition, Rice (2010) revealed that teacher experience enhances the knowledge, skills and productivity of teachers. The Zambian Ministry of Education recognised the importance of having qualified teachers to teach Zambian learners. As a result, in 1990 this ministry established the Teacher Education Directorate (TED) whose mandate is to deal with the training of teachers (Mulenga, 2012).

2.1.2 Lesson Planning and Preparation

This section highlighted lesson planning and aspects of a lesson plan. The merits and demerits of teaching methods are discussed. Mohan, (2012) defines a lesson plan as an outline of the important points of a lesson arranged in the order in which they are to be presented to learners by the teacher. A lesson plan is a detailed description of the course

of instruction for one lesson in a particular class which guides class instruction (Davar, 2012; MESVTEE, 2014). Lesson planning is a hallmark of the teaching profession.

Furthermore, Jones (1998), Muzumara, (2008) and Mohan (2012) considered lesson planning as a creative process which provides a framework for purposeful teaching and learning. Good lesson planning is the key to successful teaching. During lesson planning, a teacher reflects on issues such as objectives, delivery, the learning procedures and evaluation mechanism. Planning for a lesson also requires that a teacher thinks and reflects on how to use the teaching and learning materials to genuinely and effectively engage the learners. Petty (2009) stated that a teacher also requires sound knowledge of the subject matter, teaching strategies and the pupils he or she intends to teach. Every teaching and learning item serves a well thought out purpose. The developed and selected teaching and learning materials must bring out pupils awareness of learning objectives. Jones (1998), Muzumara (2008), Petty (2009) and Mohan (2010) highlighted the following as some of the advantages of lesson planning; helping to make the lesson well organised and systematic, enhancing the self-confidence and self-reliance of the teacher and facilitating the appropriate use of teaching and learning aids. Jones (1998) and Muzumara (2008) both agree that lesson planning enables the teacher to plan suitable learner activities that help to retain students' interest and it ensures economical use of time as each step is planned. Furthermore, Mohan (2010) asserted that lesson planning establishes proper connection between lessons and ensures continuity in the teaching-learning process. MESVTEE (2014) stated that lesson

planning helps a teacher to anticipate pupils' reactions and enables the teacher to prepare adequately in order to avoid foreseeable problems.

In this researcher's view, lesson planning is an important creative and reflective activity which provides a framework for purposeful teaching and learning. It is the key to successful teaching and learning because it helps to create a conducive teaching and learning environment. During lesson planning, the teacher carefully considers the following; what content will be covered during the lesson, duration of the lesson, prior knowledge of the learners, the teaching and learning materials, the abilities of the learners and learner centred methods and strategies of teaching to use. Planning also helps the teacher to decide how the lesson will be introduced so that learners' interest is aroused and learners are motivated to learn. Lesson planning also helps the teacher to plan how to conclude the lesson effectively. Furthermore, lesson planning helps the teacher to anticipate some challenges and think how they can be overcome.

2.1.3 Lesson Objectives

Lesson objectives are statements which set out to describe what pupils are expected to learn or demonstrate from a particular lesson in a way that allows the teacher to identify if learning has occurred. Objectives should be feasible and attainable by most learners (MESVTEE, 2014). Muzumara (2008) and Davar (2012) stated that teaching is best achieved if a teacher sets well defined objectives which provide the direction of instruction for a given topic. Behavioural objectives must clearly identify what pupils

should be able to do at the end of instruction, the condition under which the expected behaviour is to be achieved should be given and the level of acceptable performance should be indicated. Behavioural objectives are stated in terms of observable behaviour that a pupil should perform after having completed a learning task or activity.

Muzumara (2008) and Davar (2012) support this view and say that it is important to bear in mind the action verbs to use when stating the behavioural objectives. It is important to avoid using verbs that are too general and not easily observable, such as know, think, understand, desire, want, appreciate, feel, have, learn or remember. The verbs to use should easily be measured or observable such as state, define, construct, measure, identify, compute, record, classify, explain, name, describe, analyse, organise, hypothesise, draw and prepare. For example, a well written lesson objective in genetics would be; at the end of the lesson pupils should be able to name two types of variations correctly.

2.1.4 Rationale of a Lesson

Rationale is the significance of a lesson. It is the statement that emphasises the applicability of and usefulness of the contents of the lesson to the learner. The rationale affords the teacher an opportunity to see why the lesson must be taught. It also shows how the teacher understands the knowledge and skills to be taught in the lesson. There are four basic components of the rationale: content which outlines what is to be taught and learnt in a lesson, concept/value outlines why the lesson should be learnt, methods are approaches or strategies that will be used to present the lesson and location of the

period where the lesson is located out of the total number of planned periods for teaching the unit. For example, the lesson on variations will be taught in order for learners to identify the causes of differences within a species using group work and practical work this is the first lesson in a series of ten lessons in this unit. A lesson is a form of teaching and learning. A lesson has a certain flow starting from introduction, development, evaluation and conclusion (MESVTEE, 2014).

2.1.5 Lesson Introduction

The introduction of a lesson prepares the mind of the learner to participate in a lesson and sets the mood for learning (Mohan, 2010). The purpose of the introduction is to revisit prior knowledge which provides a vital link between the previous lesson and the new lesson. It also encourages the learners' interest in the new material to be learnt (Petty, 2009; Mohan, 2010). The introduction usually lasts 5 minutes at the beginning of a lesson. The teacher needs to let learners know the expected outcomes of the lesson during the introduction because it helps to arouse and maintain the interest of the learners in the lesson (Petty, 2009; Mohan, 2010; MESVTEE, 2014). The introduction plays an important role in the success of a lesson. An introduction of a lesson can be conducted using a variety of strategies (question and answer, film strips, brainstorming, lecture) depending on the content for the day's lesson. An introduction guides pupils to the understanding of a lesson (MESVTEE, 2014).

2.1.6 **Development of the Lesson**

The purpose of a lesson development is to deepen the learning. It is a collection of several activities that help to develop what is to be learnt. Activities such as practical work, group work, group discussions, case studies, role play, concept mapping, games and songs should enable learners to construct their own knowledge can be done depending on the topic being taught. This stage should be interactive and the learners should be active participants in the teaching and learning processes so as to make learning enjoyable and permanent (Mohan, 2012). The learners should be encouraged to ask questions so as to address any cognitive conflicts that they may have. The teacher's role is to facilitate learning.

2.1.7 Conclusion and Evaluation

Conclusion is a plenary session in which the learners draw out key points. The learning process is reviewed and reflected upon. Learners are encouraged to explain what they have learnt and how they can apply it in day to day life. When concluding a lesson the teacher and learners give an overview of what has taken place in the lesson. The teacher must plan in advance how the lesson will be concluded. Evaluation is the last stage in a lesson flow. The purpose of an evaluation is to assess the quality of teaching and learning that took place (MESVTEE, 2014). After a lesson, a teacher reflects on the lesson taught. This reflection enables the teacher to learn from the successes and failures of the lesson and is able to improve the teaching of the same topic in future

(Petty, 2009). In this study the researcher observed how teachers concluded their lessons and evaluated their teaching.

2.1.8 Teaching Methods and Strategies in Biology

In this section, some common teaching methods and strategies used in teaching biology are highlighted. These include lecture method, demonstration, question and answer, discussion and practical work. In order for a teacher to decide what teaching method to use and have a variety of activities during the lesson, the teacher must know what teaching methods are available, what strengths and weaknesses these methods have, what purpose each method serves and how to use the methods.

Teaching methods are chosen on the basis of fitness for a particular purpose (Petty, 2009). The teacher first clarifies the purposes of the lesson and then chooses activities which will achieve these purposes. A number of factors determine what strategies a teacher should use to accomplish a given learning outcome. These factors may include age and academic level of pupils, amount of time available, physical environment, availability of teaching and learning resources as well as the topic being presented. A variety of teaching methods increase student attention and interest. It also helps the teacher to manage the class well (Petty, 2009). Different teaching methods develop different skills in the learners as shown in Table 6.

Table 6: Some Teaching Methods or Strategies and Skills Developed in the Learners

Teaching method/strategy	Skills developed in learners
Worksheets	Reading

Design work	Creativity
Teacher talk	Listening
Group work	Communication, persuasion, team work
Practical work	Observation, analysis, synthesis
Discussion	Respect for other people's ideas

Source: Petty, 2009.

A variety of teaching methods makes the teacher's job more stimulating and enjoyable. The use of one method all the time bores teachers themselves and learners (Petty, 2009; MESVTEE, 2014).

Teaching strategies may be classified in different ways: those in which the teacher has direct control are called teacher-centred. These include lecture, teacher demonstrations and teacher questioning. Mostly learning is not reinforced by physical activities and the pupils are only mentally involved in the lesson. Pupil centred strategies actively involve pupils in the lesson. These strategies are the most recommended in teaching because they involve learners, both in hands-on and minds- on activities. These methods stress learning by doing and becoming actively involved in experiencing, formulating ideas and solving problems (Muzumara, 2008; Petty, 2009). Hence learners become critical thinkers and problem solvers. Learner centred strategies are supported by the theory of constructivism.

2.1.8.1 Lecture Method

Petty (2009) and Mohan (2012) describes lecture method as a teaching method used for the explanation of content by a teacher for passive assimilation by students. The teacher is the fountain of knowledge and the learners are empty tins that need to be filled. In a

lecture, there is little room or no room at all of asking questions by the learners. Lecture method is one of the teacher centred methods of teaching. Davar (2012) and MESVTEE (2014) mentioned that lecture method can be used when teaching a large number of students, introducing a new topic in which students have little previous knowledge, communicating basic facts, terminologies or promoting initial understanding of the concepts, summarising certain scientific concepts and principles at the end of the lesson, giving historical accounts of scientific events or history of great scientists.

The following are some advantages of a lecture method; efficient in resource requirement, one person can teach a large number of students at the same time, provides a role model by providing an insight into the thinking and problem solving abilities of the teacher, less time consuming and simplifies work of the teacher, it can be adapted to the level of the class, it is a rapid method of presenting material (Petty, 2009; Davar, 2012). In the researcher's view lecture method is one of the methods that can be used when teaching the topic genetics because learners have little prior knowledge. This method promotes initial understanding of concepts and principles. However, for this method to be very effective it should be used together with other methods such as group work, pairing, practical work and role play.

A lecture method has a number of limitations when applied to the teaching of genetics; students' involvement in the lesson is very minimal, minimises feedback from the students, teacher can't be sure how much the students have understood, identification of individual's specific learning difficulties is a challenge, evaluation of the methodology,

lesson and oneself is difficult, students get easily distracted and inattentive, scientific skills can't be developed, retention is very low and learners are not given the opportunity to use the ideas being taught. A lecture method is not suitable for slow learners and those pupils who have language problems, it can be boring, the students are not actively involved in the lesson, the concentration span for students is short (Petty, 2009; Davar, 2012).

2.1.8.2. Demonstration

Muzumara (2008) defined a demonstration as a repetition of a series of planned activities which are designed to illustrate a certain phenomenon or event. Petty (2009) defined a demonstration as 'showing how'. Demonstrations help the teacher to make some information clear. It helps the teacher to introduce certain topics vividly and clearly to pupils so that they can, on their own, carry out the activity or illustrations (Muzumara 2008). A good demonstration has the following characteristics: clearly defined aims and objectives, can be observed clearly by every learner and involves the class at every stage, uses simple apparatus whose operations can easily be understood by every learner, has a logical order of presentations, stimulates inquiry and curiosity in pupils and can easily be performed by learners themselves (Muzumara, 2008; Mohan, 2010; Davar, 2012).

Muzumara (2008) and Mohan (2010) agree that a demonstration method has several advantages that make it very useful in teaching biology. Demonstrations allow learners to observe real objects and events, it helps in economising resources, minimise risks and

hazards associated with certain experiments, can be used in large classes, learners can participate in a demonstration by, for example, taking readings and observing physical changes like colour changes.

However, a demonstration method has a number of disadvantages such as limited learner participation and pupils do not develop manipulative skills. For example, when doing a demonstration to observe mitosis in onion root tip under a microscope, the learners are told to just look under a microscope and not to touch, all learners may not be able to see the details and results of a demonstration and sometimes the pace of the demonstration may be so fast that the pupils may have problems in understanding what is going on (Muzumara, 2008; Mohan, 2010; Davar, 2012).

2.1.8.3 Question and Answer

Muzumara (2008), Petty (2009) and Mohan (2010) advised that questions must be carefully thought out so that they are precise and unambiguous for learners to benefit from them. Good questions must be clear, that is, the language in which the question is used should be at the level of learners' ability. In addition, questions must be interesting, that is, questions asked in class should stimulate and raise learners' curiosity.

2.1.8.3.1 Types of Questions and Questioning Techniques

Mohan (2010), Davar (2012) and MESVTEE (2014) stated that a teacher needs to do a number of things in order for effective learning to flourish in any classroom situation. The teacher should answer learners' questions adequately. This encourages learners to be confident of their thoughts and generate an urge to ask more questions. As much as possible, during genetics lessons the teacher should mainly ask open ended questions because they promote critical thinking necessary for unblocking the enormous potential in the learners. The teacher should ask questions that the learners are able to answer. Questions that relate to the unit being taught should be asked. Clearly worded questions should be asked and the teacher should speak clearly. Good responses should be praised in order to encourage learners to participate in the lesson. Other learners can be asked to comment on a response from a learner before the teacher does. This ensures wider participation which brings about divergent views on a particular topic. The teacher should engage in active listening when the learners are giving responses. This makes learners to think deeply of what they want to say.

The teacher should draw the learners' concentration before asking a question. This prepares the learners to listen to the question. The teacher should give learners time to think about the question asked because mental processes require some time to take effect. The wait time of 25 seconds is usually given. If no response is given after the wait time, the teacher can rephrase the question to enable the learners to answer the question. The teacher should encourage learners to ask questions (Petty, 2009; Mohan, 2010). In genetics lessons this is important because of the abstract nature of the

concepts, the learners need time to think about the answer The teacher should not answer his/her own questions.

One of the best ways of classifying questions is using Blooms' Taxonomy. There are six levels and questions at each level require a response which uses a different kind of thought process. These are: Knowledge, comprehension, application, analysis, synthesis, evaluation (Petty, 2009; Mohan, 2010; Davar, 2012). The revised version of Taxonomy of cognitive domain (from lower to higher) is Remembering, Understanding, Applying, Analysing, Evaluating and Creating (MESVTEE, 2014).

2.1.8.4 Discussion

A discussion is one of the teaching methods used to teach biology. It is an exchange of opinions or ideas. During classroom discussions (whole class or group), pupils learn how to express themselves clearly, to justify opinions and to tolerate different views. During discussions, learners also get a chance to ask for clarifications, to examine their own thinking, to evaluate ideas and to put together personal viewpoints. Some learners assume responsibility by taking leadership roles in the group. This method enables learners to collaboratively construct their knowledge (Mohan, 2010; Davar, 2012; MESVTEE, 2014). In genetics, for example, learners can construct concept maps during discussions. They can also solve questions involving case studies or genetic diagrams.

In addition, Muzumara (2008) and Petty (2009) agreed that during class discussions, pupils learn a number of skills such as being open to new ideas, making eye contact

with the speaker, being attentive, organising thoughts, speaking clearly, taking notes, allowing speakers to express their thoughts without interruption and respecting other people's ideas. The teacher's role during class discussion is to encourage learners to express their opinions and not to inform or force the teacher's opinion on learners.

2.1.8.5 Practical work

Science Community Representing Education [SCORE] (2009) defines practical work in science as hands on learning experience which prompts thinking about the world in which we live. SCORE (2009) lists activities that could be considered to be practical work in two main categories: Core activities which include investigations, laboratory procedures and techniques and feedback. Directly related activities: Teacher demonstrations, experiencing phenomena designing and planning investigations and data analysis.

Practical work in genetics enables genetics to be taught from what can be seen so that what is abstract can be understood. For example, teaching variations using different colours of bean seeds. From the phenotypes the learners then understand the genotypes of the seeds.

Practical work is a unique way of teaching science. Good quality practical work engages learners, helps them to develop important skills, helps to understand the processes of scientific investigation and develops learners to understand scientific concepts (Dillon, 2008; Woodley, 2009). It helps students to understand complex, abstract ideas and gives an opportunity to participate and to have an appreciation for the

methods of science. It involves students in hands-on activities (practical work; using wool to show the processes of mitosis and meiosis) that help them participate in scientific investigations and to verify for themselves science concepts, principles and laws.

Haambokoma *et al* (2002) established that materials and resources were insufficient or lacking in schools. They reported that this impacted adversely on learners because they were unable to do practical work. Haambokoma *et al* (2002) also reported that teachers understood and believed in the need to use locally available materials in promoting quality teaching but were not putting their belief to action.

Changwe (2008) who investigated the use of science kits in the teaching of grade 8-9 environmental science in Kitwe District from the year 2003 when science kits were introduced to 2007 reported that science kits were available in all basic schools in Kitwe District. That study established that science kits were hardly used in the teaching and learning of environmental science. The study also showed that the pupils were not given opportunity to handle science kits. Some reasons cited by teachers for lack of practical work were; some headteachers locked the science kits in the storerooms as a result the teachers had difficulties in accessing the science kits when the headteachers were not in school, lack of chemicals and lack of a system to replace lost equipment.

Another study done by Mudenda (2008) to investigate experiences of grade 12 learners at Kabwe High School in Zambia during school certificate biology practical

examinations in the year 2005 revealed that the learners experienced a number of challenges. This was a consequence of the learners not being engaged in practical work during lessons. Lack of practical work deprived the learners the opportunities to develop conceptual knowledge and process skills.

In contrast to what Changwe (2008) and Mudenda (2008) reported that many teachers do not use practical work while teaching, SCORE (2009) revealed that teachers in the United Kingdom (U.K.) engaged learners in a lot of practical work during lessons. One would argue that, the teachers in the U.K. have a lot of resources that enable them to do practical work. However, in Zambia many teachers do not carry out practical work even when resources are available (Changwe, 2008). It is worth noting that the environment within and outside school is rich with materials that can be used during practical work in genetics such as fruits, seeds, card boards and wool for making models of chromosomes. It requires thorough lesson preparation and planning by the teacher to be able to improvise teaching and learning materials for use during practical work (Mudenda, 2008).

Kalumba (2012) conducted a study which investigated whether the use of wider range of teaching methods could improve the quality of environmental learning and teaching in five Zambian primary schools in Mufulira District. The preliminary stage of the study involved nine teachers who answered questionnaires, participated in interviews and focus group discussions about the use of dominant teaching methods and teaching methods that are not commonly used. He then held a planning workshop to explain the

not commonly used teaching methods such as practical work, role play, investigation and discussion. Teachers were asked to plan lessons that required that use of these methods. Nine teachers were observed while teaching using a wide range of teaching methods. The findings of that study were the use of wider range teaching methods enhanced learning opportunities by providing learners with an enjoyable learning atmosphere during lessons. He also found that teachers gave learners homework. In the researcher's view, multiple teaching strategies when applied to teaching genetics would improve performance of learners in genetics questions.

2.1.8.6 Note Giving

Recording information and aiding reflection were the two main functions of writing notes stated by Boch and Piolat (2005). When learners re-read their notes as many times as possible, they are able to learn the content, integrate the knowledge and store it in the long term memory. This eases the load on the short term memory. Petty (2009) adds that notes given to learners should be made concise, simple and attractive.

Petty (2009) and Weimer (2013) are of the view that learners should take their own notes as the teacher is teaching. They pointed out that note taking develops listening skills, offers learners opportunities to construct their own knowledge and increases the attention span of learners. Petty (2009) suggested that a teacher can leave at least ten minutes at the end of the lesson to allow learners write their own notes. In addition, the teacher needs to check pupils' notes for accuracy and completeness. The teacher can also encourage learners to create graphic organisers such as flow diagrams and concept

maps to aid the learners' memories about concepts in genetics. Chibesakunda, Kaulu and Hakalima (2012) reported that Zambian Secondary Schools had insufficient or lacked relevant biology textbooks. Therefore, it is important that learners are given good notes to help them to remember concepts and clarify different terms in genetics to the level of secondary school learners.

2.1.8.7 Homework

According to Goldstein (1999), homework is important because it serves as a link between home and school. It helps parents to observe their children's education and express positive attitudes towards their children's education. Homework is an economic way of providing additional instruction in practice to learners. Homework is important because it gives the learner practice in what has been taught or about to be taught. Participation in learning can improve the learner's achievement. Homework that is accurately completed increases masterly of academic skills, such as reading, writing and spelling. The learner takes the assignment home, gathers information and completes the assignment and submits it for marking. This strengthens the pupil's sense of responsibility. The pupil learns management skills. The pupil also develops time management skills by completing homework. Homework keeps the parents informed about class activities. Homework helps to improve pupils' achievement in all topics including genetics.

In addition, Goldstein (1999) stated that homework is important because it improves the pupil's thinking and memory, helps the pupil to develop positive study skills and habits that the pupil can use throughout life. It encourages pupils to use time wisely, to work independently and take responsibility for learning. It also helps the pupil to review and practice what has been taught in class and helps pupil to get ready for the next class. The pupil is encouraged to explore the subject more fully than class time permits. Homework helps parents to learn more about what the child is learning at school. It helps parents to communicate about what the child is learning. This helps to spark enthusiasm in the learners. Homework set before a lesson aids understanding of the content of the next lesson. Homework helps to reinforce what has been learnt and develops pupils' research skills. Further, learners get a chance to seek information for themselves and meeting deadlines promotes self discipline in the pupils.

The types of homework in genetics that can be given to learners include the following; revision and critical reflection to consolidate learning of terms used in genetics, application of knowledge and skills in new contexts, this could be done by asking learners to solve a problem cited in a case study and preparation for the next lesson (this could involve asking learners to collect relevant materials like magazine and newspaper cuttings, specimen like bean seeds, items and information). Care should be taken that the homework given to learners is purposeful and relevant to the learners needs, appropriate to the level and capacity of the learners and that it is related to class work (Queensland Government, Department of Education, Training and the Arts, 2000).

2.1.9 Teaching and Learning Aids

Petty (2009) defined teaching and learning aids as physical or software tools that a teacher uses to make effective teaching and learning occur meaningfully and less monotonously. Teaching and learning aids should provide the right atmosphere for learning and should aid learners to direct their own learning as well as help them to construct their own knowledge. The teaching and learning aids should help learners to retain most of the concepts that have been learnt as a result of active involvement in the lesson. The teaching and learning materials should also compel teachers to use learner-centered approaches when teaching and help to sustain learners' interest in learning (Petty, 2009; Mohan, 2010; MESVTEE, 2014).

Various aids such as charts, models, specimen, work sheets, work cards, handouts, information sheets, compact discs, expert human resource, newspapers, chalkboards, electronic boards and films are used by teachers to facilitate teaching, communicate the content effectively and arouse interest. Teaching and learning aids must be relevant and appropriate for the fulfilment of the lessons set objectives. The teaching aids serve as stimulus to learning, help learners to understand the concept and meet the objectives of learning. Teaching aids are also called audio visual aids. Depending on the senses stimulated by the teaching aids they may be grouped into three categories: visual aids, audio aids and audio-visual aids. Visual aids can be seen, audio aids stimulate the sense of hearing only and audio-visual aids stimulate both eyes and ears (Petty, 2009; Davar, 2012). In the teaching of genetics, audio-visual aids such as films and visual aids such as specimen, charts, work sheets and chalk board are suitable for use.

2.1.9.1 Importance of Teaching and Learning Aids

Using teaching aids breaks the monotony of lecture method and helps to arouse pupil interest in the topic taught. Using teaching aids provides better understanding as concepts become clearer and meaningful as teacher explains with the help of teaching aids. The use of teaching aids saves time and energy of the teacher as the learners find it easy to understand when a concept is taught. Slow learners find it easy to understand and remember abstract concepts with the help of teaching aids (Muzumara, 2008; Petty, 2009; Davar 2012). For example, in genetics chromosomes can be taught using model cut outs from card boards (AIEMS, 1994). The learners retain the learnt material for a long time because the experiences are concrete. A teacher acts as a facilitator of learning by using teaching aids. The objectives of the lesson can be achieved with greater ease as concrete materials facilitate understanding and better retention of concepts of science. The teacher who uses teaching aids in a lesson caters for individual differences (Muzumara, 2008; Petty, 2009; Davar 2012).

2.1.9.2 Use of Chalkboard

The chalkboard is a teaching and learning tool that is present in any classroom. The following are some of the unique features of a chalkboard: it has a good background so that learners can easily see what is written on it; it is always strategically positioned and it is always readily available. Its usage can be maximised by demarcating it for logical flow of information, writing main points for the learners to structure their work and giving enough time to learners to capture important learning points (MESVTEE, 2014).

The researcher considers the chalk board useful during genetics lessons because a teacher can write the main points as the lesson progresses and write summarised notes on it for learners to copy. The teacher can also use it to develop flow diagrams and concept maps.

2.2 Studies on Genetics Education done outside Africa

In many parts of the world genetics is considered to be one of the most difficult topics to teach and learn in biology by teachers and pupils respectively (Bahar, Johnstone and Hansell, 1999; Lewis and Wood-Robinson, 2000). The learners have a lot of misconceptions about genetics which act as barriers to understanding of genetics. Related literature revealed the challenges teachers and pupils faced while teaching and learning genetics respectively. The strategies that teachers in other countries use to teach genetics have been reviewed.

2.2.1 Understanding of Genetics

This section presents highlights of studies done to investigate the challenges learners have in understanding the topic genetics.

2.2.1.1 Studies done in the United States of America

In one study undertaken in the United State of America (U.S.A), students were asked to write an essay on why it was important for everyone to know about genetics and what human genetics researchers do. They were also asked to give reasons for their responses. (Shaw *et al*, 2008).While many essays submitted demonstrated a clear

understanding of genetics and its implications, a significant number of these essays revealed firmly held misinformation and misconceptions about genetics by U.S.A. students in grade 9-12 (Shaw *et al,* 2008). Some common misconceptions as revealed by student essays were classified into the following themes; genetic terminology, patterns of inheritance, deterministic nature of genes and genetic material as shown in Table 7.

Table 7: Some Common Misconceptions as Revealed by Student Essays

Theme	Quotation from student essay	Correct conception
Genetic Terminology	"When people who cannot have children and want their own children from their own blood, meaning having their genes, what will stop them from putting some cells into a cow to get their child."	Genetics as a field is not considering human embryos using other species as incubators.
Patterns of inheritance	"If you were to have three chromosomes instead of normal two, the child will have Down's syndrome."	Humans have 23 pairs of chromosomes. Only an extra copy of chromosome 21 causes Down's syndrome.
Deterministic nature of genes	"Genes determine everything from your sex and hair colour to what disease you may have and how high you may grow."	Genes are not necessarily deterministic. More frequently environmental influences coupled with genotype determine height. Multiple alleles, nutrition and environment play a role.
Nature of genes and genetic material	"All humans have DNA, as do animals, and most bacteria and fungi."	All living organisms including fungi have DNA.

Source: Shaw *et al,* 2008:1162-1163

Student misconceptions about genetics were also revealed in a study conducted in Michigan State of the U.S.A. by Manokore and Williams (2012). A total of 250 seventh grade students participated in the study and completed a web based unit on genetics. The researchers found that approximately half of the students considered the traits of offspring to be inherited directly and solely from which ever parent they resemble for

that characteristic, rather than viewing it as the result of the interaction of alleles contributed equally by both parents. They also noted that this wrong concept may influence students learning and understanding of Mendel`s law of segregation.

Williams, Debarger, Montgomery, Zhou and Tate (2011) agreed with Knipples *et al* (2005) that the study of genetics centres on unseen processes at different organisational levels such as proteins, genes, chromosomes and cells, tissues and organs. In turn many high school and undergraduate students find genetics to be abstract and difficult. Knippels *et al,* (2005) in their study identified five major difficulties: The domain specific vocabulary and terminology, the mathematical content of Mendelian genetics tasks, the cytological processes, the abstract and complex nature of genetics. In addition, Knippels *et al,* (2005), stated that these difficulties were not isolated and may worsen each other. Students face problems in representing genetics texts into schemes and symbols. To understand classical genetics problems knowledge of the extensive genetics vocabulary is required. Students may get confused because the terms look and sound very similar, for example, homologue, homologous, homozygous and homozygote. Misuses of genetic terms by teachers and textbook writers also confuse students (Knippels *et al,* 2005).

A study by Williams *et al* (2011) examined students understanding of the non normative conceptions between key concepts of cell division and understanding biological principles that are critical for an in depth understanding of genetic inheritance. A total of 209 seventh grade students at the only middle school located in

Midwest suburban school district in the U.S.A. participated in the study. During the study, the students were taught genetics by two teachers using a genetics inheritance instructional material for five weeks during the fall of 2008-2009 school years. Content based assessments were administered to all the students. Analysis of student responses revealed a strong relationship between the concept of genetic inheritance and cell division and provided evidence of the nature of difficulties that students have when trying to understanding genetic inheritance and cell division.

The students found challenges in demonstrating an integrated understanding of the differences between mitosis and meiosis processes. Some students could not explain the importance of these processes as they relate to the passage of genetic material. Students have difficulties in understanding the relationship between genes, chromosomes and genetic information that would enable them to draw connections between the doubling of chromosomes in cell division and the passage of genetic information between generations. The lack of knowledge about chromosomes and their importance makes it difficult for students to form deep understanding of the differences between mitosis and meiosis and the significance of those differences. Students had a great deal of confusion. As a result of these difficulties in understanding the concepts of cell division that lead to the production of sex cells they have a lot of confusions about the differences between sex cells and somatic cells (Williams *et al*, 2011).

Williams *et al* (2011) also reported that students have confusions in understanding the process of fertilisation. Meiosis is among the central concepts of biological passage of

genetic information from one generation to the next. Mitosis is a division process occurring in somatic cells and associated with cellular replacements or organisational growth, while meiosis occurs in sex cells and results in gametes that are the core of gene transmission and resulting phenotypes from one generation to the next.

In this sub-section, the studies reviewed revealed firmly held misinformation and misconceptions about genetics by U.S.A. students. Five major difficulties were identified: The domain specific vocabulary and terminology, the mathematical content of Mendelian genetics tasks, the cytological processes, and the abstract and complex nature of genetics. The students found challenges in demonstrating an integrated understanding of the differences between mitosis and meiosis processes.

2.2.1.2 Studies done in Turkey

Pupils learning difficulties in genetics have also been reported in Turkey (Topcu and Sahin– Pekmez, 2009). A study undertaken by Topcu and Sahin – Pekmez (2009) involved 128 pupils of which 62 were males and 66 females from two public elementary schools in Izmir to investigated students' difficulties in learning genetics, revealed a number of interesting findings. One of the findings was that students could not explain the function of cell and chromosome concepts.

A questionnaire with open ended questions and a structured interview schedule were used by Topcu and Sahin – Pekmez (2009) to collect data from the students. The open ended questionnaire had questions about the functions of the cell, nucleus, chromosome, DNA and gene. The first question asked about the genetic structures (cell, nucleus,

chromosome, DNA and gene) in order of size from the largest to the smallest. The genetic structures were correctly ranked by 84% of the students. However, 16% of the students did not rank the genetic structures correctly. The second question, the students were asked to write the functions of cell, nucleus, chromosome, DNA and gene. Students defined the terms instead of giving their functions because they had memorised the definitions of the terms but had difficulties in explaining the functions. A similar observation was made by Tekkaya, Ozkan and Sungur (2001) who interviewed 14 Turkish high school teachers of biology so as to determine possible reasons behind student learning difficulties. The teachers said that the students found learning genetics difficult because students memorised the concepts, mixed the terms and forgot them after some time.

The study by Topcu and Salim- Pekmez (2009) also showed that students did not understand concepts such as cell division (mitosis and meiosis), reproduction and basic mathematical calculations. The study by Topcu and Sahin – Pekmez (2009) also revealed difficulties related to teaching methods, textbooks and mathematical expression. The students were given questionnaires to answer but no lesson observations were done to find out how teachers presented lessons which the current study did.

Tekkaya, Ozkan and Sungur, (2001) conducted a study to determine what content in biology was perceived as difficult by Turkish students to learn. The study also determined whether gender differences affect student perception. An equal number of

boys (184) and girls (184) from high schools participated in the study. Fourteen (14) high school teachers of biology also participated in that study. Data was collected using interviews, examination of the school biology syllabus and questionnaires. The study found that the difficult concepts for Turkish high school students were: hormones, genes and chromosomes, mitosis and meiosis, nervous system and Mendelian genetics. This revealed that Turkish students perceive biology topics on genetics as being difficult. The teachers gave the following reasons: most of the students found learning mitosis and meiosis difficult because of complicated terminology (that included terms that were foreign in origin such as chromosome, gene, allele, chromatid and DNA) and the abstract level of concepts. The foreign textbooks required students to have rich vocabulary in English to understand them. The laboratory conditions and equipment were insufficient. Other sources of difficulties given were: the interdisciplinary nature of concepts, teaching strategies, students motivation and interest, the Turkish biology curriculum was bulky as a result enough time was not given to each topic to be studied deeply.

In addition, the study by Tekkaya *et al* (2001) revealed that more boys perceived biological concepts easy to understand than girls. This suggests that based on this study perception of difficult topics by students is influenced by gender. This was attributed to socialisation factors and classroom experiences leading to passive dependent behaviour among girls.

The study concluded that possible sources of learners' difficulties in understanding genetics can be attributed to the bulky high school curriculum, teaching and learning strategies, the interdisciplinary nature of genetics, textbooks and insufficient laboratory conditions and equipment.

These Turkish studies showed that students did not understand concepts such as cell division (mitosis and meiosis), reproduction basic mathematical calculations. The students found learning genetics difficult because students memorised the concepts, mixed the terms and forgot them after some time (Tekkaya *et al*, 2001; Topcu and Salim- Pekmez, 2009).

2.2.1.3 Taiwanese Study

A study done in Taiwan by Chu (2008) explored problem of genetics learning and developed as well as test ways by which the situation might be improved. Chu (2008) claimed that due to the nature of the subject matter and the way learning processes occur and possibly the way genetics is being taught causes the understanding of genetics ideas of the majority of students in Taiwan to be very poor and full of confusion and alternative views. This was due to the abstract subject matter and the way processes occur. Furthermore, Chu (2008) in her study explored the problems of genetics learning among junior high school students in Taiwan. The learners' pre-requisite knowledge about genetics was explored. The results showed that those essential foundation concepts such as structure and function of cell and its organelles were not understood. These problems are similar to those experienced by North

American students and Turkish students as reported by Shaw *et al* (2008) and Topcu and Salim- Pekmez (2009) respectively.

2.2.1.4 Study done in the Netherlands

In the Netherlands, a study was conducted by Knippels, Waarlo and Boesma (2005) to investigate teaching and learning difficulties in genetics. In that study, focus group interviews with teachers, student interviews and content analysis of school genetics text books were used to collect data. That study found that Dutch teachers and students had difficulties with the abstract and complex nature of genetics. The researchers also found out that the separation of inheritance, reproduction and meiosis in the Dutch biology curriculum accounted for the abstract nature of genetics. They also found that the different levels of organization contributed to the complex nature of genetics (Knippels *et al*, 2005). The study concluded that the teaching of inheritance, reproduction and meiosis should not be separated but should be integrated so as to show the inter relationships between these concepts.

2.2.1.5 Australian Study

In Australia, Venville, Gribble and Donovan, (2005) investigated 9 to15 year-old students' emerging understanding of genetics by examining whether they can differentiate between biological and cultural inheritance and by examining their ideas, if any, about the concepts of gene and DNA. The study also investigated how emerging

understandings of genetics integrate with the children's more holistic theories of biology or their understanding of what is living and what is non living. Qualitative data collection methods (one-on-one interviews) were used in order to probe deeply and analyse intensively students understanding of fundamental concepts of inheritance and genetics. A cross sectional case study was used to explore the students understanding of basic inheritance and molecular genetics concepts such as gene and DNA. The sample consisted of 90 students, approximately 15 students from each of years 5, 6, 7, 8, 9 and 10 and included 39 females and 59 males. Each group of students was randomly selected from four different government funded schools so that students with a broad range of interests and school attainment levels were interviewed. The schools were two primary schools and two secondary schools in Perth, Australia.

The data collected was analysed quantitatively and qualitatively. The results indicated that the majority of students had a theory of kinship because they could differentiate between socially and genetically inherited characteristics. Venville *et al* (2005) found that the students had heard of the concepts gene and DNA but did not know where genes are or what they do.

2.2.1.6 Indian Study

A study was conducted in Meghalaya state, India to assess conceptual understanding of two processes mitosis and meiosis by Chattopadhyay, (2012) among student teachers in Northeast India. He sampled 289 (158 boys and 131 girls) students of class 12 from three different undergraduate colleges. Among these colleges one was for boys only, one college for girls only and the third was co-educational. The same Biology syllabus

was followed in all the three colleges. In the study data was collected using written open ended questionnaires administered at each specific college classes within a class period of 45 minutes with the help of class teachers. Questionnaires were distributed to all the students present in classes. The questionnaire was designed to assess conceptual understanding of mitosis and meiosis (Chattopadhyay, 2012).

From his study Chattopadhyay (2012) observed that the understanding of cell division was limited, confused and inconsistent. The students had no coherent conceptualization of cell division processes. The students had no understanding of how mitosis and meiosis took place. In addition, the students were not clear about the nature of differences between mitosis and meiosis. The students were confused by the very similar words 'mitosis and meiosis.' Students recognized only mitosis as cell division. Meiosis appeared to be linked with reproduction and confused it with fertilization. Furthermore, many students had little awareness of the relationship between chromosomes and genetic information. Therefore, it can be presumed that undergraduate students have misconceptions about mitosis and meiosis. Since many of these students will be future teachers it is possible that their misconceptions in cell division will pass to future generations of students.

2.2.1.7 Brazilian Study

In Brazil, a study was conducted by Malachias, Madilha, Weller and Santos (2010) to investigate the comprehension of basic genetic concepts by Brazilian undergraduate students. Malachias et al (2010) used questionnaires to collect data. The participants in

the study were drawn from six different Brazilian undergraduate courses (biology, medicine, dentistry, psychology, nutrition and phonology). Two hundred and seventeen (217) undergraduate students from the University of Sao Paulo took part in that study. All of the sampled students could not answer 30% of the questions, while some did not adequately answer more than 60% of the questions. The questionnaires were given to first year and last year students. The results of that study revealed that future teachers have misconceptions of elementary genetics. This finding is similar to what Sebitosi in South Africa (2007) and Chattopadhyay in India (2012) Sebitosi in South Africa (2007) found.

2.2.2 Teaching of Genetics

This section discusses some of the strategies used by countries outside Africa to teach genetics. These strategies include the following; learning cycle, project-based, inquiry, concept mapping, video games, simulations, case studies, worksheets and analogies.

Atay and Tekkaya (2008) conducted a study in Turkey to investigate the effectiveness of using the learning cycle when teaching genetics. The study was conducted using the experimental approach. The experimental group had 104 learners who were taught genetics using the learning cycle (by teachers who were trained to use this method) and 109 learners were in the control group that were taught using expository methods of teaching. The learners were drawn from two elementary schools in Ankara, Turkey (Atay and Tekkaya, 2008). The groups were taught genetics for four weeks. The

Genetic achievement Test (GAT), Learning Approach Questionnaire (LAQ), Test of Logistical Thinking (TOLT), and Self-Efficacy Questionnaire were used to collect data.

It was observed that the group instructed using the learning cycle had a better acquisition of genetics concepts than the one taught with expository methods of teaching. The students in the experimental group performed better than those in the control group because the various experiences gave participants the opportunity to question and formulate problems, manipulate materials, observe and record data, and reflect on and construct knowledge from data. This allowed learners to become active participants in the learning process as they constructed an understanding of scientific concepts. The students were able to see the links among concepts explicitly and connect newly learned concepts to the ones they already possessed (Atay and Tekkaya, 2008). Concepts in genetics include many interrelated ideas and facts. To achieve meaningful understanding of genetics learners must actually relate the ideas and facts that make up the concept. In expository lessons the teacher connected ideas for the learners.

The learning cycle is an inquiry based teaching strategy that divides the instruction into three phases: exploration, concept introduction and concept application. During exploration the teacher provides learners with concrete experiences related to the content to be learned. The learners mentally examine ideas by brainstorming to identify what they already know. The teacher then introduces the concepts to the learners more explicitly. The teacher promotes a discussion period in which learners share their observations with peers. The teacher then links learner experiences with relevant

scientific concepts. Then the learners engage in additional activities in which they apply their newly developed knowledge to new situations (Atay and Tekkaya, 2008).

In the U.S.A. the National Research Council is encouraging the use of a project-based genetics unit in biology classrooms. Project-based teaching is an approach that deviates from traditional transmission methods of teaching and promotes the building of knowledge. This approach has the potential to enhance students subject matter knowledge and thinking in science classrooms and particularly in genetics (Alozie *et al,* 2010). Project based science engages students in real and meaningful problems that are potentially important to the learners and are similar to what scientists do in the field. In project based learning environment, learners encounter five essential features: firstly, a driving question or a central question that guides instruction and that learners find meaningful and important; secondly, situated inquiry in which students investigate specific questions and problems that are central to the unit; thirdly, collaboration, in which students learning opportunities are extended beyond the individual to include other members of the learning environment, the learners build a shared understanding of genetics and become participants in science discussions; fourthly, technology which serves as a cognitive tool to enhance learning and fifthly, creation of artefacts whereby students create an external representation of their understanding (Alozie *et al,* 2010).

The following example illustrates how project based teaching strategy can be used to teach an aspect of genetics called variations in secondary schools in Kitwe District. At the beginning of the lesson a teacher can pose a driving question; how similar or

different are people from each other? This question prompts learners to consider physical similarities and differences such as eye colour, skin colour, sex, height and weight. From this activity, learners learn that many of their physical characteristics are similar and a few are different.

The learners are then encouraged to ask questions. They then investigate the similarities and differences in groups at deeper levels such as cell and gene levels. For instance, learners can be given pictures of people and cells from different parts of the world (Zambia, Vietnam, India and Iran) to examine different colours of skin, consider what is similar and different about the people and the cells. This is the situated inquiry and collaboration stage. From this activity, learners learn that although skin cells are similar among different kinds of people, the amount of melanin produced is different and is the cause of the variety of human skin colours. This activity helps learners to construct knowledge about the skin of an albino. The pictures of people and cells act as technology which serves as a cognitive tool to enhance learning and the lists of similarities and differences are the artefacts (external representation of their understanding) that are produced.

Annetta, Cheng and Holmes (2010) conducted a quasi-experimental study to investigate how video games can be used in educational settings as teaching and learning tools. The participants comprised biology students from different classes taught by the same teacher. The sample consisted of 131 (70 males and 61 females) high school biology students of similar ability. Students were observed during an exposure to a teacher-

created Multiplayer Educational Gaming Application (MEGA) for high school students. The MEGA (video game) was used to assess the twenty-first century skills of digital age literacy, creative thinking and effective communication skills of learners. The MEGA was created in Active worlds, a 3D virtual environment.

The MEGA entitled "The stolen fortune of Mr. Megabucks" was set in a multiplayer environment. Students were asked to solve a mystery using their understanding of pedigrees, Mendelian inheritance, blood types and DNA finger printing. The background story was the tragic death of a wealthy couple from lightening. The couple left a large inheritance to a number of relatives. On the day when everyone showed up for the reading of the will the inheritance was stolen. The thief left blood stains and finger prints on the crime scene. The students had to go to the lab to analyze the clues to find out who had stolen the inheritance (Annetta *et al,* 2010).

The pupils reinforced and reviewed the unit on genetics using the game. The study reported that the pupils were very engaged through interactions with their teacher while playing the MEGA. The students eagerly raised their hands to ask questions. The students were able to discuss with their peers and finish three tasks: making a pedigree, eliminating suspects and identifying the thief. Games are useful for teaching cause and effect relationships and learners retain what they learn from games because they are interactive. This video game helped learners to understand the complex and abstract concept of genetics. (Annetta *et al,* 2010).

White, Bolker, Koolar, Ma and Maw (2007) developed a Virtual Genetics Laboratory (VGL), a computer simulation of transmission genetics in a hypothetical insect. A genetic phenomenon is presented to the student by the program about the inheritance of a trait selected at random. The student is asked to determine how the trait is inherited. He or she constructs a genetic model by designing his/her own experimental crosses. The results of the crosses are then generated by the software. He or she then analyses the results. The simulation supports a variety of strategies for genetic analysis because it is open ended. Technology is used by biology teachers to supplement biology teaching. A variety of computer programs have been used to enhance student learning of genetics. For example, Biologica is an interactive multimedia program used for learning introductory genetics. In this program, a student can select or make changes to the graphics and text objects and observe the results according to the laws of Mendelian genetics (Tsui and Treagust, 2004).

The topic genetics has a lot of terms that pupils have to learn in order to understand the topic. Constructivist methods of teaching such as pairing can be used to promote intelligent discussions on genetics. May, Cook and May, (2013) conducted a study using biological dialogues. Students in a collegiate undergraduate genetics course were asked to choose a partner and the pair was asked to write a dialogue based on a vocabulary word list of 25-30 words provided by the instructor. The pairs wrote and practiced their dialogues and later made 5 minute presentations of the dialogues to the class. This helped pupils to understand contextual meanings of the terms rather than just memorizing definitions. This is because vocabulary building was related to what the

students knew already, vocabulary instruction was active and that the repetition of the words by students helped students to learn them. Students find memorising of terms tedious and boring.

Furthermore, Styer (2009) revealed that inquiry based learning including the use of case studies is one of the types of active learning that make learners to acquire critical thinking skills. The use of case studies also develops skills in group learning and helps to make science relevant to learners. Mendelian genetics can be taught using case studies involving inherited conditions. Case studies can be used to assess how well learners have learned and can apply genetic principles to real world situations.

Learners have difficulties understanding genetics because the terms used in genetics have no common usage outside the genetics classroom. For example, terms like heterozygote or genotype, allele or locus are used. Learning genetics is like learning a foreign language. Many terms in genetics are defined in opposition to similar sounding terms whose meanings are quite distinct. For example, heterozygous and homozygous, if a student does not understand one of these paired terms, the student cannot understand the other (Woody and Himelblau, 2013). The use of analogy can help learners to understand the vocabulary of genetics. For example, loci and genes can be explained using the analogy of street addresses.

The literature reviewed in this section revealed that teachers outside Africa employ a variety of learner centred approaches, such as case studies, dialogues, project work,

practical work, pairing and computer games, which are effective in teaching genetics as opposed to employing teacher centred strategies, such as lecture and teacher demonstrations only.

2.3 Studies on Genetics Education done in Africa

Not much research has been done in relation to teaching of genetics in Africa. A few studies undertaken have concentrated on pupils understanding of genetics. One such study was done in South Africa, Sebitosi (2007) investigated the understanding of concepts about genetic inheritance in rural schools in two provinces. The participants were 15 teachers registered for a biology module presented by Sebitosi and 100 grade 11 learners who were taught by participating teachers. The schools were in rural areas. Research instruments used were written questionnaires, interviews, pre-and post tests and focus group discussions. The findings of that study were that learners lacked understanding of the mechanisms and processes involved in genetics. The learners had problems with understanding the difference between genes and chromosomes, what is inherited and what is not, what Mendelian inheritance entails and the conflict between traditional beliefs and scientific reasoning.

In South Africa, Dlamini (1999) also conducted a study to determine the level of competency in the knowledge, understanding and problem solving skills in genetics by student teachers. A class of 1998 consisting of 25 students was used for the study. The research found that the overall performance of participants in the tasks that tested higher order learning genetics was poor. The participants did better in questions that tested

lower order cognitive levels such as recall. The participants showed difficulty in understanding the process of meiosis but where quite comfortable on the questions of mitosis.

In addition, the study by Dlamini (1999) showed that there was a significant positive correlation between subjects' knowledge and understanding of meiosis and ability to find solutions to genetics problems. The understanding of genetics was found to be critical in the succession solution of genetics problems. Student teachers showed a lack of interpretive and analytical skills during practical work. This was evident in that some student teachers wrote models that showed more than one pair of chromosomes instead of showing a pair only. The students` lack of ability to interpret simple instructions pointed to poor language facility. Dlamini (1999) further stated that not much research on genetics has been done in South Africa.

In Nigeria a study was conducted by Okoye and Okechukwu (2006) which examined the effect of concept mapping and problem-solving strategies on achievement in genetics among Nigerian secondary school students. The study used a quasi-experiment pre-test post test treatment method. The sample consisted of 113 senior secondary school three (SSSIII) students randomly selected from three mixed secondary schools in Delta State.

The experimental group was taught selected topics in genetics using concept mapping and problem-solving strategies while the control group was taught using the traditional

lecture method. The experimental group was taught by trained teachers who were significantly trained for the purpose of the study. The result of the study showed that the experimental group performed significantly better in genetics than the control group (Okoye and Okechukwu, 2006).

2.4 Studies on Genetics Education done in Zambia

Studies carried out in Zambia show that genetics was perceived as a difficult topic for many pupils and teachers. Action to improve English, Mathematics and Science (AIEMS, 1994) conducted a base-line study to identify difficult topics in science subjects. Data on what topics in science and biology in particular they found difficult to learn was collected from pupils using questionnaires. The study reported that in biology genetics was one of the difficult topics identified by pupils to learn because of its abstract and complex nature. Pupils cannot actually see what happens in the crosses that are discussed. Hence, it was suggested that to teach the topic successfully pupils could be given "chromosomes" made of cardboard and letting them perform the crosses and analyse the results. Only at a later stage can the teacher switch to the use of letters as symbols for representing chromosomes. The study concluded that the theoretical approach to genetics is sometimes made worse by the use of many textbook examples using peas, flowers, etc. Crosses are much more appealing to pupils if examples of inheritance in man and other mammals are used.

Haambokoma *et al* (2002) carried out a survey on the teaching and learning of mathematics and science subjects in high schools in Zambia. One of the objectives of

this study was to find out which topics pupils find difficult to learn in mathematics and science subjects studied at high schools in Zambia. According to this study, one of the topics that teachers and heads of departments said were difficult to teach in biology was genetics. In addition, the largest number of teachers who participated in this study indicated that they were less comfortable to teach genetics. The heads of departments (HODs) who participated in this baseline survey recommended that the teachers needed help to be more effective in teaching this topic. Ten years later, a study undertaken by Manda (2012) investigated the nature and causes of learning difficulties pupils experience in biology in high schools in Samfya District. A descriptive sample survey design was used. The research instruments used were interview guides and self completion questionnaires. The study revealed that one of the topics that teachers and pupils found difficult to teach and learn respectively was genetics.

Another related study was undertaken in Zambia by Haambokoma (2007) in order to find out the nature and causes of learning difficulties grade 12 learners experience when learning genetics. The study was a descriptive survey. Questionnaires were used to collect data from former grade 12 pupils. The study found that the factors which contributed to pupils finding it difficult to understand genetics were: inability by teachers to explain clearly, the topic not taught at all, topic taught near examinations by some teachers, belief by pupils that genetics is difficult to learn, lack of appropriate teaching aids, inadequate time allocated to teaching the topic and unfriendly teachers. In the same study, crosses, calculations, genetics terms, mutation, mitosis and meiosis, sex determination, variations and co-dominance were reported to be areas where pupils had difficulties. This research used questionnaires only but no lesson observations were

done. The current study used lesson observation to determine how genetics is taught in secondary schools in Kitwe District.

2.4.1 Examinations Council of Zambia Examiner's Reports on Performance of Candidates in Genetics.

Chief examiner reports for biology theory paper reveal that grade 12 pupils do not respond well to questions on genetics in the final school certificate examination. The question on genetics is usually found in the compulsory section A of biology paper 2. But this question is attempted by very few candidates. Most of those who attempt show little knowledge and write wrong responses and score poorly. Each year most candidates fail to draw correctly labelled genetic diagrams. Each year most candidates failed to put an X between parental phenotypes to represent mating and lost marks (ECZ: 2006; 2007; 2008; 2009; 2010). Table 8 is a summary of chief examiners reports for biology for five years 2007 to 2011 showing the following; the year, question, correct response, most common wrong response and chief examiner's comments.

Table 8: A Summary of Chief Examiner's Reports for Biology for 2007 to 2011

Year	Question	Correct Response	Most common wrong response	Chief examiner's Comment or Observation
2007	a) Describe the events during meiosis which cause each ovum to be genetically different from another. b) A couple who both have the sickle-cell trait had a child with sickle-cell. (ii) Explain using a fully labelled genetic diagram show how sickle cell	During prophase1 of meiosis homologous chromosomes pair up and their chromatids exchange pieces. This process called crossing over is one cause of genetic differences between ova. During anaphase1 of meiosis the homologous chromosomes are randomly separated from each other and are pulled to the opposite poles. This process is called random assortment of chromosomes is one cause of genetic variations among daughter cells. a)(ii) Man X woman Parental Phenotype: carrier X carrier Parental Genotype Hh Hh Gametes: H h H h Offspring Genotype HH Hh Hh hh Offspring Phenotypes: normal, carrier, carrier, sickle-celled	Writing about mitosis instead of meiosis. Writing about meiosis without mentioning the events which cause the ova to be genetically different.	Most of the candidates seemed not to have learnt the topic meiosis and as a result failed to answer the question, they left it blank. Those who attempted failed to bring out the actual events during meiosis which can

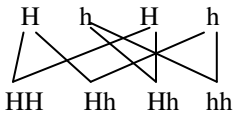
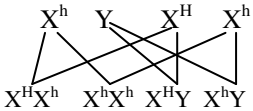
	would be inherited by the child (use the letters H and h for the alleles). [5] (iii)What is the chance of the child being sickle-celled? [1]	iii) 25% chance	 iii) 0.25	cause each ovum to be genetically different from another. Most candidates failed to draw correctly labelled genetic diagrams.

Table 8 Table 8 Cont A Summary of Chief Examiner's Reports for Biology for 2007 to 2011.

Year	Question	Correct response	Most common wrong response	Chief examiner's comment or observation
2008	(a) Haemophilia a sex linked disease is caused by a recessive gene. A haemophiliac man married a normal woman and they had a haemophiliac daughter. (i) State the genotype of the mother.[1] (ii) Using a genetic diagram, show how they could	(a)(i) $X^H X^h$ a)(ii) Man X woman Parental Phenotype: haemophiliac X Parental Genotyp $X^h Y$ $X^H X^h$ Gametes: X^h Y X^H X^h Offspring Genotype $X^H X^h$ $X^h X^h$ $X^H Y$ $X^h Y$ Offspring Phenotypes: Normal female Haemophiliac female, Normal male Haemophiliac male	(a)(i) homozygous, heterozygous, X Y , XX, HH and Hh (a)(ii) Most of the candidates who attempted did not put a cross on the genotypes of the parents.  	Most candidates failed to write the correct genotype of the mother. Some candidates did not attach the genes to the sex chromosomes and lost marks. ii) Very few candidates scored

	have a daughter who is a haemophiliac. (note use the symbols H and h for the alleles)[4] (iii) What proportion of the children will be normal?[1]			marks on the genetic diagram..

Table 8 Table 8 Cont A Summary of Chief Examiner's Reports for Biology for 2007 to 2011,

year	Question	Correct response	Most common wrong response	Chief examiner's comment or observation

2009	(i) What is a sex linked characteristic? [1] (ii) Explain why males are more likely to suffer from sex linked diseases than females?[2] (iii) Colour blindness is a sex linked disease. Using a genetic diagram show the chances of having a colour blind child from a couple made up of a normal male parent and a carrier female parent (use the symbols X^R and X^r)[7]	(a)(i) A sex linked characteristic is one that is controlled by genes on the X and Y chromosomes. (a)(ii)Haemophilia is more expressed in males than in females because the gene for haemophilia is found on the X chromosome. A man inherits one X chromosome and a Y chromosome. Some men inherit the h allele and cannot make the clotting factor. They are haemophiliacs. If a female inherited this allele its effect would be masked by the presence of the H allele on the other X chromosome. It is very rare that a woman inherits the two h alleles on sex chromosomes (a)(iii Man X woman Parental Phenotype: normal X carrier Parental Genotype: X^RY X^RX^r Gametes: X^R Y X^R X^r Offspring Genotypes X^RX^R X^RX^r X^RY X^rY Offspring Phenotypes: Normal female, Carrier female Normal male, Colour blind mal	(a)(ii) males are more likely to suffer from haemophilia because; occurrence of an X chromosome, the trait is only determined by one gene, it is a characteristic found on the sex chromosome. (a)(iii) Candidates wrote genetic diagrams without labels. X^R Y X^R X^r X^RX^R X^RX^r X^RY X^rY	Most poorly answered question. Candidates did not understand the difference between a characteristi c and a gene.

Table 8 Table 8 Cont A Summary of Chief Examiner's Reports for Biology for 2007 to 2011.

Year	Question	Correct Responses	Most Common wrong response	Chief examiner's Comment or Observation

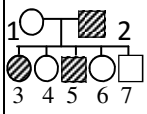
2010	The figure shows the inheritance of haemophilia in a family.  **KEY** Male Haemophiliac Female Haemophiliac Normal Male Normal Female (a)Taking the allele for haemophilia to be X^h, What is the genotype of offspring 3 and 7?[2] (b) Offspring 4 marries a person with similar genotype to offspring 7. (i)Draw a genetic diagram to show the genotypes and phenotypes of the offspring.[5] (ii) What is the probability of them having a normal child?[1] (iii) What is the probability of them having a child who is a carrier?[1]	(a)Offspring 3 X^h X^h Offspring 7 X^H Y (b) Man X woman Parental Phenotype: haemophiliac X normal Parental Genotype: X^HY X^hX^h Gametes: . X^H Y X^h X^h Offspring Genotypes: X^HX^h X^HX^h X^hY X^hY Offspring Phenotypes: Normal female Normal female Normal male Colour blind male (ii) 3/4 , 75%, 3 out of (iii) 1/2 , 50%, 1 out of 2	X^HX^H , X^H X^h , X^H Y^H , X^h Y X^H Y X^h X^h X^HX^h X^HX^h X^hY X^hY (iii) 0.75	Was a poorly tackled question by candidates. Candidates did not explain the symbols used.

Table 8 Table 8 Cont A Summary of Chief Examiner's Reports for Biology for 2007 to 2011

Year	Question	Correct Response	Most common wrong response	Chief examiner 's comment or

				observation
2011	In an experiment to demonstrate the inheritance of coat colour in cattle, a roan bull was repeatedly crossed with a roan cow and produced roan, white and red calves. (a) Which coat colour is as a result of co-dominance?[1] (b) Determine the genotypes of the three coat colours, given that C^R is the gene for red colour and C^W is the gene for white colour.[3] (c) Show using a genetic diagram the possible offspring which could be produced when a red bull was crossed with a roan cow.[4]	a) Roan b) White- C^WC^W Red- C^RC^R Roan- C^RC^W c) bull x cow Parental Phenotype: Red x Roan Parental Genotype: C^RC^R x C^RC^W Gametes: C^R C^R C^R C^W Offspring Genotypes: C^RC^R C^RC^W C^RC^R C^RC^W Offspring Phenotypes:Red, Roan, Roan, Roan	White, Red White- WW Red- RR Roan- RW C^R C^R C^R C^W C^RC^R C^RC^W C^RC^R C^RC^W	Most candidates did not attempt this question. Most of the candidates who attempted this question scored fairly good marks.

2.5 Conclusion

From the literature review it is clear that many studies have been done on genetics education outside Africa, in Africa and in Zambia which shed some light on difficulties

experienced by learners in genetics. The researchers used interviews and questionnaires to collect data from participants. As observed in the literature reviewed no study has been done in Zambia to observe how genetics was taught in secondary schools particularly in Kitwe schools. There is a knowledge gap which this study attempted to contribute to. This made the current study necessary.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter presents information on the methodologies used to answer the research questions under the following sub headings**;** research design, research sites, target population, sample and sampling procedures, research instruments, data collection procedures, data analysis, ethical issues and limitations of the study.

3.1 Research Design

This study used a cross sectional survey design (Kumar, 1996). It is also known as one-short or status studies that investigate things such as the prevalence of a phenomenon, situation, problem, attitude or issues by taking a cross-section of the population. The design gives an overall picture of the problem under study as it was at the time of study. This design was used because it was the most appropriate for collecting data at a particular time during the school year (term 3) when genetics is taught to grade 12 learners. This design was used because it also helped to address the research questions and to generate the type of data required as suggested by Kumar (1996) and Creswell (2003). It was mainly a qualitative research.

3.2 Research Sites

The study was undertaken in Kitwe District on the Copperbelt Province of Zambia at three selected secondary schools. For the ethical reasons the secondary schools have been given the following pseudo names: Buffalo, Elephant and Impala Secondary School. Buffalo Secondary School was chosen because it is a single sex girls` secondary school. Elephant Secondary School was chosen because it is a single sex boys` secondary school. Impala was chosen because it is a co-education school.

3.3 Target Population

The target population were all teachers of biology who taught genetics in secondary schools in Kitwe District. Information was also obtained from pupils and heads of natural sciences departments.

3.4 Sample and Sampling Procedures

The sample was made up of a total of 18 teachers of biology drawn from three selected secondary schools in Kitwe District. Purposive sampling method was used in order to choose participants who would provide the best information to answer the research questions (Kumar, 1996; Creswell, 2003) and to include male and female teachers of biology. The schools were also purposively sampled in order to include single and mixed sex schools.

The researcher sampled teachers who taught biology and genetics in particular for lesson observations and to answer questionnaires. After each lesson ten grade 12 pupils who attended lessons were given questionnaires to answer. Those who answered the questionnaire were picked at random using lottery method (Kumar, 1996; Creswell, 2003). Learners' names were written on separate pieces of paper and placed in a box. A piece of paper at a time was picked from the box at random. The learners whose names were picked (180 learners [90 girls and 90 boys]) were given questionnaires to answer. Heads of natural science departments from the three selected secondary schools were interviewed.

3.5 Research Instruments

The following research instruments were used to collect data: Open ended Questionnaires, interview guides (see appendices A, B and C for details of each instrument) and lesson observation note book. Lesson observation method was used to collect data on classroom interaction and lesson presentation. This method has been used by other researchers investigating classroom interactions (Sinyangwe and Chilangwa, 1995; Nkoya, 2006; Kalumba, 2012). A pilot study was conducted before the main study at Zebra Secondary School to check for ambiguity of questions in the questionnaire, test the validity and reliability of research instruments and data collection procedures. Zebra Secondary School was chosen as a pilot school for this study because it had similar characteristics to schools which participated in the actual study

3.6 Data Collection Procedure.

Data collection took place in the third term of 2012 academic year in September and October. Before data collection permission was sought from District Education Board Secretary (DEBS) in Kitwe and headteachers of sampled schools using an introductory letter from the University of Zambia (Appendix D), permission was sought orally from HODs, teachers and pupils. The purpose of this research was explained to DEBS in Kitwe, headteachers of sampled schools, teachers and pupils. Written permission was granted by the DEBS and headteachers (see appendix E and F) heads of natural science departments, teachers and learners gave oral permission. The researcher asked the head of natural science department at each selected school for schedules of periods when

teachers would be teaching genetics in grade 12. The schedules from each school were noted down. The purpose of this research was explained to each teacher of biology who participated in the study and to each grade 12 biology class before the lesson observation.

The researcher then visited the schools without prior arrangements with the teachers so as to be able to observe how the teachers teach when no observer was around. Appointments would have made the teachers to go extra miles to prepare to be observed. This would not have given the researcher the correct picture of what goes on when genetics is being taught. Permission from the teachers and learners to observe their lessons was sought on the day of observing the lesson.

During each lesson observation the researcher sat at the back of the class from the beginning to the end of each genetics lesson observed. The researcher watched and listened to classroom interaction as the lessons were going on. The researcher wrote notes in a note book on what was happening in the class as the lesson progressed. Lesson observations focussed on the following; lesson plan, lesson introduction, lesson progression and teaching strategies, questioning skills, teaching and learning aids, note taking, class exercises and homework , lesson evaluation, summary and conclusion. Lesson plans of the observed lessons were also collected after the lesson observation. This was done in order to check the following: teacher preparedness for the lesson, the rationale for the lesson, the lesson objectives. This also helped to check if what was

planned was what was delivered. Eighteen teachers of biology were observed while teaching genetics and answered the teachers' questionnaire.

The use of the observation method and the questionnaires was a way of triangulating (Harris 2002; Howie and Grayson, 2002) said that questionnaires must not be used alone when finding out what teacher practice was. Howie and Grayson (2002) said that teachers do not practice what they say. They are of the view that the best way to find out about the strategies teachers use is to observe what they actually do in class. Hence, lesson observation approach was used, questionnaires and interviews were used. Heads of natural science departments were interviewed using an interview guide (Appendix B). Heads of natural science departments were interviewed because they are the immediate supervisors of the teachers. One of the duties of HODs is to observe teachers while teaching therefore they could give information on how teachers taught genetics.

After explaining the purpose of this research to teachers of biology, open ended questionnaires were given to them. The questionnaires were left for two weeks with the teachers to answer. Teachers handed the questionnaires to the head of natural science department at each participating school after they completed answering the questions. The researcher went back to each selected school to collect the completed questionnaires from HODs. The researcher collected the questionnaires from pupils the same day for fear that if they were left with them for a long time some would go missing and pupils may have copied responses from each other. The open ended

questions on the open ended questionnaires for teachers and pupils were framed so as to enable the respondents to supply the required data for the research questions.

3.7 Data Analysis

Data collected were analysed using qualitative content analysis. Qualitative content analysis has been defined by Hsieh and Shannon (2005:1278) as: "*A research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns."* Mayring (2000:2) defined qualitative content analysis as; "*an approach of empirical, methodological controlled analysis of texts within their context of communication following content analytic rules and step by step models, without rash quantification.*" The process of qualitative content analysis involves the following set of systematic and transparent procedures for processing data; Preparing the data for analysis, defining the unit analysis, developing categories and a coding scheme, testing the coding scheme on a sample of questionnaires, coding all the text, assessing the coding consistency and drawing conclusions from the coded data (Weber, 1990; Kumar, 1999; Creswell, 2003).

Completed samples of open-ended questionnaires, interview notes and lesson observation notes were examined one at a time using content analysis (Creswell, 2003). An open ended question from one questionnaire was selected and the response(s) to that question were written down on a sheet of paper. If the respondent gave more than one response, the responses were written separately on the same sheet of paper. Similarly, from the same questionnaire another question was selected and the responses to that

question were written down on a separate sheet piece of paper. In the same way all questions in the questionnaire had responses written down on separate sheets of paper. Another questionnaire was picked and went through the same process, the researcher added responses given for the same question on the sheet for that question. This process continued until all the responses from the sample questionnaires were written down. Then one by one the responses to each question were examined to ascertain the similarities and differences. Responses that were similar in meaning were combined under a category or theme. The themes or categories developed were the units of analysis. The categories were abbreviated as codes and were written next to the appropriate segment of the text. A code was assigned to each theme or category (Kumar, 1999; Creswell, 2003). For example, teaching and learning aids was given a code TLA.

Categories and coding schemes were inductively derived from the data. A comparison of each text assigned to a category with each of those already assigned to that category was done in order to fully understand the theoretical properties of the category. To ensure consistency of coding, a coding manual was developed in which category names, definitions, rules for assigning codes and examples were written (Weber, 1990).

The coding scheme was tested by using it to code a sample of questionnaires. After coding the sample, the coding consistency was checked. When sufficient consistency was achieved the coding rules were applied to all the questionnaires. Text segments

belonging to each category were cut out and placed on notecards. The researcher analysed the themes or categories identified. Reconstructions of meanings derived from the data were made. Typical quotations from participants were used to justify conclusions (Kumar, 1999; Creswell, 2003). Quantitative data was obtained by determining the frequency of the themes (Kumar, 1999). The results were presented in form of tables.

3.8 Ethical Considerations

A number of ethical issues were taken into consideration during this study and steps taken to ensure that the study is undertaken in ethically acceptable ways. In this regard, the following were done: Before data collection permission was sought in writing from the DEBS in Kitwe. The DEBS gave this researcher permission to carry out research in the selected schools in Kitwe. When the researcher visited each sampled school, the researcher reported to the Headteacher, introduced herself and explained the purpose of this research. Then permission was sought from the headteacher. The headteacher gave written permission for research to be conducted in the school. The researcher then met the head of natural sciences department, explained the research and sought permission to conduct research. Permission was also sought from teachers of biology and pupils after explaining the purpose of the research to them separately. Heads of natural science departments, teachers and learners gave permission to carry out research and willingly participated in the study.

Anonymity was respected by not exposing the names of the teachers of biology whose lessons were observed by giving them codes from A to R. The participating schools were given pseudonyms. The information given by teachers and pupils in the questionnaires was treated with confidentiality.

3.9 Limitations of the Study

This study was carried out in three selected secondary schools Kitwe District though it would have been preferred to get information from all schools in Kitwe District or the whole Copperbelt Province or the whole country. However, this was not possible because of time and financial constraints. Sometimes the researcher could not observe a lesson because the teacher had not yet started teaching genetics as a topic. Some teachers of biology started teaching genetics late in the third term just before grade 12 final examinations. This limited the number of teachers that were observed while teaching. When examinations started it was not possible to continue with lesson observations. The teaching of this topic could only be done in the third term. In addition, it was difficult to extract actual genetics marks obtained by candidates in the examinations at the examinations council of Zambia. But the researcher was able to get examiners feedback on the performance of candidates in genetics questions from the chief examiners reports.

CHAPTER FOUR

PRESENTATION OF FINDINGS

4.0 Introduction

In this chapter the findings of this study are presented according to research questions.

4.1 Research Question 1: Characteristics of Teachers who teach Genetics in Three Selected Secondary Schools in Kitwe District?

To answer this question data was collected on the sex, age, professional qualification and teaching experience of teachers of biology. These are presented below.

4.1.1. Sex of Teachers

Table 9 shows the sex distribution of teachers of Biology who participated in the current study.

Table 9: Teachers of biology by Sex (n=18)

Sex	Frequency	Percentage (%)
Male	08	44
Female	10	56
Total	**18**	**100**

As it can be seen in Table 9, slightly above half of the teachers who taught biology in general and genetics in particular in schools sampled were female.

4.1.2 Age of Teachers

Table 10 shows the age range of the teachers who took part in the study.

Table 10: Teachers by Age (n=18)

Age	Frequency	Percentage (%)
Less than 30 years	3	17
31-40 years	8	44
41-50 years	7	39
Total	**18**	**100**

Most of the teachers in this study teaching biology of which genetics is part of were above 30 years old.

4.1.3 Highest Professional Qualification of Teachers

Table 11 shows the highest professional qualification of teachers of biology who participated in the study.

Table 11: Highest Professional Qualification of Teachers of Biology (n=18)

Professional Qualification	**Frequency**	**Percentage (%)**
Diploma	14	78
Advanced Diploma	1	5
Degree	03	17
Total	**18**	**100**

The majority of teachers who taught genetics among those who took part in this study were holders of secondary teacher diploma in science.

4.1.4 Teaching Experience of Teachers of Biology

Table 12 shows the teaching experience of teachers of biology who participated in the study.

Table 12: Teaching Experience of Teachers (n=18)

Teaching Experience (Years)	Frequency	Percentage (%)
1-2	02	11
3-5	01	6
6-10	08	44
Above 10 years	07	39
Total	**18**	**100**

Most of the teachers of biology, who participated in the study, had more than five years experience in teaching biology in general and genetics in particular.

4.2 Research Question 2. How is genetics taught in secondary schools in Kitwe District?

To answer the research question above, data on lesson planning, lesson introductions, lesson progressions, questioning skills, teaching and learning aids, pupil activities, lesson evaluations, summary, conclusion, homework and note taking was collected. This is presented below.

4.2.1. Lesson planning

Fifty percent (50%) of the teachers observed had prepared lesson plans. However, the lesson plans did not have clear objectives for the lessons. The objectives only had the

action part without the level of achievement and the condition statement being stated. For example, one objective read; *"To solve genetics questions using punnet squares"*. This made it very difficult to establish if the objectives were achieved or not. All the participating teachers of biology who wrote lesson plans did not write the following: teaching aids to be used during the lessons, the worksheets to be used during individual or group work, practical work and homework tasks. The lessons observed were on the following subtopics: Types of crosses, variations, Inheritance of blood groups and Inheritance of sex-linked characteristics.

4.2.2 Lesson Introductions

In all the lessons observed the intended outcomes of the lesson were not told to the learners at the beginning of the lesson. Seven of the teachers observed introduced their lessons by reviewing the previous lessons using question and answer technique. In this regard the teachers asked the questions orally and the pupils gave oral answers. Most of the questions that teachers asked were low order questions. For example, Teacher A from Buffalo Secondary School asked learners, *"State the types of blood groups in human beings?"* A learner answered, "*The types of blood groups found in human beings are blood group A, B, AB and O*." Teacher A also asked the learners*, "State the possible genotypes for blood group A*?" Another learner answered, *"The possible genotypes for blood group A are* I^AI^A *and* I^AI^O*."* Teacher E of Elephant School asked the learners, *"Name two sex linked diseases?"* One of the learners answered, *"Haemophilia and colour blindness are sex linked diseases."* These examples illustrate the fact that most of the questions were low order questions. These questions did not encourage pupils to

think. Teacher C from Impala School started his lesson by asking revision questions on grade 9 topic selective breeding with the class. Teacher D, a female from Elephant School did a very long introduction (23 minutes) to the lesson using question and answer technique. This teacher started the lesson by asking learners to define the terminologies used in genetics. The teacher then went on to revise, variation, continuous variation and discontinuous variation, mutation, causes of mutation and DNA structure. The learners in this particular lesson had challenges understanding DNA structure. In spite of the learners not understanding the structure of the DNA, the teacher went on to teach Mendelian crosses. The pupils said that they did not understand Mendelian crosses.

The lesson introductions in seventeen of the observed lessons did very little to arouse pupils interest and capture their minds. However, the lesson introduction by Teacher B raised learners' interest. Teacher B introduced the lesson on variations by asking the learners, "*What characteristics do you want to see in your future husband?"* The learners were very attentive and active. They gave a variety of responses. The introductions were relevant except the one by Teacher E of Elephant secondary school which took 23 minutes revising content of all previous lessons. In all the lessons, learners were involved by answering questions paused by teachers. The introductions linked what the learners knew to what the lesson was about. The biology teachers that were observed did not define new terms that the pupils were going to learn during the lesson. All the teachers of biology that were observed clearly wrote the topic of the lesson on the board after the lesson was introduced.

4.2.3 Lesson Progressions and Teaching Strategies

The main teaching methods that teachers of biology used were question and answer, lecture method and group work.

Table 13: Teaching Strategies and Topics

Teacher	Teaching Strategies	Topic
A	Lecture, Question and Answer	Mechanism of AOB inheritance (blood groups)
B	Group work, Question and Answer	Variations
C	Group work, Question and Answer	Monohybrid cross
D	Lecture, Question and Answer	Mendelian crosses
G	Lecture, Question and Answer	Mendelian crosses
H	Lecture, Question and Answer	Inheritance of albinism
I	Lecture, Question and Answer	Mechanism of AOB inheritance (blood groups)
J	Lecture, Question and Answer	Sex linked characteristics
K	Lecture, Question and Answer	Mendelian crosses
L	Lecture, Question and Answer	Mechanism of AOB inheritance (blood groups)
M	Lecture, Question and Answer	Monohybrid cross
N	Lecture, Question and Answer	Co dominance
O	Lecture, Question and Answer	Sex linked characteristics
P	Lecture, Question and Answer	Co dominance
Q	Group work, Question and Answer	Mechanism of AOB inheritance (blood groups)
R	Lecture, Question and Answer	Mechanism of AOB inheritance (blood groups)
P	Lecture, Question and Answer	Co dominance
Q	Group work, Question and Answer	Mechanism of AOB inheritance (blood groups)
R	Lecture, Question and Answer	Mechanism of AOB inheritance (blood groups)

From Table 13 it can be noted that 13 teachers observed used lecture method and these teachers talked while learners listened. Five teachers used group work. All the teachers used question and answer technique at some point during the lesson.

4.2.3.1 Group work

Groups were formed at random. Learners joined any group that they wanted. The teachers did not assign groups to the learners. There were no instructions from the teachers as to who would be the chairperson of the group or the secretary. Each of the five teachers of biology wrote the questions for group work on the chalk board. For example, Teacher F at Impala Secondary School asked pupils to form ten groups with five pupils in each group. Then the teacher wrote the following question on the board for learners to answer in groups.

An allele A is dominant and determines the production of melanin a skin pigment. A person where such a gene is present has a skin colour. A person where such a gene is not present has no skin colour; such a person is called an albino.

1. Use a cross diagram to show the inheritance of this allele in each of the following:
    a) A homozygous dominant normal skinned woman marries an albino man.
    b) A normal skinned man marries a normal skinned woman both heterozygous.
    c) An albino man marries a heterozygous normal skinned woman.
    d) Two albinos marry.

This teacher asked each group to make their presentation of their responses to the class after group work was concluded. This teacher went round the class checking what the learners were doing and guiding them. The learners interacted well with one another. There was educational noise as the group work was going on. The teacher did not ask the learners to keep quiet. This was good because learners were able to share ideas freely and were actively involved in the lesson.

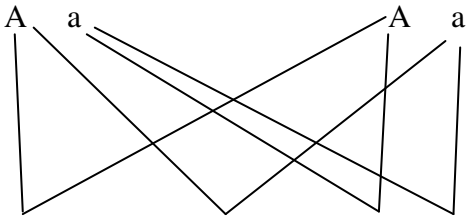
Then the teacher asked one learner from a group that answered the questions correctly to draw genetic diagrams. The pupil answered question 1a. as shown below:

1a. **Parents** Male X Female

Parental phenotypes normal skin normal skin

Parental genotypes A a A a

Gametes



Offspring genotypes AA Aa Aa aa

Offspring phenotypes normal skin normal skin normal skin albino

Teacher B, from Buffalo Secondary School and Teacher C from Elephant Secondary School also went round the classes checking and marking what the learners were writing. This was good practice because it gave the teachers and learners prompt feedback. Most of the groups from these five classes that used group work reported

correct answers to their classes. The pupils who came forward to report answers after group work in the co-education school were boys. The girls took the role of secretaries to record the answers of the group work.

4.2.3.2 Question and Answer Method

All the teachers observed in this study used question and answer strategy at some point during their lessons. This technique was used during lesson introductions and lesson progressions. Most of the questions were oral questions. After posing a question, teachers waited, allowed learners to think about the response. When the learners had reasonable time to think (say 15 seconds), one of the learners was asked to answer. Most of the questions teachers asked were low order questions which were not effective in making learners to critically think about the topic at hand. For example Teacher E asked learners, *"Define a sex linked disease?"* Teacher D asked, *"What is a phenotype?"* The teachers asked the questions clearly such that the learners were able to understand and answer them. Teachers showed that they acknowledged the responses offered by praising correct answers by for example, saying *"good"* or *"very good"*. This boosted learners' confidence. The teachers received wrong responses well by not ridiculing wrong responses. The teacher of biology observed accepted the first correct responses that were given by learners. When asking questions to a class the teachers distributed the questions to all parts of the class. However, only the pupils who had their hands up were given chance to answer questions. Where the class was a mixed one, the

boys were the ones who mostly put up their hands and were given opportunities to answer questions.

However, in all the lessons observed only two learners asked their teachers questions. One learner at Impala Secondary School wanted to know where genes were found. The teacher responded that genes are found on chromosomes. A learner at Elephant Secondary School asked a question on the structure of DNA. Almost all the questions in the lessons observed were asked by teachers. Teachers did not encourage the learners to ask questions.

The teachers of biology observed in this study did not give practical work to the learners.

4.2.4 Teaching and Learning Aids

All the teachers that were observed did not use any kind of teaching aids apart from the chalk board and chalk. It was surprising to observe teacher B from Buffalo School Secondary teach the subtopic variations without any teaching aid because this is a topic where the teacher could have brought a variety of teaching and learning materials such as different varieties of bean seeds, different varieties of the same fruit. The teacher could have used the learners themselves to teach discontinuous variations using characteristics such as tongue rolling, sex of pupils and attachment of ear lobes.

4.2.5 Note Giving

In five of the eighteen lessons observed the teachers gave summarised notes to the class. The lessons observed were on sex linked characteristics, genetic crosses and inheritance of blood groups. During lessons on sex linked characteristics and inheritance of blood groups the teachers developed the notes as the lessons progressed and gave learners time to copy the notes. The notes were clearly written on the chalk board. The notes were useful because they contained the main points of the lesson. The other thirteen teachers did not give learners notes. When the researcher asked when the learners would be given notes, the teachers said that the notes would be given the next period.

4.2.6 Lesson Evaluation, Summary and Conclusion

All the lessons observed were not evaluated to find out if the learners had attained the lesson objectives. In all the lessons that were observed the teachers did not summarize the main points of the lesson. The lessons ended abruptly when the bells rang without concluding the lessons.

4.2.7 Homework

All the teachers observed did not give homework to the learners.

4.3 Research Question 3: What challenges do teachers of biology and pupils face when teaching and learning genetics respectively?

One of the difficulties teachers of biology encountered when teaching genetics to secondary school learners was the non-availability of actual organisms for teaching genetics. For example, one participant who has been teaching for ten years wrote:

> "*Obtaining real organisms with distinct characteristics to show learners when teaching co-dominance for example is a challenge. Teaching and learning aids are very scarce commodities in school. For example, text books are few and no charts of cell division. Lack of teaching aids that can make a teacher simplify the topic for the learners."* (Male teacher, Buffalo Secondary School).

A female Biology teacher at Elephant Secondary School who has been teaching for five years wrote, "*It is difficult to find suitable teaching and learning aids to help learners to comprehend. It is difficult to improvise. It is difficult to have a practical."* Another teacher said that "*powerful microscopes to observe mitosis in onion root tips are difficult to acquire because they are expensive.*" (Male teacher, Buffalo Secondary School).

A teacher of biology lamented that;

> "*Practical teaching cannot easily be taught because the offspring of the parental generation takes long to be studied and have the results concluded. For example, maize plants take 3 to 4 months to mature and be harvested."* (Female teacher, Impala secondary School)

The teachers of biology also found it difficult to improvise appropriate teaching and learning aids for teaching genetics on their own for this particular topic. In this regard, one of the teachers wrote as follows;

"*Improvising teaching and learning aids requires being creative and resourceful but the high period load makes it difficult for teachers to find time to improvise teaching and learning aids*." (Male teacher, Impala Secondary School).

In Kitwe District teachers of biology have an average teaching load of 30 periods per week.

A male teacher said that; "*improvising teaching and learning aids cost the teacher money. The teacher has to buy materials to use when making the teaching and learning aids*." (Male teacher, Buffalo Secondary school).

Another challenge teachers cited was the issue of textbooks from which to get information. A teacher who has been teaching for ten years stated that, *"Lack of textbooks on genetics is a challenge and where available, they are expensive."* (Male teacher, Elephant Secondary School).

A male teacher who has been teaching for two years said, "*Lack of films, slides, projectors, microscopes and equipment (DSTV, decoders, television sets) in schools to use to fully teach genetics* (Elephant Secondary School).

Lack of background knowledge in genetics and poor English language background by pupils were cited as challenges biology teachers faced when teaching genetics. For example, a male teacher with three years teaching experience wrote,

"*Most of the learners do not have background knowledge about genetics. Most of the learners do not understand the terms used, they lack the connection aspect; the learners do not link what they learn to day to day activities".*

Another teacher said that "*learners forget terminologies as they are new. The learners do not understand the terms used"* (Male Teacher, Buffalo Secondary School).

Furthermore, teachers cited the wide High School Biology syllabus as one of the challenges they faced when teaching genetics. A female teacher said that "*the syllabus for biology is too wide as a result time to teach genetics is very short before pupils write their final examinations."* (*Female* teacher, Elephant Secondary School). Another teacher complained that,

> *"Time allocated for genetics is not enough for it to be taught well. Mostly genetics is schemed to be taught in Grade 12 in the third term when most learners have their minds in panic state. Hence, learners' concentration towards learning is reduced. At this time most learners are interested in knowing how to do simple genetic calculations and genetic diagrams."* (Female teacher, Buffalo Secondary School).

Another challenge that teachers who teach genetics cited was the negative attitude by learners towards genetics. Two teachers said that,

> *"Pupils have negative attitude towards genetics. They consider it to be a difficult topic as a result they do not pay much attention when it is being taught."* (Male teacher, Elephant Secondary School).

"Pupils attitude towards the topic genetics is bad, they consider it to be difficult as such they do not apply extra effort to understand it." (Male teacher, Buffalo Secondary school*)*

Learners cited a number of challenges which they encounter in genetics. Lack of background knowledge was one of the challenges that secondary school learners faced while learning genetics. A boy of Impala Secondary School wrote, *"There are many complicated terms in genetics. Some of the terms I have never heard them before."*

The learners also mentioned that the topic genetics was wide. A girl of Buffalo Secondary School wrote, *"I find genetics difficult because it is wide."* The learners stated that they found learning genetics difficult because the topic is taught just before the Grade 12 examinations. Another boy from Impala Secondary School wrote, "*The teachers teach the topic genetics at a fast pace at a time when examinations are near*." More than 60% of the learners cited mitosis and meiosis as a challenge. An 18 year old boy from Impala Secondary School wrote, *"Meiosis and mitosis are difficult to understand because it is difficult to see where they take place."* Another 18 year old boy from Buffalo Secondary School wrote: *"I find mitosis and meiosis difficult because the terms confuse a lot because at times they seem to be the same. This subtopic has a lot of diagrams."*

Some learners mentioned that they did not understand genetics because of the way the teachers taught the topic. An 18 year old boy of Elephant Secondary School wrote:

"Teachers do not teach us in such a way that we understand." A 19 year old boy from Elephant Secondary School wrote, *"I find learning genetics difficult because we have not done any experiments."* A 17 year old girl from Buffalo Secondary School wrote, *"You have to go in detail to understand the topic genetics and the main points are not clearly indicated. You have to make the points on your own and some books do not give much detail about genetics."*

4.4 Research Question 4: How can the teaching of genetics be improved?

Teachers who participated in the study proposed a number of ways of improving the teaching of genetics. One participant said that "*varying methods of teaching can improve learners' understanding because doing so caters for learners individual differences."* (Female Teacher, Buffalo Secondary School).

When the natural science HOD of Buffalo Secondary School was asked to suggest how the teaching of genetics can be improved, the HOD said,

> "*The teachers can use bean seeds with different colours to teach variation. The teacher can use the learners to teach variation in skin colour, colour of eyes, tongue rolling and non tongue rolling and sex of pupils in class. Teachers can use pictures from magazines to teach genetics, for example, when teaching co-dominance cut outs of different colours of rose flowers (red, white and pink) can be used."* (HOD, Buffalo Secondary School).

Natural Science HOD of Elephant Secondary School suggested that,

"*Learners can play a game while singing a song. The teacher can use this game to revise the previous lesson. The teacher can write questions about the previous lesson on pieces of paper, fold the papers and put the papers in a box with an opening on top. One learner is made to pick a question. Reads the question and moves around to choose a learner to answer the question on the picked piece of paper. Then the learner who was picked is also made to pick a piece of paper and to nominate the next learner to answer the picked question. This continues until all the questions are picked and the class stops singing."*

A teacher at Impala Secondary School suggested that,

"Mitosis in onion root tip cells can be taught by making learners to view the onion cells under a microscope. Mitosis and meiosis can also be taught using films to show how processes are taking place. The stages in the processes of meiosis and mitosis can be presented using charts."

Pupils proposed a number of ways they thought challenges would be overcome. An 18 year old girl from Impala Secondary School wrote: *"Studying the topic genetics frequently can help me to understand it."* Another 18 year old girl from Impala Secondary school wrote: *"Going through biology past paper 2 and answering questions on genetics can make me know how to answer examination questions on genetics."* A 19 year old boy from Buffalo Secondary School wrote: *"I can understand genetics by studying with those who understand genetics well."*

The learners suggested that the topic genetics be taught earlier in Grade 11 or in the first term of Grade 12. An 18 year old boy of Elephant Secondary School wrote, *"Teachers that teach the subject must ensure that they teach the topic when there is time, not in term 3 of Grade 12 when we are about to write examinations. The topic genetics can be taught in Grade 11 or first term in Grade 12."*

The learners also mentioned that using textbooks during personal study time can also help in understanding genetics. One 17 year old boy from Elephant Secondary School wrote: *"By learning the topic genetics in depth using more than one textbook at least 3 to 4 powerful textbooks."*

The learners also recognized the importance of teachers in helping them to understand genetics. A 16 year old girl from Buffalo Secondary School wrote, *"I can understand genetics by consulting with teachers of biology."* A boy aged 17 from Impala Secondary School wrote, *"Teachers should use easy terms when teaching genetics. Teachers should not rush through when teaching genetics. Teachers should explain more on terms."*

A 19 year old boy from Elephant Secondary School wrote, *"Teachers should give simplified notes on genetics. Teachers should give a lot of exercises on genetics."* A 16 year old girl from Buffalo Secondary School wrote, *"The teachers should let us do experiments to see what goes on; then I can believe".*

CHAPTER FIVE

DISCUSSION OF FINDINGS

5 Introduction

This chapter presents the discussion of the findings of this study under the following themes or categories; teacher qualifications, teaching experience, lesson planning, methods of teaching, use of teaching and learning aids, availability of textbooks, questioning techniques, homework, note giving, lesson evaluation, background knowledge of genetics, practical work, non coverage of the topic genetics, learner attitudes and width and depth of genetics

5.1 Teacher Qualifications

The observation that degree holders presented their lessons with higher confidence than diploma holders can be attributed to the fact that, degree holders are given a lot of content during training to enable them to teach at senior secondary school level unlike diploma holders whose content during training is aimed at enabling them to teach at junior secondary school level. As a result, degree holders understand the content better than diploma holders. What teachers know and do is the most important influence on what students learn. They used group work which is learner centred method to teach genetics. The results of this study, that teacher qualification is important for a teacher to teach with confidence, are in line with what Haycock (1998), Edu *et al*, (2012) and Onyekuru and Ibegbunam (2013) reported.

5.2 Teaching Experience

Although 15 (83%) teachers were more than five (5) years in service and could be classified as experienced teachers (Rice, 2010), they used lecture method which is an ineffective teacher centred method to teach aspects of genetics (Muzumara, 2008). Such teachers gain wrong experience in teaching genetics using ineffective methods year in year out. For experience to produce positive learner achievements it must be the correct experience. Contrary to the findings of the current study, Onyekuru and Ibegbunam

(2013), Edu *et al*, (2012) and Rice (2010) reported that experienced teachers were observed to face fewer difficulties in teaching than the inexperienced ones.

5.3 Lesson Planning

Lesson planning is the hallmark of any teaching and learning as it prepares the teacher for lesson delivery (McBer, 2000). From the findings of this study, it can be seen that nine (9, 50%) of the teachers went to the classes relatively unprepared. Failure to plan or inadequate planning for a lesson entailed that a lot of learning time was wasted during the lessons and the delivery of content was compromised, to the disadvantage of the learners (Jones, 1998). The absence of clearly stated measurable objectives made it difficult to evaluate learning. This is very cardinal in challenging topics such as genetics because a teacher would plan for the lesson based on previous challenges.

This failure to plan led to unsystematic and ineffective lesson presentation because the teachers did not set clear objectives for each lesson. This lack of planning also led to teachers introducing the lessons using question and answer only which did very little to arouse the interests of the learners. As a result, learners did not ask questions during lessons. Moreover, the teacher's unpreparedness impacted negatively on the confidence of some teachers during lesson presentation (McBer, 2000 ; Petty, 2009).

Lesson planning, though not mentioned as a way to improve results in genetics by either teachers or HODs is an important activity that should be undertaken by teachers in general and teachers of biology in particular. Lesson planning is important for effective

lesson presentation because it helps the teacher to plan and set clear objectives for each lesson leading to systematic teaching. Lesson planning helps the teacher to decide how to introduce the lesson, what questions to ask learners what answers to expect from the learners, what teaching strategies to use so as to meet the objectives of the lesson, summarize the lesson and how to end the lesson. Lesson planning helps to create maximum opportunities to learn and no time is wasted, making the classroom environment purposeful and business-like (McBer, 2000). Lesson planning also helps the teacher to teach clearly and confidently because the teacher knows what he/she is doing and why it is being taught. This helps learners to see links with their earlier learning and then develop their knowledge further (McBer, 2000; Petty, 2009).

Since genetics is considered to be a difficult topic to teach lessons can be planned in groups of biology teachers or teachers of biology from schools in the same zone. Team planning can also be done at District level during Continuous Professional Development (CPD) meetings. Such planning can bring together a wealth of ideas from different teachers of biology (old, young, male, female, diploma holders and degree holders). The new entrants can learn about the expected problems when teaching genetics and how to overcome them. The new entrants can inform those who have been in the teaching service for some time about the new methods of teaching and the possible practical work on genetics that can be done. The new entrants can also bring to the table the new theories about how children learn.

5.4 Methods of Teaching

Furthermore, these teachers who did not prepare their lessons were confined to the use of one method of teaching (lecture method) which was not effective. This is similar to what Haambokoma *et al* (2002) and Manda (2012) found. The teaching of genetics requires that teachers of biology are eclectic in their methods. Those teachers with lesson plans still used the common methods of teaching (question and answer, lecture and group work). They did not do practical work. Lack of questions from the learners could point to the fact that the teaching failed to capture the interests of the learners, which spilled over to the other parts of the lessons.

The observation that most of the teachers observed on this study used lecture method to teach is in line with what Onwu (2012) and Haambokoma *et al* (2002) reported. The implication of this finding is that the learners were not able to construct their own knowledge because they were passive in the lessons. The learners did not develop scientific skills because learners did not learn by doing an experiment. It also implies that the teacher did not get any feedback on the understanding of learners. The retention was low as the pupils were not given opportunities to use the ideas being taught. The learners found the lessons monotonous as a result genetics topic presented huge problems to learners.

However, the teachers who used group work should have supervised the formation of groups so as to ensure that learners with high intellectual calibres were mixed with learners with low intellectual calibres. This could have enabled collaborative learning to occur effectively in the groups (Petty, 2009). It was also important to choose

chairpersons to lead and control the groups so as to ensure that there is order in the group. Teachers should also ensure that girls are active participants in group work. This study confirms the findings of Maimbolwa-Sinyangwe and Chilangwa (1995) that girls do not actively participate in classroom activities. In addition, it is important that the teacher monitors, guides and facilitates the group work activity.

Since teachers who participated in this study did not use a variety of teaching methods, this implied that the teachers did not cater for individual differences in the learners. This consistent with what Haambokoma *et al* (2002), Maimbolwa-Sinyangwe and Chilangwa (1995) observed that the majority of teachers used lecture and question and answer methods to teach. Contrary to the findings of this study, Nkoya (2006) reported that in his study, teachers used a variety of teaching methods, where on average, teachers used at least three learner centred methods such as group work (practical), demonstrations, discussions, project, problem solving, question and answer in their teaching. Another study conducted by Kalumba (2012) also found that teachers used learner centred methods to teach. Nkoya (2006) and Kalumba (2012) recorded improved learner performance. However, it is critical to note that Nkoya (2006) and Kalumba (2012) used controlled studies of teachers who went through workshops in teaching methods.

The implications of the lack of variety of teaching methods are that teachers did not cater for individual learning differences of the learners. It is common knowledge that lack of differentiated learning results in monotony in lesson delivery which in turn

adversely impacts on learner concentration and interest. In the current study, this was evident by the lack of questions from the learners in almost all the lessons observed.

The submission by teachers and HODs that the teaching of genetics can be improved by using learner centred methods of teaching is in agreement with the constructivist thought. Constructivists argue that humans construct meaning from current knowledge structures (Creswell, 2003; Petty, 2009). Learners who are actively involved in a lesson construct their own knowledge. The teachers should facilitate this construction of knowledge by providing enabling environments for knowledge construction. Practical work by the learners should be an integral part of activities that learners do as they construct their knowledge. The absence of practical work in lessons on genetics deprived the learners the opportunities to discover principles, concepts and facts for themselves. Reality is constructed by the learners' activities.

5.5 Use of Teaching and Learning Aids

Since the teachers observed during this study did not use any teaching aids, there was ineffective teaching because learners found it difficult to remember everything that the teacher talked about (Petty, 2009). The non-use of teaching and learning aids made it difficult for learners to understand concepts and ideas especially for an abstract topic like genetics. This finding is similar to what Manda (2012) reported, that schools in Samfya had insufficient text books, teaching and learning materials. The findings of this

study are also consistent with Asokhia's (2009) findings that teachers do not have a regular supply of teaching aids and where they are available, they are so inadequate. The non-use of teaching aids implied that the learning was not made easy, enjoyable and permanent (Asokhia, 2009). An effective learning situation requires the use of teaching aids. Teaching and learning aids that can be used to teach genetics suggested by the teachers can be made available by either procuring them or improvising from locally available materials. It requires careful planning for a teacher to prepare the teaching and learning materials.

5.5.1 Availability of Textbooks

The lack of biology textbooks implied that the pupils were not able to study genetics outside school time and were not able to practice answering genetics questions. It also meant that the teachers did not have books to use when giving class exercises. The challenge about lack of textbooks revealed in this study is similar to what Chibesakunda *et al* (2012) reported, that secondary schools in Zambia had a shortage of textbooks. Manda (2012) noted that seven learners shared a single biology textbook. This means that learners did not have books to read ahead of the teacher before a topic is taught for them to have the relevant knowledge or to consolidate the content learnt in class by reading as well as practising to answer questions in the books. This finding is also in line with what Tekkaya and others (2001) and Topcu and Pecmez (2009) reported that Turkish schools had a shortage of textbooks.

5.6 Questioning Techniques

Distribution of questions to the whole class helped all the learners to feel part of the class. However, giving only pupils who had their hands raised chances to answer questions did very little to encourage all learners to think as the learners knew that they will not be asked to respond when the hand is not raised. This finding is similar to what Nkoya (2006) found. It is recommended by Petty (2009) that a teacher asks even learners whose hands are not raised in order to challenge every learner to think.

Similar to the findings of Maimbolwa-Sinyangwe (1995), this study found that the teachers used low order questions during the observed lessons. The implication of this finding is that the use of low order questions reinforced rote learning with its failure to develop critical thinking skills which are required in the understanding and answering of the genetics question in school certificate biology examinations (MESVTEE, 2014). Most questions in school certificate biology examinations tend to dwell on critical analysis of the given content. Thus, rote learning only enables candidates to score low marks, if any. Another implication is that teachers compounded the learning difficulties by using low order questions to facilitate abstract topics such as genetics in the classroom. Furthermore, the teaching atmosphere did not encourage learner engagement in the learning process through two-way communication which would enable the teacher to assess knowledge with understanding of the learnt facts, concepts and ideas (Maimbolwa-Sinyangwe and Chilangwa, 1995). The lack of two-way communication by way of appropriate questioning techniques did not help teachers to clarify many misconceptions that learners hold.

Questioning in a lesson is vital, regardless of the methodology being used. Good questioning skill directs the pupils' thoughts to what they are expected to do. The questions must be concise and thought provoking. The use of question and answer strategy during lesson introductions was a good practice as it ensured that learning was built on prior knowledge. This enabled the learners to bring their previous experiences to the current lesson (Petty, 2009).

Teachers' gratefulness for pupil responses by praising correct answers is recommended by Skinner as it helped learners to have confidence to participate in the lessons. The teachers' comments after a response is given are important as they gave the learners an indication on how they were doing and encouraged the learners to answer more questions in class (Petty, 2009). This finding is in line with what Nkoya (2006) found that teachers received learners responses well.

5.7 Homework

The lack of homework implied that learners were deprived of the chance to review their work and consolidate their learning. The learners did not get opportunities to consult their parents and peers on how to answer questions on a given topic. Parents did not get opportunities to know what their children were learning at school. The learners did not learn time management skills (Goldstein and Zental, 1999). The learners were also deprived of the chance to construct knowledge, to work independently by carrying out

research, develop analytical thinking skills and take responsibility of their work (Good and Brophy, 2003). Such skills would definitely be important in the teaching and learning of genetics in secondary schools in Kitwe District. In addition, this implied that learners were not given chance to explore the topic genetics more fully than class time permitted (Goldstein and Zental, 1999). Furthermore, this lack of homework meant that the pupils did not get feedback on their learning. It also meant that teachers did not assess whether the pupils had understood the topic or not and were not able to find other strategies to make pupils understand. The findings of this study are similar to what Maimbolwa-Sinyangwe (1995) found when studying classroom interactions that teachers rarely give learners homework.

5.8 Note Giving

Notes on genetics are very important since they help clarify and simplify different terms and concepts to the level of secondary school learners. The lack of notes giving as was observed in most lessons during the study contributed to the ineffective teaching of genetics. Boch and Piolat (2005) stated two major functions of writing lesson notes: to record information and to aid reflection. The teachers (four of them during this study) who wrote notes on the board for learners to copy helped the learners to build up a stable external memory in a form that can be used at a later date. Learners have a lot of subjects that they study, writing notes helps them to avoid forgetting. The writing of notes eases the load on the working memory. When learners re-read their notes as many times as possible, they are able to learn the content, integrate the knowledge and store it

in the long term memory. Thus, the load on the working memory is reduced (Chu, 2008).

However, Weiner (2013) is of the view that learners should take their own notes as the teacher is teaching. He believed that the practice of taking notes develops listening skills and offers the learners opportunities to construct their own knowledge. When learners write their own notes they pay more attention during the lesson than when notes are given to them.

The teacher can leave at least five minutes at the end of the lesson for students to write their own notes. Students' note making raises achievement by an average of two grades (Petty, 2009). However, the teacher needs to check student notes. After note making, the learners are asked the important points that the notes cover. These points are confirmed and learners are asked to improve their notes. They are also encouraged to create graphic organisers (flow diagrams, concept maps). A learner writing their own notes helps to create personal understanding of the topic. This is very constructivist. Writing notes for the learners or giving hand-outs is not as effective as asking learners to write their own notes The notes should be made concise, simple and attractive (Petty, 2009).

The teachers who developed the notes as the lesson progressed and then gave the learners time to copy helped the learners to have the main points of the lesson that learners can easily understand and remember. When learners are not given notes it

becomes difficult for them to narrow down to key concepts covered in the lesson and it becomes very difficult to remember important concepts. Lack of notes reduces learners' confidence in writing examinations (Weimer, 2013).

It is also helpful to check the notes that learners write on their own and those from the chalkboard for accuracy and completeness. To help the learners remember and understand key concepts the use of mnemonics can be encouraged. Good notes given by teachers can supplement the lack or insufficient textbooks in schools (Chibesakunda *et al*, 2012).

5.9 Lesson Evaluation

The lack of lesson evaluation of the observed lessons deprived the learners of review of the main points in the lesson. The teachers could not tell whether the lessons delivered were effective or not. Consequently, there was no feedback from the learners. This could explain the poor results in genetics. It was difficult to tell whether the lesson objectives were achieved or not. Evaluating a lesson provides feedback on the effectiveness of instruction and gives students a measure of their progress (Muzumara, 2008). It also helps to plan for the next lesson better.

5.10 Practical Work

The lack of practical work was a challenge mentioned by teachers and learners. This implied that the learners did not get the opportunity to do hands on activities, to develop critical thinking skills and accurate observation skills. Furthermore, the lack of practical

work deprived the learners of opportunities to develop skills to help them understand concepts involved in genetics. The teachers failed to arouse and maintain learners' interest in genetics. Practical work enables learners to understand and what they are taught.

This finding is similar to what Manda (2012) reported, that pupils complained that teachers concentrate on teaching the theory part forgetting the practical. The findings of this study are also consistent with what Mudenda (2012) revealed, that candidates do not score good marks in the biology practical paper because they do not perform experiments during lessons. Similarly, Changwe (2008) in her study also observed that most teachers of science, biology included, just explained and drew diagrams of the arrangement of apparatus without carrying out the actual practical work. This would only exacerbate the challenges learners have in grasping concepts and ideas in genetics and the commonly held belief that learners only required to learn for the examinations rather than for knowledge's sake. Consequentially, learners are misled to believe that passing is more important at school certificate level than understanding the content taught. However, it is a well known fact that biology learners would prefer to replicate Mendel's investigation in their school laboratories and such usually generates enthusiasm in the learners helping them to progress their learning from the known to the unknown in topics involving inheritance (Eddleman, 2013).

As a result of lack of practical work, learners were unable to build bridges between what they could see and scientific ideas that account for their observations. Good

practical tasks help to effectively communicate clearly defined set of ideas such as those in genetics (SCORE, 2009). Practical work requires readily available materials which are sometimes expensive and or costly to maintain. This point which links effective learning and teaching of science subjects like biology to enough and relevant practical work in topics such as genetics is supported by SCORE (2009). Teaching genetics also involves laboratory procedure to verify as many seemingly confusing concepts as possible.

Surprisingly, the teachers who did not use practical work in their teaching also gave practical work as one way of improving the teaching of genetics. Learners come from different backgrounds, have different interests and abilities. To effectively teach these learners, there is need to vary the teaching methods in order to cater for individual differences.

5.11 Background Knowledge of Genetics

The concern by teachers of biology that learners lack background knowledge and find the terminology used in genetics confusing is consistent with what was found in literature reviewed. Knippels *et al (*2005) Atay and Tekkaya (2008), Haambokoma (2007) acknowledged that learners lack background knowledge in genetics and that the learners are confused because of the terms sound very similar. The lack of understanding of terms used in genetics by learners could be one of the reasons why learners perform poorly in genetics questions during grade 12 final examinations.

Some of the challenges that the learners faced when learning genetics were similar to those that the teachers mentioned. The teachers and the learners agreed that one of the challenges that learners face when learning genetics is lack of background knowledge about genetics. The lack of background knowledge implied that the learners had challenges in constructing knowledge about genetics. The learners were also likely to form alternative conceptions or misconceptions. The misconceptions formed made it difficult for learners to understand genetics. This finding is consistent with what Ataya and Tekkaya (2008), Tekkaya *et al* (2001), Knippels *et al* (2005) and Chu (2008) reported.

5.12 Non Coverage of the Topic Genetics

Some of the teachers who the researcher asked for permission to observe their genetics lessons said that they had not yet covered the topic genetics. The researcher was left to wonder when this topic would be taught because that was just before examinations started. The non-teaching of the topic genetics by the teachers of biology could be one of the reasons why candidates taking the school certificate biology examination to leave the whole question on genetics unanswered and lose marks (ECZ: 2006; 2007; 2008; 2009; 2010; 2011). The citing of the bulkiness of the biology syllabus as one of the challenges that teachers faced by sampled teachers of Biology was consistent with the findings of Tekkaya *et al* (2001), who reported that Turkish biology teachers could not teach genetics effectively because the Turkish Biology Syllabus was bulky. The Zambian High School Biology Syllabus has 13 units. The topic genetics is placed in unit 12 and as a result, chances of genetics not being taught are very high.

5.13 Learner Attitudes

Negative attitudes of learners towards genetics resulted from the way genetics is taught which makes learners not to understand the concepts. The implications of this finding are that it adversely impacted on the motivation and interest of learning genetics. The learners did not put much effort to understand genetics. The learners memorised many concepts in order to pass examinations (Tekkaya *et al*, 2001). Learners found this very tedious to do because they had other subjects to learn. This finding is consistent with what Tekkaya (2001), Haambokoma (2002) and Manda (2012)'s findngs that learners had negative attitudes towards genetics.

5.14 Width and Depth of Genetics

The finding that the teachers and learners found the topic genetics wide was similar to what Tekkaya *et al (*2001), Knippels *et al* (2005) found when they were investigating learning difficulties in genetics by Turkish learners. The challenges posed by the teaching of genetics just before the final Grade 12 Examinations was mentioned by teachers and learners. The implication of this finding is that the teachers teach the topic at a fast pace and as a result, the pupils do not understand. The fast pace at which the topic genetics is taught may not make it easy for the learners to learn genetics. Learners need time to revise what has been taught many times in order for them to remember the terms and concepts in genetics. The teaching of the topic just before the examination is one of the reasons why candidates score poorly or leave the question on genetics blank.

The revelation that pupils who participated in this study found mitosis and meiosis as the most difficult aspect in genetics. This finding is similar to what Chattopandhyay (2012) found. This challenge can be overcome by showing the learners film strips showing simulations of how these processes occur. Further, onion root tips can be viewed under a microscope to show mitosis.

5.15 Conclusion

This chapter discussed the findings of this study as highlighted below; one of the most important teacher characteristic that enhances learner achievement is teacher qualification. Most of the teachers, including experienced ones, taught genetics using lecture (teacher centred) and question and answer method. This implied that the learners' individual differences were not catered for during lessons. The lack of practical work, the non use of teaching and learning aids and lack of background knowledge made it difficult for learners to construct knowledge about genetics. Furthermore, the lack of homework and the lack of notes giving by over 80% of the teachers compounded the challenges that learners faced during genetics lessons. In extreme cases the topic genetics was not taught at all. Learners' negative attitudes towards genetics resulted from the way this topic is taught.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Introduction

This chapter presents the conclusion and recommendations based on the findings of the study.

6.1 Conclusion

The study established that teachers who had bachelor's degrees taught genetics with a lot of confidence because their conceptual knowledge was adequate.

From the study, it can be concluded that lack of practical work during lessons contributed to ineffective teaching of genetics because the learners were not engaged in the lessons. The learners did not develop critical thinking skill to help them understand the abstract and complex concepts in genetics. They were not involved in hands-on, minds-on activities that help them participate in scientific investigations and to verify for themselves science concepts, principles and laws.

In addition, it can be concluded that poor or lack of planning contributed to ineffective lesson presentation because it made the lesson presentations unsystematic. This is because the teacher did not think and reflect on how to use the teaching and learning materials to genuinely and effectively engage the learners. As a result, a lot of learning time was wasted.

It was also revealed that teachers did not use any teaching and learning aid apart from the chalkboard. This also resulted in ineffective teaching of genetics. It is important to use teaching and learning aids because they break the monotony of lecture method and

help to arouse pupil interest in genetics. Using teaching aids provides better understanding as concepts become clearer and meaningful as teacher explains with the help of teaching aids. The use of teaching aids saves time and energy of the teacher as the learners find it easy to understand when a concept is taught. Slow learners find it easy to understand and remember abstract concepts like genetics with the help of teaching aids. The learners retain the learnt material for a long time because the experiences are concrete.

Furthermore, from this study, it was concluded that teachers who teach genetics mainly use lecture method and question and answer method. Lecture method is one of the teacher-centred methods of teaching as such there was little room or no room at all of asking questions by the learners. Lecture method has a number of limitations such as very minimal students' involvement in the lesson which minimises feedback from the students, as a result, teachers can't be sure how much the students have understood. Identification of an individual learner's specific learning difficulties is difficult. The evaluation of the methodology used in the lesson and oneself is difficult. During a lecture students get easily distracted and inattentive, scientific skills are not developed, retention is very low and learners are not given the opportunity to use the ideas being taught (Petty, 2009). A lecture method is not suitable for slow learners. This is because the learners are not actively involved in the lesson and their concentration span is short.

It was further concluded that the use of low order questions during lesson presentation contributed to poor lesson delivery because these questions did very little to develop the learners critical thinking. As much as possible, the teacher should ask open ended

questions because they promote critical thinking necessary for unblocking the enormous potential in the learners.

The study also concluded that one of the challenges that teachers and learners face when teaching and learning genetics is the abstract nature of the topic. The lack of practical work and learning aids compounds this problem. The lack of learners' background knowledge makes it difficult for learners to construct their own knowledge. They have difficulties in connecting the new knowledge to prior knowledge because the terminologies used are new and are not used everyday language. Another challenge was the lack of biology textbooks in the participating schools and as a result, learners were not able to study genetics on their own. Learners depended on the notes from the teacher. In addition, learners have a negative attitude to genetics. This makes it difficult to teach because the learners are already defeated even before they are taught. The teachers also have heavy teaching loads.

The study further established that genetics as a topic in biology is usually taught in the third term of grade 12 just before the school certificate examinations. As such, the teachers were unable to complete teaching the wide topic or taught the topic at a fast pace. Learners found it difficult to understand the topic because they were panicking. The teaching of genetics can be improved if teachers prepared lesson plans, used practical work, group discussions in teaching genetics. The teaching strategies used in other countries such as computer simulations, video games, project, learning cycle, dialogues and concept mapping can also be used to teach genetics in Kitwe District.

6.2 Recommendations

6.2.1 Recommendations for Policy Makers

1. Zambia Association for Science Educators (ZASE) should prepare teaching notes on genetics for teachers to use. The notes should contain summary notes on genetics including practical work for learners to do in order to improve the delivery of lessons by teachers who teach genetics and understanding of concepts in genetics by the learners.
2. The MESVTEE through (ZASE) should conduct short in-service courses teachers of biology in genetics so as to increase the content knowledge of genetics by the teachers and retrain the teachers on how to use learner centred methods of teaching.
3. Headteachers should procure teaching and learning aids for use during genetics lessons as this will make it possible for teachers to give practical work to learners. In addition, the teachers should be involved in the procurement of the teaching and learning resources (including textbooks) since they usually understand the aids that may be urgently required and would benefit the learners the most.
4. The MESVTEE should be able to include in its planning process the procurement of technological resources such as computer hardware and software for use in the teaching of genetics, which have become increasingly important in the teaching of biology topics in the twenty-first century (Anneta *et al,* 2010).

5. Headteachers, deputy headteachers and heads of departments should intensify internal monitoring of teaching and learning process. They should ensure that teachers;
    a. Use a variety of teaching methods in order to cater for individual differences.
    b. Prepare lesson plans for all lessons to be taught so that they deliver quality lessons that are systematic and effective. Although all lessons should be guided by a lesson plan, it is the quality of such a teaching document that should be emphasised.
    c. Prepare teaching and learning aids in order to help learners to conceptualise and remember concepts.
    d. Implement the homework policy because homework helps learners to revise their work and learn from parents, siblings and peers.

6.2.2 Recommendations for Teachers.

1. The topic genetics should be schemed to be taught in the first term of Grade 12 in order to give learners time to learn the concepts involved. This gives time to do practical work, for example, carrying out Mendelian experiments with peas.
2. Improvisation of safe teaching and learning aids should be encouraged. With careful planning and preparation a teacher can improvise teaching and learning aids using locally available materials.
3. Teaching of mitosis and meiosis should be done in separate lessons to reduce on the chances of the learners being confused by the two. An experiment can be

performed to show mitosis in the onion root tip. Films showing stages in mitosis and then meiosis can be shown on separate days. Asking learners to summarize what they saw in the film is a good practice as it helps learners to be active.

6.2.3 Recommendation for further Research

Further research can be conducted to investigate the effect of using the learning cycle in teaching genetics. Research can be done to find the effect of using concept maps to teach genetics to secondary school learners. A research can also be conducted to find out what misconceptions about genetics the Zambian learners have.

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APPENDIX A

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

RESEARCH TOPIC

THE TEACHING OF GENETICS IN SELECTED SECONDARY SCHOOLS IN KITWE DISTRICT, ZAMBIA

SCHOOL: _____

SEX: _____ HIGHEST QUALIFICATION: _____

QUESTIONNAIRE FOR TEACHERS

I am a Masters Student at the University of Zambia conducting a study on the topic: The Teaching of Genetics in selected secondary schools in Kitwe District, Zambia.

You are requested to participate in this research by answering this questionnaire. You are requested to give your honest answers to all the questions in this questionnaire by filling in the information appropriately. Read each item carefully and respond as it applies to you. Please be frank and honest as all the information is for academic purposes and will be treated in the strictest confidence.

INSTRUCTIONS

Answer all questions by giving responses in the spaces provided. There are no wrong or right responses.

1. For how long (in years) have you been teaching biology? A.1- 2___ B. 3-5 ____C. 5-10____ D. 10 off ____

2. Where were you trained? _____

3. a. What methods do you use to teach the following aspects of genetics?

b. Give reasons why you use such methods?

Fill in the table below.

Aspect	**Method**	**Reasons for using the method**
i. Variations		
ii. Mitosis and meiosis		
iii. Inheritance		
Monohybrid cross		
Mendelian genetics		
iv. Terms,		
v. Simple calculations		
vi. Sex linked characteristics		
vii. Mechanism of AOB inheritance		
viii. Co-dominance		

4. What teaching aid(s) do you use to teach the following aspects of genetics?

Aspect	**Teaching Aid(s)**
i. Variations in plants and animal species -	
ii. Continuous variation	

iii. Discontinuous variations	
iv. Mitosis and meiosis	
v. Inheritance Monohybrid cross	
Mendelian genetics	
vi. Simple crossing	
vii. Genetics Terms	
viii. Simple calculations	
ix. Sex linked characteristics	
xi. Mechanism of AOB inheritance	
xii. Co-dominance	
xiii. Mutation	

5. What challenges do you face when teaching genetics to high school learners?

_____

_____

_____

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APPENDIX B

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

RESEARCH TOPIC

THE TEACHING OF GENETICS IN SELECTED SECONDARY SCHOOLS IN KITWE DISTRICT, ZAMBIA

INTERVIEW GUIDE FOR HEADS OF DEPARTMENTS

1. What methods are mostly used by teachers of biology when teaching genetics?
2. What methods can teachers use to teach genetics effectively?
3. What teaching aids can teachers use to teach the following aspects of genetics effectively?
    a. Variations
    b. Mitosis and meiosis
    c. Inheritance
        -Mono hybrid cross
        -Mendelian genetics
        -Simple crossing
    d. Terms like homozygous, heterozygous. recessive, dominant, gene, chromosome alleles, phenotype, genotype
    e. Simple calculations
    f. Sex linked characteristics
    g. Mechanism of AOB inheritance
    h. Co-dominance
4. What challenges do teachers face when teaching genetics?

5. What challenges do pupils face when learning genetics?

APPENDIX C

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

RESEARCH TOPIC

THE TEACHING OF GENETICS IN SELECTED SECONDARY SCHOOLS IN KITWE DISTRICT, ZAMBIA

SCHOOL: _____ AGE: _____

SEX: _____ CLASS: _____

QUESTIONNAIRE FOR PUPILS

I am a Masters Student at the University of Zambia conducting a study on the topic: The teaching of genetics in secondary schools in Kitwe District, Zambia. I am requesting you to spend some time to answer this questionnaire.

INSTRUCTIONS

You are requested to give your answers to the questions in this questionnaire by filling in the information appropriately in the spaces provided. All the information is for academic purposes and will be treated in the strictest confidence. There are no wrong or right responses.

The following sub topics are covered in genetics:

a. Variations
b. Mitosis and meiosis
c. Inheritance

- Mono hybrid cross
- Mendelian genetics
- Simple crossing

d. Terms like homozygous, heterozygous, recessive, dominant, gene, chromosome, Alleles, phenotype, genotype
e. Simple calculations
f. Sex linked characteristics
g. Mechanism of AOB inheritance
h. Co-dominance

1. Which sub topics of genetics do you find easy to understand?

2.Why do you find these sub topics easy to understand?

3. Which sub topics of genetics do you find difficult to understand?

4. Why do you find these sub topics of genetics difficult to understand?

5. Suggest how these difficulties (named in No. 4) can be overcome.

APPENDIX D

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

Telephone: 291381
Telegram: UNZA, LUSAKA
Telex: UNZALU ZA 44370
Fax: + 260-1-292702

P O Box 32379
Lusaka, Zambia

Your Ref.:

31st July 2012

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RE: MRS. SIAME

The above named is our Student pursuing a Masters degree in Science Education by research in the University. As part of her part fulfillment of the degree requirements she requires to collect and compile data from your schools and other institutions.

The University requests your kind assistance to enable her complete her work successfully.

With thanks.

Dr. S. Mbewe

G.A. Chibesakunda
HOD, MSE

THE UNIVERSITY OF ZAMBIA SCHOOL OF EDUCATION
31 JUL 2012
DEPT OF MATHS & SCIENCE EDUCATION P.O. BOX 32379, LUSAKA

APPENDIX E

All Correspondence to be addressed to the
District Education Board Secretary

Tel/ Fax 021 2 228381

In reply please quote
No:.....

REPUBLIC OF ZAMBIA

MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING AND EARLY EDUCATION

KITWE DISTRICT EDUCATION BOARD

Office of the District Education Board Secretary
P.O. BOX 20560
Kitwe
Zambia

TS 80612

10th August, 2012

The Head teacher
Chimwemwe Secondary School
KITWE

RE: PERMISSION TO CONDUCT RESEARCH: MRS. JUSTINA CHIFWA SIAME

This minute serves to introduce to you Mrs. Siame a student from the University of Zambia and also one of our Deputy Head Teachers in Kitwe District.

She has been given permission to conduct a research on the teaching of genetics in selected schools in Kitwe District.

Kindly assist her in any way possible.

K.K. Mwale
District Education Board Secretary
KITWE DISTRICT

/ekm

APPENDIX F

All correspondence should be addressed to

The Headteacher

In reply please quote

No.:.....

REPUBLIC OF ZAMBIA

MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING AND EARLY EDUCATION

CHIMWEMWE SECONDARY SCHOOL
EDUCATION BOARD
P.O. Box 280086
KITWE

14th AUGUST 2012

MRS JUSTINA CHIFWA SIAME (STUDENT NUMBER: 531000118)
MUKUBA SECONDARY SCHOOL
PO BOX 20497
KITWE

Dear MRS. SIAME

RE: REQUEST TO CONDUCT RESEARCH AT CHIMWEMWE SECONDARY SCHOOL

Reference is made to the above stated matter. I'm pleased to inform you that your request to conduct a research at this school has been granted.

Get in touch with the Head of Department (Natural Sciences) to facilitate your research.

Yours faithfully

FUNGA G.M
HEADTEACHER

REPUBLIC OF ZAMBIA
MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING & EARLY EDUCATION
14 AUG 2012
HEAD TEACHER
CHIMWEMWE SECONDARY SCHOOL
P.O. BOX 280086, KITWE

APPENDIX G

APPENDIX G

All correspondence should be addressed to
The Headteacher

Telephone:+260 212 226390
Headteacher: +260 212 224903

In reply please quote

No:.....

REPUBLIC OF ZAMBIA

MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING AND EARLY EDUCATION

HELEN KAUNDA SECONDARY SCHOOL
EDUCATION BOARD
P.O. BOX 20777
KITWE

13th August, 2012

Mrs. Justina Chifwa Siame (Student No: 531000118),

Mukuba Secondary School,

P.O. Box 20497,

KITWE.

Dear Mrs. Siame,

Re: REQUEST TO CONDUCT RESEARCH AT HELEN KAUNDA SECONDARY SCHOOL

Reference is made to the above stated captioned.

I hereby write to inform you that your request to conduct research at Helen Kaunda Secondary School has been granted. By the receipt of this letter, you are advised to get in touch with the Head of Natural Sciences Department Mrs. Kaira to facilitate your research techniques.

Looking forward to working with you on your research.

Yours faithfully,

Kabamba M. (Mr.)

D/Head teacher

For/Head teacher

HELEN KAUNDA SECONDARY SCHOOL

HIV/AIDS is real, Together we can fight it

APPENDIX H

REPUBLIC OF ZAMBIA

MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING AND EARLY EDUCATION

All communications should be addressed to: In reply please quote
MUKUBA SECONDRY SCHOOL EDUCATION BOARD
P.O. BOX 20497 KITWE, ZAMBIA
The Head teacher
Telephone: 213131/ 210094
No .....
Tel/Fax: 213131

13th August, 2012.

Mrs. Justina Chifwa Siame (Student No. 531000118),
Mukuba Secondary School,
P.O Box 20497,
Kitwe.

Dear Justina,

I am pleased to inform you that your request to conduct research at Mukuba Secondary School has been granted.

Yours faithfully,

REPUBLIC OF ZAMBIA
MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING AND EARLY EDUCATION
13 AUG 2012
HEADTEACHER
MUKUBA SECONDARY SCHOOL
P.O BOX 20497 KITWE

CHIYUNGI C.J. (MR)
HEADTEACHER
MUKUBA SECONDARY SCHOOL

APPENDIX I

All correspondence should be addressed to
The Headteacher

Tel: +260 212 251 304

In reply please quote
No.: .....

REPUBLIC OF ZAMBIA
MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING & EARLY EDUCATION
NDEKE SECONDARY SCHOOL

MINISTRY OF EDUCATION SCIENCE & VOCATIONAL TRAINING & EARLY EDUCATION
NDEKE HIGH SCHOOL
P.O. BOX 21498, KITWE

P.O. Box 21498
KITWE - ZAMBIA
Email: ndekehighsch@zamtel.zm

10th September, 2012.

RE: JUSTINA CHIFWA SIAME STUDENT NO. 531000118
MASTER OF EDUCATION IN SCIENCE EDUCATION

This serves to confirm that the above named student has been given permission to conduct research in our school.

Yours faithfully.

C. Nkandu
Deputy Headteacher
For/Headteacher