IMPLEMENTATION OF BIOLOGY CURRICULUM: A COMPARISON OF UPGRADED AND OLD ESTABLISHED SECONDARY SCHOOLS IN NDOLA DISTRICT OF ZAMBIA

By

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

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DECLARATION

I **Mwamba Ndakasha Stephen**, hereby declare that this dissertation titled 'Implementation of Biology Science Curriculum: A Comparison of Upgraded and Old established Secondary Schools in Ndola district of Zambia' is my own work and that it has not been previously submitted for award of any degree at the University of Zambia or any other university.

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

APPROVAL

This dissertation by Mwamba Ndakasha Stephen is approved as partial fulfilment of the requirement for the award of the Degree of Master of Education in Science Education by the University of Zambia.

Hereby signed by the examiners:

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ABSTRACT

This study was aimed at investigating whether there was a significant difference in the implementation of the biology science curriculum between the upgraded and old established secondary schools. The study subsequently sought to assess the nature of school infrastructure in the two sets of schools; the availability and state of teaching and learning materials; and to investigate the biology teaching staff and their practices in the two sets of schools regarding implementation of biology curriculum.

The study employed a mixed method research approach with an embedded method and descriptive survey technique that targeted non-grant aided government secondary schools of Ndola district. Six schools and 32 biology teachers were purposively sampled with 625 biology learners randomly sampled; additionally one teacher was randomly sampled for biology lesson observations. Data collection instruments included biology learners' survey questionnaire (BLSQ); biology curriculum evaluation questionnaire (BCEQ); biology lesson observation schedule (BLOS); document analysis of ECZ grade 12 biology final examinations results; and structured interview with an official from MoGE. Descriptive statistics, ANOVA, binomial, chi-square and correlation tests were used to analyse quantitative data while qualitative data was analysed through establishment of common themes.

Findings of the study showed a difference in the distribution of school infrastructure between the two sets of schools with old established schools having better infrastructure but there was no difference in the impact on curriculum implementation. There was no statistical significant impact of school infrastructure on learner academic performance in grade 12 biology final examinations at P=.05, N=36 and df=1 as all the calculated P values were greater than the statistical P value of 0.05. It was also found that distribution of teaching and learning materials was poor in both sets of school and its impact on curriculum implementation and learner academic performance was negative. The study also found that the teaching practices were characterised by limited use of teaching methods, teaching aids, and lack of practical lessons and limited promotion of learner-centred activities which impacted negatively on curriculum implementation in both sets of schools.

It was concluded that there is no significant difference in the implementation of biology curriculum between upgraded and old established secondary schools and that the biology curriculum is not effectively implemented in both sets of secondary schools. It was also concluded that biology curriculum implementation is mainly anchored on schema theory of learning as opposed to socio-constructivist theory of learning. The implications of the study are that school infrastructure has not been well utilised to support effective teaching and learning biology and that teachers need to be trained to implement biology curriculum amidst challenges of poor school infrastructure and inadequate teaching materials.

It was recommended that the Ministry of General Education review its policy of upgrading basic schools by first addressing the challenge of school infrastructure and teaching and learning materials. It was further recommended that the mandate of the school inspectorate department of MoGE should be extended to encompass extensive research activities. It was also recommended that the curriculum designers should consider prescribing teaching and learning materials that are locally and readily available materials.

DEDICATION

This work is dedicated to my late parents Mr Joseph M Mwamba and Mrs Fostina B Mwamba who always encouraged me to love education and pursue it diligently and my family that has greatly supported me in pursuing education to this level. Indeed it would take me another dissertation to describe your distinguished support for me.

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ABBREVIATIONS

BCEQ: Biology Curriculum Evaluation Questionnaire

BLOS: Biology Lesson Observation Schedule

BLSQ: Biology Learners' Survey Questionnaire

CDC: Curriculum Development Centre

CPD: Continuing Professional Development

ECZ: Examinations Council of Zambia

JICA: Japanese International Cooperation Agency

LAB: Laboratory

MDG: Millennium Development Goal

MESVTEE: Ministry of Education, Science, Vocational Training and Early Education

MoE: Ministry of Education

MoGE: Ministry of General Education

MoJ: Ministry of Justice

OL: Old Established Secondary School

PEO: Provincial Education officer

SIMC: School Infrastructure and Materials Checklist

UP: Upgraded Secondary School

ZICTA: Zambia Informational and Communications Technology Authority

CHAPTER ONE

INTRODUCTION

This chapter looks at the background of the study, the statement of the problem, research objectives, research questions, scope of the study, theoretical and conceptual framework, ethical considerations that surrounded the study and the operational definitions of the study.

1.1 Background of the study

In its quest to achieve the Millennium Development Goal (MDG) of providing education for all by the year 2015, the Zambian government through the Ministry of General Education (MoGE) has been implementing a number of educational policies. One such policy is the upgrading of some basic schools and community schools into secondary schools which started in the year 2004. This policy has been necessitated by inadequate school infrastructure caused by the changes in the Zambian education system and increased school enrolment (Ministry of Education [MoE], 1996). The policy of upgrading some basic schools has resulted in two types of government secondary schools namely upgraded and old established secondary schools. Old established secondary schools are those schools that have always operated as secondary schools from their inception and able to enrol learners from grades 8-12 while upgraded secondary schools are those schools that initially operated as basic schools with previous enrolment capacity of only up to grade 9 but upgraded to a secondary school to enrol Grades 8-12. However, both types of schools are referred to as secondary schools although they are graded differently according to infrastructure, staffing and learner enrolment levels (MoE, 1996). For instance, most old established secondary schools are graded as super grade one while the upgraded secondary schools are graded as either grade three or two secondary school.

Zambia's formal education system currently consists of two years of early childhood education, seven years of primary education (grades 1-7), two years of junior secondary education (grades 8-9), three years of senior secondary education (grades 10-12) and two to seven years of tertiary education (Ministry of Education, Science, Vocational Training and Early Education [MESVTEE], 2013). This education system denoted as 7-2-3-4 was reintroduced in the year 2011 which saw the change in school nomenclature from basic and high school setup to primary and secondary school setup.

The senior secondary school curriculum offers a number of subjects with biology being one of the natural science subjects. The science subjects like biology are of a practical nature that requires special learning infrastructure such as laboratories and other learning materials such as laboratory reagents and apparatus. In addition, of the three O- level sciences (biology, chemistry and physics) offered at senior secondary level, biology was the only pure science offered across all schools over the years with practical component in the grade 12 final examination assessment until the year 2015 when practical examination component was introduced in physical science. Other practical subjects offered in secondary schools include technology subjects like metalwork and woodwork. The later subjects are only offered in secondary schools with the required school infrastructure and machinery. However, the biology curriculum is implemented in most Zambian government secondary schools regardless of whether they have prescribed infrastructure and learning materials or not.

In the methodology section of the senior secondary school biology syllabus, it has been stated that the success of biology can be achieved by maximum participation of the learners. It has also been prescribed that learners are expected to conduct experiments, study tours, field work, group work, individual work and project work to enhance learning of biology (Curriculum Development Centre [CDC], 2013). The question is whether the schools tasked with biology curriculum implementation are adhering to these curriculum prescriptions or not, taking into account the nature of each of the two types of secondary schools.

The Parliamentary committee report on Education, Science and Technology showed that most of the primary schools that were upgraded to secondary status were meant to operate as primary schools in the initial place. When the said schools were upgraded to basic schools so that they could take on grades 8 and 9, they lacked the necessary space and facilities fitting a junior secondary school. However, it was some of these primary schools that had since been further upgraded to secondary schools. The committee further questioned how the upgraded basic schools would effectively operate as secondary schools amidst perceived challenges of space, facilities and equipment (Ministry of Justice [MoJ], 2013).

1.2 Statement of the problem

Despite the perceived infrastructure difference between the upgraded and old established secondary schools highlighted by the Zambian parliamentary report, the upgraded secondary schools are expected to implement the biology curriculum. The case of school infrastructure highlighted suggests a possible impact on the quality of teaching and learning biology. It was also not known how the government policy of upgrading basic schools to secondary schools impacted on the biology curriculum implementation. From the reviewed literature and based on this researcher's experience as well as the information from the MoGE official that the Directorate of Standards and Curriculum has never conducted a research to ascertain the performance of upgraded secondary schools in implementing any science curriculum, a knowledge gap to show the effectiveness of the upgraded secondary schools in implementing the biology curriculum in comparison to the old established secondary schools was identified.

1.3 Purpose of the study

The purpose of the study was to investigate whether there was a significant difference in the implementation of the biology science curriculum between upgraded and old established secondary schools.

1.4 Research objectives

The objectives of the study were:

1. To assess the nature of school infrastructure for teaching and learning of biology in the two sets of secondary schools.

2. To determine the availability and state of teaching and learning materials for biology in the two sets of secondary schools.

3. To investigate the teaching practices of teachers of biology in implementing the biology curriculum in the two sets of secondary schools.

1.5 Research questions

The study was guided by the following research questions:

1. What is the nature of school infrastructure in the two sets of secondary schools in relation to implementation of the biology curriculum?

2. What is the availability and state of teaching and learning materials for biology in the two sets of secondary schools?

3. How do the teaching practices of teachers of biology in the two sets of secondary schools relate to implementation of biology curriculum?

1.6 Significance of the study

It was hoped that this study would generate knowledge that may be useful to the science curriculum developers during the curriculum review process and serve as a basis for situational analysis in the development of future biology curricula. The knowledge from this study is may also help in understanding the impact of the Zambian government policy of upgrading some of the basic schools to secondary schools on quality of teaching and learning biology. The findings of the study may also be useful for future research on biology curriculum implementation.

1.7 Limitation and Delimitation of the study

The delimitation of this study is that it was only conducted in the government secondary schools in the urban district of Ndola. The limitation to this study is that, generalisation of the findings may be limited to urban government secondary schools only.

1.8 Theoretical framework of the study

This study was guided by the constructivist and the Schema theories of learning. The socio-constructivist theory of learning proposed by Vygotsky (1978) states that learners construct and build their own knowledge of the world around them through life experiences. Social constructivism has been a theoretical basis of science education for many years. For instance, Matthews (1993) noted this theory underpins major research programs in science education, particularly those dealing with children's learning in science, misconceptions and with curriculum development. In addition many other countries have developed their school's science curricula based on constructivist theory (Matthews, 1993). No doubt, the biology science curriculum under consideration shows a number of teaching approaches that point to the constructivist epistemology (CDC, 2013). For instance, strategies for implementing the biology science curriculum include use of laboratory apparatus and use of learner-centred methodologies among other strategies. Constructivism has been of much use in the field of science education as it alerts teachers to their function of facilitating prior learning by stressing the importance of understanding as a goal of science instruction even through learner-centred lessons (Matthews, 2002).

Matthew (2002) argues from some of Von Glasersfeld's ontological themes that constructivist knowledge can be created by an individual from historical and cultural context; knowledge can be regarded as an individuals' experience as opposed to the world; and that conceptual structures constitute knowledge when individuals regard them as viable in relation to their experience. Similarly Martin, Jean-Sigur, and Schmidt (2005) point out constructivism as a form of pragmatism as well as an argument that postulates the process-oriented inquiry method of teaching science as the learner-centred approach. Based on these arguments, the socio-constructivism as a theory of learning in science education and as a science curriculum basis was therefore adopted as this study's theoretical framework.

Vygotsky believed that there is an important connection and interaction between the spontaneous learning experiences and nonspontaneous scientific concepts in that, what a learner is learning in school influences the course of development of concepts acquired through everyday experience and vice versa (Duschl, 2008; Mustafa, 2008). Some of the learners' experiences may emanate from their interaction with the school environment including the infrastructure, teaching and learning materials and the teachers. It must be noted that the school in which a learner is enrolled serves as his/her social institution whereas science education (teaching and learning of biology) stands as sociocultural perspective. Equally the school infrastructure, teaching and learning and the teaching staff constitute part of the school culture (Lemke, 2001).

This theory further proposes that learners construct their own understanding by actively participating in the learning process. The learners' participation in the learning of biology is associated with the manipulation of objects and materials to engage the learners with the biological concepts of what the teacher knows (Duschl, 2008). It is also believed that learners with different skills and backgrounds need to collaborate on tasks, such as when they are doing practical work together in order to arrive at a shared understanding of the truth in a biology lesson (Crawford, 1996). Therefore, it can be said that the learner's experiences may be created through doing of practical work especially in the learning of biology as a natural science subject. Other learning activities that can help create learner-centred experiences include field trips, project work, study tour and group work tasks (MESVTEE, 2013).

Constructivism also entails that the active learners construct their own knowledge while the teacher facilitates the learning process (Ratanaroutal & Yutakom, 2006). Learning biology through practical work in the laboratories allows the learners to experience reality as the learners do not easily forget what they have seen with their own eyes. This is made an experiential reality during practical lessons where the learners can handle and manipulate learning materials such as specimens and laboratory apparatus (Driscoll, 1994). Additionally, Matthew (1993) noted that one of the important points about constructivism is that it stresses on understanding as a goal of science instruction which stands as its major advancement over the rote learning that characterises most science classrooms. Therefore, learners should be given practical work in biology to promote their active participation in the learning process.

Constructivism as a method has had considerable success in the classroom because the types of alternative learning strategies it offers have contributed immensely to understanding of the learner and learning process and as such, constructivism is noted to have generated a large body of empirical data that has been vital in improving teachers' knowledge and conception of learners' scientific thinking (Shumba, Ndofirepi & Gwirayi, 2011). Constructivist approach of learning science supports learner-centred strategies as the most effective for teaching and learning science. In a constructivist learning environment, the teachers' role is to serve as facilitator of learning in which learners are encouraged to be responsible, autonomous, and construct their own understanding of each of the scientific concepts. Hence the activities are learner-centred, democratic, and interactive. The teacher also provides learners with experiences that allow them to use science process skills (Akinbobola & Afolabi, 2010).

Constructivism also employs teachers to recognise their learners' alternative ideas, and to take them into account their planning and lesson delivery, so that the aim of conceptual change is fulfilled (Tsaparlis, 2001). Since curriculum implementation is anchored on the schools' culture in the form of the school infrastructure, teaching and learning materials as well as the teaching staff (Meier, 2012), the socio-constructivist theory stood as one of the relevant theories for the study on biology curriculum implementation.

Constructivism alone may not fully inform this study especially on topics in biology that are abstract in nature and have no prescribed experimentation in the biology curriculum. The social constructivist theory is silent about the importance of teaching biology by following the logical sequencing of topics. For instance, Duschl (2008) notes that the cognitive, social, and cultural dynamics of learning are mutually supportive of one another and intertwined together. Based on this, my study was also informed by the schema theory of learning. The schema theory advanced by Ausubel (1963) proposes that meaningful learning takes place when the new information can be related to similar concepts acquired earlier by the learner. This theory promotes the lecture method of teaching (teacher exposition); however, it discourages rote learning by making use of advance organisers that act as existing schemata to which new concept can be linked (Davis, 2013).

The schema theory being a form of cognitive constructivism proposes that meaningful learning in biology as a science may not necessarily take place by giving learners a sequence of experiments but that mind cognition is very important. For instance, Cakir (2008) argues that organisational processes are essential for building conceptual networks and that the teachers can support learners' organisational processes by techniques such as concept mapping. Teaching methods such as the lecture method are to be used to invoke learners to construct biology concept maps that can enable them link their new concepts to the already existing scientific concepts.

Learners can use prior knowledge either from life experiences or learnt scientific concepts to solve academic problems. For instance, if learners have direct experience with the scenario, prior schemata are activated and problem solving is facilitated. According to this view, people rely mainly on every domain for specific knowledge, wherein specific recollections of prior experiences are used to solve problems (Price & Driscoll, 1997). The schema theory as part of cognitive constructivism emphasizes the importance of learners having prior knowledge about the new phenomenon that is to be learnt (Shumba, Ndofirepi & Gwirayi, 2011). This form of cognition can be useful in teaching certain abstract topics in biology that may be difficult to learn through practical work in form of experimentations. This theory also recognises the importance of brainstorming, lecture and problem solving as teaching methodologies. The theory also espouses the importance of recapitulation of the previous lessons during instruction delivery.

1.9 Operational definitions

Biology curriculum implementation: In this study, curriculum implementation means the application of school infrastructure, teaching and learning materials and teacher classroom practices in the teaching and learning of biology.

Biology curriculum: This is the planned content, structure and process of teaching and learning biology with a view of achieving aims, goals and objectives of science education with respect to principles of biology.

Effective curriculum implementation: This is the realisation of at least 60% of the aims of teaching and learning of biology as a science as the result of the application of school infrastructure, teaching and learning materials and teacher classroom practices.

Improvised chart: A large diagrammatic drawing (not drawn to scale) generated using simple materials such as manila paper and marker pens that is allows the achievement of the aims of teaching and learning science.

Old Established Secondary School: A secondary school that enrols Grades 8-12 and has been implementing both the junior and senior secondary school curriculum from its inception under the Zambian formal education system.

Teacher practices: In this study, this means a description of teacher's behaviour in terms of use of teaching methods, teaching aids, assessing of learners, and management of time in the implementation of biology curriculum.

Upgraded Secondary School: This is a school that initially served as either a primary or basic school (enrolling Grades 1-7 or 1-9) and having school infrastructure of a primary or basic school, but upgraded to a secondary school to enrol Grades 8-12 under the Zambian formal education system.

1.10 Ethical considerations

During the study, the participants were treated with respect and reserved the right to participate or not. Written consent was obtained from the participants. The researcher explained what the study was all about before the participants were asked for their participation. Clearance for the study was obtained from the University of Zambia Ethics Committee. In upholding confidentiality, the sampled secondary schools were assigned arbitrary code names as opposed to use of their actual names. The code names were as follows; upgraded secondary school one (UP1); old established secondary school two (OL2); upgraded secondary school three (UP3); old established secondary school four (OL4); upgraded secondary school five (UP5) and old established secondary school six (OL6).

1.11 Chapter summary

This chapter looked at the background to the study as arising from the government policy of upgrading some basic schools to secondary schools, and the nature of the biology science curriculum. The statement of the problem was presented in relation to the background of the study as well as based on researcher's knowledge while the research objectives aimed at school infrastructure, teaching and learning materials and teacher practices in both upgraded and old established secondary schools as the key variables to biology curriculum implementation as reflected in the conceptual framework of the study. The chapter also discussed the constructivist and schema theories of learning as the underpinning theoretical framework of the study. Key terms of the study were operationally defined and ethical considerations of the study were outlined under this chapter. The next chapter looks at literature review.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews literature on some of the curriculum concepts; Zambian science curriculum and factors that are thought to influence the implementation of a science curriculum namely, school infrastructure for teaching and learning; teaching and learning materials; and teaching staff and their classroom teaching practices.

2.1 Some curriculum concepts

The term curriculum is defined differently by various scholars. For instance, Gatawa (1999) relates curriculum to what parents generally see as the academic programme offered by the school. This definition shows weakness as it only focuses on the parents' view of the curriculum, and the term academic programme is also too restrictive to mere academic achievement. Farrant (1980) defines curriculum as that set of broad decisions about what is taught and how it is taught, that determines the general framework within which lessons are planned and learning takes place. The definition by Farrant (1980) points out the important aspect of curriculum implementation which is teaching in terms of the teaching methodology and content structure. The curriculum implementation, this study considered, mainly focused on the teaching and learning of biology. MoE (1996) describes curriculum as that which consists in the content, structure and process of teaching and learning which the school provides in accordance with its educational objectives and values. It includes the concepts, knowledge, skills, attitudes and values which pupils incorporate through the process of schooling. The description of the term curriculum by MoE (1996) vividly brings out the concept of curriculum implementation by stating the importance of teaching and learning in respect to the set educational objectives and values. This definition by describing the curriculum as that, which consists in the process of teaching and learning, clearly shows the importance of evaluating the curriculum implementation process for any of the school curricula.

Curriculum implementation is an important process of any of the education systems. For instance, Fullan and Pomfret (1977) argue that failure to examine curriculum implementation makes it difficult to interpret the learning outcomes and their subsequent relation to the possible determinants. It is further argued that there is positive relationship between curriculum implementation and student achievement scores. A study of the curriculum implementation process may also help to learn why new educational policy changes fail to succeed. A study on the biology curriculum implementation by Öztürk (2003) indicated that curriculum implementation process of the new high school biology curriculum showed differences at local, school and classroom level factors. These differences relied on the physical structure and facilities of schools, some teacher characteristics and some teacher beliefs and perceptions. Öztürk's study brings out the importance of factors that influence curriculum implementation. The influence of some such factors on the Zambian biology curriculum implementation has not been investigated and is therefore the focus of this study with respect to teaching and learning of biology in the secondary schools. The process of curriculum implementation can be influenced by a range of factors such as the learners, teachers, teaching and learning materials, cultural environment, the school infrastructure, curriculum innovation among other factors (Fullan & Pomfret, 1977; MESVTEE, 2013).

The MESVTEE (2013) acknowledges that curriculum implementation is dependent on many factors that mainly consist of the inputs, processes and outcomes of the Zambian education system. It is further pointed out that such factors include the physical environment (classrooms and laboratories), planning and resource management, teaching staff, teaching methodologies, assessments, time allocation and management, co-curricular activities, subject associations and Continuing Professional Development (CPD). This study therefore looked at the biology curriculum implementation influences from the perspective of school infrastructure, teaching and learning materials and classroom teacher practices.

2.2 Zambian secondary school curriculum – an overview

The senior secondary school curriculum consists of two curriculum pathways namely the vocational and academic pathways. The academic career pathway consists of the following options: Social Sciences, Business Studies and Natural Sciences. The vocational and technical career pathway offers the following options; Agriculture, Technology, Home economics and hospitality, Performing and creative arts and Physical education and sports. Under the academic pathway, biology is offered in all the three streams while in the vocational pathway biology is offered in all streams except in the Agriculture, Performing and creative arts streams. Other sciences offered in the science curriculum include chemistry, physics and physical science (combination of chemistry and physics). Over the years, biology has been one of the natural science subjects (apart from pure chemistry and physics) with a practical examination component until the recent re-introduction of practical examinations in the physical science in the year 2016 and introduction of vocational pathway in which biology is optional in some of the subject combinations (MESVTEE, 2013). The provision of biology in both academic pathways of the Zambian curriculum justified the consideration of its implementation process in the secondary schools.

Successful implementation of the curriculum is projected to enable learners acquire competencies in knowledge with understanding; handling information and solving problems; and experimental skills and investigations. The learning time allocated is at least 3 hours and 25 minutes which translates into five learning periods in a week with each period lasting 40 minutes. Assessments during implementation include school based assessment tests that may be in the form of diagnostic, aptitude, achievement, oral and performance of learners. The final assessment is conducted by the Examinations Council of Zambia where learners sit for biology paper 1 (multiple choice questions); paper 2 (mainly theory consisting of short answer structured and essay questions) and paper 3 (practical component). However, the final score is given as an aggregate of the three papers (CDC, 2013).

In a study to review the Zambian high school biology curriculum materials, Chabalengula, Mumba, Lorsbach, and Moore (2008) found that the basic knowledge of science and investigative nature of science received more coverage in the biology textbooks and in the biology syllabus content objectives. On the other hand, science as a way of knowing, and investigative nature of science themes received the most coverage in the biology examinations, and aims and assessment objectives sections of the biology syllabus. The interaction between science, technology and society theme was the least covered theme across the biology curriculum materials. The study by Chabalengula *et al.* (2008) is important as it reviewed the previous biology syllabus which is not very different from the current biology syllabus whose implementation was being assessed by this study. It also brings out the science literacy themes that are covered in the current biology science curriculum. However, their study didn't show how the science literacy themes covered in the syllabus are implemented during the teaching and learning process.

Some of the studies related to the biology science curriculum have cited its associated challenges as the biology syllabus being bulky; insufficient time allocation for teaching and learning; and scarcity of the learning materials prescribed in the syllabus (Chifwa, 2015;

Haambokoma, 2007; Manda, 2012). However, some studies have also indicated the strengths of the biology science curriculum such as clearly stated learning objectives, elaborate prescription of teaching and learning materials (Chabalengula *et al.*, 2008); and the logical sequencing of the biology curriculum content (Manda, 2012).

2.3 School Infrastructure for teaching and learning biology

Ayeni and Adelabu (2011) refer to school learning infrastructure as the site, building, furniture and equipment that contribute to a positive learning environment and quality education for all learners. However, school infrastructure may not necessarily contribute to a positive learning environment but may at times fall short of the requirement of that positive contribution. In this study, school infrastructure mainly implies the physical facilities such as science laboratories, classrooms, staffroom, school assembly hall, school library, computer laboratory, and school environment aimed at promoting teaching and learning of biology. These facilities are needed to facilitate effective teaching and learning in any of the secondary schools. The quality of school infrastructure and learning environment has strong influence on the academic standard which is an index of quality assurance in the school (Ayeni & Adelabu, 2011). On the other hand, some studies have shown that school infrastructure can motivate the teachers (Roy & Sengupta, 2014) despite not showing to what extent such teacher motivation influences the implementation of the school curriculum. Although good school infrastructure can motivate teachers, over enrolment in the classes and inadequate learning time allocation may erode the teacher's motivation. But it must be noted that quality school infrastructure such as large classroom space, adequate furniture, well equipped science laboratories and a conducive staffroom may facilitate teachers' use of effective teaching methodologies and adequate lesson preparation respectively thereby promoting good teaching of biology.

When considering the learning of biology as a science, much attention is given to the availability and state of the science laboratory as the only teaching and learning infrastructure, however, school infrastructure such as the classroom, staffroom and the assembly hall are equally important in the learning of biology as a science. For instance, in a school where there is enough classroom space for the teachers to walk round while delivering a lesson may promote rapt attention of learners and good academic performance. Equally a classroom large enough and adequate for the enrolment levels may promote effective use of teaching methods such as group discussion and demonstration as well as classroom management which in turn promotes effective learning (Ayeni & Adelabu, 2011; Ogundare, 1999). Durosaro (1998) reported that even if the educational curriculum is sound and well operated while the school facilities are in disrepair and badly managed, the result of the teaching and learning activities will be negative. He further argues that there is a positive relationship between good school environment and effective teaching and learning activities. This shows the importance of the school infrastructure in the implementation of the curriculum. Each of the school infrastructure mentioned above may have its own specific contribution to the biology curriculum implementation in the upgraded and old established secondary schools.

School infrastructure is very important to the teaching and learning as it forms part of the educational culture. For instance, Branham (2004) points out that the school infrastructure has crucial consequences on the performance of learners and school attendance as well as school dropout rate. He further argues that this is because learners are vulnerable to whims of social disorder caused by the dilapidated infrastructure. It was further noted from Branham's study that there is a strong correlation between the quality of school infrastructure and the school attendance in secondary schools. His finding implies that poor school infrastructure may lead to poor school attendance which in turn may make it difficult for the implementation of the school curriculum as both teachers and learners are cardinal in the curriculum implementation process. This study however, sought to interrogate the influence of school infrastructure on biology curriculum implementation in terms of the teaching methodologies and use of learner-centred approach in teaching and learning of biology as opposed to learner attendance in school.

Similarly, Mansour (2013) found out from his study on modelling of sociocultural contexts of science education, that the school infrastructure formed part of the learning/school culture which subsequently affected provision of science education in the Egyptian secondary schools. This may help to explain the influence of school physical facilities on application of constructivism in the teaching and learning of biology, although, Mansour's study does not show the school culture obtaining in the upgraded and old established secondary schools in relation to biology science curriculum implementation. School infrastructure is indeed part of the school culture, for instance, Lemke (2001), defines sociocultural perspective on science education as viewing science, science education and research on science education as human social activities within institutional and cultural frameworks. This definition suggests that the institutional framework in this case is the school as an institution in which science education is offered. Lemke (2001) further explains that social activities in the research perspectives in science education are concerned with questions that seek to answer how social interaction influences the teaching and learning of science as well as research in science education. This is consistent with the constructivist theory of learning science in the secondary schools. This further implies that school infrastructure influences social interactions between learners and teachers and subsequently influencing the way of learning biology in the two sets of secondary schools. Therefore, good teaching of biology may imply teachers' use of the school infrastructure to foster a school cultural environment in which learners can learn biology through practical means.

2.3.1 Conventional classrooms

Although biology is a science subject, it is not only taught and learnt from the science laboratory but also from the conventional classrooms. The nature of the subject content of the particular topic of the biology curriculum may dictate the venue of a lesson although other factors such as lesson time allocation, availability of learning materials and class enrolment levels may influence the choice of the venue of the lesson. Wong and Fraser 1996 (cited in Aladejana & Aderibigbe, 2007) points out that an important determinant of student learning is the classroom learning environment. It is also argued that the classroom environment has a positive influence on the learners' attitudinal and academic achievement outcomes. Factors related to teaching styles, classroom design, and the learning environments interact to influence learner's satisfaction with learning. The classroom environment is more than just the physical space; it is the entire setting for learning. It encompasses the variety of tools and information resources, the interactions, the relationships between and among learners and teachers, as well as the expectations and norms for learning and behaviour (Aladejana & Aderibigbe, 2007). This also illustrates the importance of the classroom in supporting social constructivist form of learning science in the classroom.

Use of the conventional classroom in teaching and learning biology may mainly favour cognitive learning of biology, however, classroom factors such as the sitting arrangement, enrolment levels, classroom fittings and space may also influence teaching and learning of biology by either promoting learner-centred or teacher-centred approach. For instance, Nkoya (2008) noted that although teachers of chemistry taught average class enrolment of 55 learners, the teachers were still able to use various learner-centred methods during the chemistry lessons. He further noted that the learner-centred methods used were mainly group discussion, problem solving, question and answer and project. Nkoya (2008) argues that learner-centred lessons rely on strategies that encourage learner's interaction with the content, with one another, with the teacher and with the learning process. It must be noted that these strategies also rely on the classroom factors mentioned above. This interaction can be enhanced with quality classroom infrastructure.

Conventional classroom may be used as a venue for practical lessons especially when laboratory infrastructure is absent (Njiru, 2012). However, the conventional classroom may not be as effective as the science laboratory for teaching and learning biology. Practical teaching methods such as demonstration can be implored even in the conventional classroom but methodologies such as experimentation and field work may not be feasible in the classroom setup. For instance, in a study by Milner, Templin and Czerniak (2011) it was established that constructivist teaching practices were found to occur more often in the life science laboratory than in the regular classroom. It was also found that although constructivist teaching practices increased at each observation time in both the conventional classroom and in the life science laboratory, a Friedman test determined that there was no statistically significant increase. The question of whether the conventional classroom favours constructivist learning methods was to be ascertained by this study on curriculum implementation in the upgraded and old established secondary schools.

2.3.2 Science laboratories

As observed from literature on the significance of the conventional classrooms in the teaching and learning process, the laboratories are very important in the teaching and learning of natural science based subjects. The science laboratory can be defined as a learning environment with special structures, equipment and materials necessary for teaching and learning of practical science lessons (Nghipandulwa, 2012). For instance, Hofstein and Mamlok-Naaman (2007, p. 105) observed that "over the years, many scholars have argued that science cannot be meaningful to students without worthwhile practical experiences in the school laboratory''. Many research studies have been conducted to investigate the educational effectiveness of laboratory work in science education in facilitating the attainment of the cognitive, affective, and practical goals (Hofstein & Mamlok-Naaman, 2007). It was however not known as to whether the school infrastructure in the Zambian secondary schools provided for laboratory space and if so to what extent the existence of these laboratories promoted the learning of biology.

As reviewed earlier in the section of conventional classrooms, Milner, Templin and Czerniak (2011) established that constructivist teaching practices were found to occur more often in the life science laboratory than in the regular classroom. It was also found that learner motivation and learning strategies were higher in the life science laboratory than in the regular classroom. Their study is cardinal as it signifies the laboratory infrastructure in the teaching and learning of biology. The learner motivation springing from the learning of biology in the laboratory may be an important factor in fostering learning of science through constructivism as the learners get hands on experience. In addition, Aladejana and Aderibigbe (2007) indicated that there is a positive correlation between laboratory environment and learner academic performance.

In trying to establish the provision of teaching and learning materials in science subjects in high schools in Northern Province of Zambia, Siwale (2013) noted that 52 percent of the high schools had no science laboratories and that these high schools were mostly those that were upgraded from basic schools. Despite this remarkable finding that the lack of science laboratories is not only limited to upgraded secondary schools but also old established secondary schools, his study does not show the influence of that on science curriculum implementation; moreover the schools sampled in his study were from rural and peri-urban areas. This study therefore sought to find out if the distribution of the science laboratories in urban secondary schools was consistent with Siwale's findings and how the distribution influenced biology curriculum implementation.

2.3.3 Other school physical facilities that support biology curriculum implementation

Because the school serves as a social institution and its physical structures and environment constitute part of the school culture (Mansour, 2013), it's imperative to consider the importance of other school facilities such as the staffroom, school library and the school hall. School infrastructure other than the classroom and science laboratory may not directly influence the teaching and learning of science but is nonetheless important in supporting the social constructivist approach among both the teachers and learners. For instance, Edwards (2006) found out that there was a significant connection between the condition of the school learners attended and their own levels of motivation, conduct and academic achievement. His findings also showed that learners regarded the quality of teaching and administrative staffing in their educational environments as being largely contingent upon the condition of the school itself.

In the Zambian secondary schools, a school hall facilitates assembly of learners and the school administration and the teaching staff for school administration to communicate important information to learners such as the ECZ examination regulations. The school hall may also serve as a study room where learners can meet in small groups to work out the academic assignments or to study. The school hall serves as a study room in the absence of a school library as most of the classrooms are often utilised by the afternoon learners (MoE, 1996). The school hall as school infrastructure helps manipulate the learning experiences of the learners thereby promoting of construction of the science knowledge from the school social background. The usage of the school hall as the study room by the learners helps to lessen on the usage of the classrooms and at times the science laboratory for studying purposes.

Ayeni and Adelabu (2011) sought to determine the effect of learning environment and infrastructure on teaching and learning in secondary schools by using a descriptive survey method. They found among other findings that the school infrastructure impacted on the teacher instructional performance and learner academic performance with a positive correlation. Staffroom infrastructure impacts on the instructional delivery of the teacher. A suitable staffroom environment may enable the teacher to plan his/her lessons. A suitable staffroom may be said to be one with enough working space and adequate furniture. In the absence of suitable staffroom conditions, teacher performance may be impacted negatively and the effect may in turn be transferable to learners through social interaction resulting from teaching practices.

2.3.4 Some key studies on school infrastructure

The study by Öztürk (2003) on the implementation of biology curriculum in high schools of Turkey found that only 75 percent of the schools had biology laboratory and that the biology laboratory in respective schools served other purposes other than the implementation of the new biology curriculum. It was further observed that there were no independent biology laboratories as the existing laboratories were shared among other science subjects. This impacted negatively on biology curriculum implementation in that the biology laboratory work was rarely carried out. This study is remarkable as it brings out the negative effect of lack of school infrastructure on the biology curriculum implementation. It is observed that Öztürk's study was conducted under an educational system different from the Zambian educational system. Therefore, this study sought to find out the nature of school infrastructure in upgraded and old established secondary schools and how this influences the quality of teaching and learning biology.

Another study conducted by Kagoda (2011) to evaluate the influence of the schools' learning environment on the performance of teacher trainees on school practice found that the school infrastructure exerted a negative influence in that the classrooms were dilapidated and usually congested. School libraries were missing while schools that had libraries lacked the necessary books. In addition, the science laboratories were dilapidated and had obsolete equipment. The existing science laboratories were only used by special classes while the rest of the classes had no access. This study is important as it shows impact of school infrastructure on teaching of science in most secondary schools in Africa. However, Kagoda's study does not show the full extent of the impact on the curriculum implementation as his source of data were experiences of the trainee teachers as opposed to observing the actual science lessons in such infrastructure. The teacher trainee performance should have also been triangulated by observing the candidates on their teaching practice. This study looked at the impact of school infrastructure by actual observation of the biology lessons in relation to the existing school infrastructure.

In summary, the literature reviewed above shows the importance of school infrastructure in fostering constructivist learning of biology and implementation of the biology curriculum. The key school physical facilities considered in the various literature reviewed include classrooms, science laboratories, school hall and staffroom. Knowledge gaps identified from the reviewed literature included lack of research findings to show how biology curriculum implementation is influenced by infrastructure in both upgraded and old established secondary schools. Knowledge gaps also emanated from the limitations in research methodologies for the reviewed studies where the findings were not adequately triangulated while other studies were conducted under very different educational systems from that of the Zambian educational system where distribution of physical facilities may be different.

2.4 Teaching and learning materials in biology

Curriculum implementation, which can be said to be the translation of the intended curriculum into operational curriculum, is influenced by the teaching and learning materials as well as teaching strategies (Fullan, 1991). Nghipandulwa (2012) also points out that the problems associated with curriculum implementation include the lack of equipment, enough time for practical work, safety precautions in the laboratory, and learners' participation. This section looks at the studies on the various teaching and learning resources that are cardinal to the teaching and learning of biology in both upgraded and old established secondary schools.

2.4.1 Curriculum materials

Curriculum materials which include biology textbooks, the biology syllabus and examination papers are important to the implementation of the biology curriculum. For instance, Beyer, Delgado, Davies and Krajcik (2009) argue that curriculum materials can also foster teaching and learning by providing teachers with implementation guidance with detailed recommendations on how to implement curricular suggestions to achieve productive instructional ends. These materials typically contain content and skills for learners to learn, prescribe learning experiences, and specify pedagogical methods. This is the case with the curriculum document the biology syllabus which has elaborate prescriptions of the delivery of particular content, the learning methods, the science process skills and means of learner academic assessment (CDC, 2013). Teachers often use curriculum materials to guide their planning and enactment of lessons (Beyer *et al.*, 2009). However, Chabalengula *et al.* (2008) observed that the interaction between science, technology and society theme was the least covered theme across the Zambian biology curriculum materials. The findings by Chabalengula *et al.* (2008) suggest a negative relationship between the biology curriculum and the Zambian society in that the socio-constructivist may not be effective in communicating the scientific concepts of the curriculum to the learners. Teaching and learning materials for biology range from laboratory apparatus, laboratory reagents, specimens, and biology models to biology text books. Laboratory materials are often used to conduct biology practical lessons while the textbooks and syllabus document can be used as a teaching aid in the ordinary classroom or as a reference material during practical biology lessons and conventional lesson delivery (CDC, 2013).

Well written textbooks can serve the teacher from writing notes on the chalkboard which often takes much of the lesson time. Reference to diagrams in the absence of a wall chart can be achieved with the use of textbook. The availability of textbooks has also been found to impact positively on the learning of biology. Learners can make reference of their lessons to the material in the textbook and thus promoting learner-centred approach (Ottevanger, 2001). Ottevanger (2001) also noted that the teacher edition textbooks enhance teachers’ role in the implementation of the science curriculum. His study is important as it established the positive impact of availability of the textbooks on the implementation of a science curriculum.

However, this study sought to compare the availability of the textbooks in the upgraded and old established secondary schools and how it impacted on the biology curriculum implementation.

Lee and Zuilkowski (2015) demonstrated the importance of textbooks. They found out that the pupil-textbook ratio was very high in most of the schools. Their findings also indicated that teachers regarded textbooks as very important teaching materials, in that, textbooks facilitated learner-centred methods of learning. However, the pupil textbook ratios noted were those in primary and basic schools with different subject curricula. Similarly, Siwale (2013) established that there was inadequate teaching and learning materials in the three major sciences (Biology, Chemistry and Physics). His findings also indicated that the learner book ratio was high and that most schools did not have some of the prescribed biology textbooks. However, the two studies couldn't establish the impact of the book distribution on the curriculum implementation later on the biology curriculum. Therefore, this study sought to find out the influence of learner textbook distribution on the curriculum implementation through the teaching and learning of biology.

2.4.2 Teaching and learning aids in biology

The importance of teaching aids usage in science education received its emphasis as early as the 1940s. For instance, Galbreath (1946) argued that one of the chief aims of teaching biology is to acquaint learners with the nature they live in and that this can be achieved through the use of such visual aids as specimens, displays, museums, exhibits, charts, models, diagrams, slides, pictures or through the use of educational films. Today, use of teaching aids such as specimens, models and charts as well as projected aid can help enhance constructivist learning of biology in both upgraded and old established secondary schools. In addition, Galbreath (1946) identified the field trip as a teaching and learning aid in biology that provides one of the best methods of gaining first-hand experience with living things to the learners. He further argued that field trips, which are well planned, and purposeful, connect the classroom to the great outdoors and give the learners in classes the best opportunity to observe the inter-relationship among living things in their natural habitat. However, Bryan (1948) identified the field trip as a teaching method. Despite this contrast by the two scholars, field trip in biology can serve both as a teaching aid and teaching method to the attainment of the aims of teaching biology and subsequent curriculum implementation.

Teaching aids such as the computer and overhead projector can help enhance active learning among the learners of biology thereby promoting the quality of teaching and learning biology as one of the aims of biology curriculum is to stimulate learners to sustain their interest and the appreciation of the biological sciences. For instance, Proulx and Matray (1995) investigated the integration of computer technology in high school biology curriculum and found that computers provide an opportunity to present biological material in an exciting and engaging manner because software programmes can be used to illustrate and elucidate biological concepts that can be more clearly and effectively communicated through computer technology than through more traditional means like lecture, discussion or conventional laboratory activities. The use of ICT can also help the learners to actively participate during the biology lessons which in turn reduce on learner passivity thereby promoting constructivist approach of implementing the biology curriculum (Proulx & Matray, 1995). This is mostly because the ICT facilities often arouse the learners' interest. However, the use of ICT in implementing biology curriculum has not been emphasised by the overall national educational curriculum although the study of computer studies at junior secondary school level has been introduced (MESVTEE, 2013). Since computer technology can help serve effectively in illustrating and elucidating the biological concepts, it can serve as an intervention in the school environment where most of the teaching and learning materials are scarce especially that the Zambia Informational and Communications Technology Authority (ZICTA) has been assisting the secondary schools with ICT infrastructure and materials.

Biology being a natural science subject and of a practical nature requires special materials for teaching and learning. The use of specimens and models in teaching biology is critical as this helps in providing concrete learning experience to the learners. For instance, Heinich, Molenda and Russell (1989, p12) state that 'concrete experiences facilitate learning and the acquisition, retention and usability of abstract symbols'. Learners can therefore be helped to make inference during the learning of biology from the concrete experiences that can be provided by use of specimens and models as well as participating in carrying out experiments in biology. Similarly, Das (1993) argues that a concept that has never been learnt before can only be meaningful if instructional tools are used. Therefore, showing of real objects or giving first-hand experience of the real world becomes necessary in teaching. However, the argument advanced by Das (1993) implies that the schema theory of learning may not be effective in the absence of such learning materials as the specimens and models. The presence of the specimens and models may not fully guarantee effective implementation of the biology curriculum, but the state and utilisation of these materials may impact on the teaching and learning as the utilisation of such materials may also be dependent on teacher's skills in conducting practical lessons (Haambokoma *et al*, 2002).

Biological specimens such as those of plantae nature may be sourced from the school environment and learners may be cardinal in the sourcing of such materials (Tlala, 2006). Asking learners to help source the specimens from the school environment can help engage the learners and thereby fostering constructivist approach of learning science because the learners can actively participate in the learning process. This in addition helps in invoking the learners' interest in biology and enhancement of their practical skills development (Mudenda, 2008). However, the quest to source local biological specimens may be hampered by the time constraint both on the part of learners and teachers. In most cases teachers prefer readily available teaching materials in an attempt to manage the allocated lesson time. For instance, Chifwa (2015) noted that availability of time and resources influences the choice of teaching method. It can be inferred from Chifwa's observation that availability of time may influence the choice of teaching and learning materials for a biology lesson.

Biological models (physical representations) are of great importance in communicating and illustrating the different concepts of biology especially those to do with the human body since use of humans as specimens is highly restrictive in the teaching and learning of secondary school biology. For plant biology, the specimens may be obtained from the environment and at times can be grown for experimental purposes. However, in animal biology, live specimens may not be readily available. For instance CDC (2013), in senior secondary school biology syllabus, prescribes one of the critical science process skills of observing organs, tissues or systems. In the section on respiratory system, it's prescribed that learners observe nostrils, trachea, bronchi, bronchioles, alveoli of the human respiratory system. Getting actual alveoli for a biology lesson may be highly unattainable and therefore use of a biological model proves necessary in such a case. Biological models may not necessarily offer the real life experiences but can greatly provide concrete experiences to the learners (Heinich, Molenda & Russell, 1989). In order for the biological models to provide a constructivist background, learners must be allowed to manipulate the models, discuss among themselves and share meanings from their experiences with the learning models. Handling of models by learners during lessons may foster learner-centred learning thereby encouraging learners to own the process of knowledge acquisition (Matthews, 2002).

Not only biological specimens and models provide concrete learning experiences but charts can also be used to illustrate the abstract concepts. Charts can either be sourced from commercial sellers or improvised by the teachers and learners. Improvised charts are drawn to illustrate a process or concept while commercial charts in most cases may be a microscopic graphs printed on a large poster. Charts may enhance time management during biology lessons by reducing on time to draw diagrams on the chalkboard. Use of charts can equally promote learner-centred learning. Apart from promoting learner-centred approach instructional media such as charts are known to motivate learners and provide a fulfilling learning experience (Omariba, 2012).

Laboratory equipment and apparatus as well as reagents are very cardinal in the teaching and learning of biology. For biology, relevant apparatus includes glassware, microscopes, hand lens, water bath, thermometers and beam balances to mention but a few. Reagents are also important especially for experiments like food tests, illustration of transport system in plants, illustration of diffusion, osmosis and active transport (CDC, 2013). The availability of the laboratory apparatus and other materials has been a problem in some of the schools as noted by Haambokoma *et al*. (2002) that most Zambian secondary schools lacked the teaching and learning resources. They further argued that improvisation of learning materials and equipment was an inescapable alternative in the under resourced secondary schools.

Manda (2012) investigated the nature and causes of learning difficulties grade 12 pupils experience in biology in high schools of Samfya district of Zambia. One of his findings showed that the pupils experienced difficulties in biology due to lack of practical lessons which was also as a result of lack of laboratory materials that were only scarcely provided during grade 12 mid-year and final examinations. The materials such as laboratory apparatus are important in conducting practical lessons. However, it was not known how the teaching and learning materials were distributed in the upgraded and old established secondary schools and to what extent this affected the biology curriculum implementation. Manda’s findings on the acquisition of the materials during the final examinations may help in explaining some of the schools’ cultural tendencies in the provision of science education through the implementation of the biology curriculum.

In a study by Nghipandulwa (2012) which aimed at investigating the Biology teachers’ perceptions of the importance of practical work in biology, one of the objectives was to find out whether the selected secondary schools had all the necessary resources needed to conduct meaningful practical lessons in Biology. The findings of the study showed that the laboratory materials were either unavailable or inadequate for the biology practical lessons. But she also noted from her study that the teachers of biology perceived practical work as experiments that could only be conducted with complex laboratory materials. The study was well triangulated as the researcher conducted a document analysis of the biology syllabus document for the study in question. However, the findings did not indicate how the inadequate laboratory materials impacted on the overall implementation of the biology curriculum especially that some of the teachers had misconceptions about practical work. This study is also limited in that it only focused on laboratory materials as the only teaching materials by not assessing other materials like textbooks and how this could have influenced the biology curriculum implementation.

Mudenda (2008) observed that lack of laboratory materials impacted negatively on the implementation of the biology curriculum in that during practical lesson most of the learners were merely spectators with a few learners demonstrating the procedure. He further found this trend to have continued even during the practical examinations. This scenario of most learners spectating at the few learners during the biology practical examinations may be attributed to the findings by Manda (2012) that laboratory materials are mostly procured during examinations as opposed to provision during the entire curriculum implementation process. The non-exposure of learners to handling laboratory materials during the biology lessons is what may have led most learners to merely spectate at others during the practical examinations.

2.4.3 Teaching and learning materials and academic performance

Teaching and learning materials have been cited in a number of studies to impact on the learner academic performance, for instance, Malambo (2012) showed from his study that learner academic performance in non-grant aided secondary schools was unsatisfactory as compared to grant aided secondary schools in that the non-grant aided schools had few or no teaching and learning materials among other findings while the learner academic performance was better and good in the grant aided secondary schools due to availability of teaching and learning materials. This study helps to explain the link between the availability of learning materials and learner academic performance. Although the study by Malambo (2012) shows the impact of the learning materials, it doesn't show how the teaching and learning materials impacted on biology curriculum implementation as his study evaluated overall learner performance and in addition, his study didn't triangulate the findings by conducting lesson observations which could have shown the impact of lack of teaching and learning materials on the actual teaching and learning process.

Mlozi, Kaguo and Nyamba (2013) investigated the factors that influenced academic performance of learners in the community and government built secondary schools, and found out that there were not enough teaching and learning materials. In addition they observed that teaching and learning processes were poor in the community built secondary schools. Their study used a cross sectional survey with random sampling of the population of learners and teachers, and purposive sampling of educational administrators. Although their study assessed the factor of teaching and learning materials in the two sets of secondary schools with a difference in school infrastructure, the study mainly considered teaching and learning materials of the print nature and in subjects other than biology. In addition, their study could not show how the distribution of the teaching and learning materials influenced the actual teaching and learning of the actual subjects as the learner performance could be subject to other factors.

In summary, the literature reviewed above shows the importance of both curriculum materials and various teaching aids. The two studies by Mlozi, Kaguo and Nyamba (2013) and Malambo (2012) showed the impact of teaching and learning materials on learner academic performance. However, the reviewed literature could not establish distribution of the teaching and learning materials with respect to upgraded and old established secondary schools. In addition, most of the studies could not identify how the specific teaching and learning materials impacted on the teaching and learning of biology later on biology curriculum implementation owing to gaps in the methodology used.

2.5 Teaching staff and teaching practices in biology

Teachers are the most important human resource in curriculum implementation since they are the ones who adopt and implement the ideas and aspirations of the curriculum designers. This implies that success of the curriculum depends on the teachers and learners. It has long been recognized that teachers have a major role in determining and implementing the curriculum. They interpret and give life to the curriculum specifications of governments and ministries, and translate curriculum intentions into classroom practices (Norris, 1998). Montero-Sieburth (1992) also pointed out that teachers play the central role in the implementation of the new curriculum in the classroom in both developed and developing countries. He further argued that the teacher's level of training, experience and professionalism impact on curriculum implementation. Cronin-Jones (1991) also points out that, teachers' perceptions and beliefs play a critical role in the curriculum implementation process. He further argued that teachers do not often implement the curriculum as prescribed by the curriculum designers but often change implementation to suit their style of teaching.

Teachers being at the centre of curriculum implementation may be able to articulate the factors influencing biology curriculum implementation. For instance, Scott (1994) points out the limiting factors identified by teachers in implementing the curriculum in the intended ways, as time constraints, lack of resources and facilities, own limited knowledge, pressure of examinations, and bulky syllabus.

2.5.1 Teacher qualification and teaching experience

Some studies have shown that teacher qualification and teaching experience influences the teacher classroom practices. For instance, Lederman (1999) argues that years of teaching experience causes clear differences in terms of classroom practices of teachers, in that teachers with more years of teaching experience exhibited classroom practices consistent with their professed views about the nature of science with varying instructional methods. Similarly, in a study by Shamsudeen (2015) to ascertain teacher factors that influence their ability to conduct practical biology lessons, it was found that teacher qualification and experience affected teachers' ability to use laboratory equipment in biology practical work. It was further shown that teachers with higher qualification such as undergraduate and postgraduate degrees either trained or untrained graduate teachers were good at assembling and handling laboratory equipment for biology practical lessons. The study also showed that teachers that were more experienced assembled and handled laboratory equipment better than those that were less experienced. These findings are remarkable as they show the positive impact of teacher qualification and experience on biology curriculum implementation through conducting of practical lessons. However, the study's only use of a questionnaire for data collection showed a weakness in that the lesson observation could have enhanced its finding. Because of this limitation, the study couldn't fully ascertain the extent to which qualification and experience impacted on actual instructional delivery during the practical lessons. For instance, Ngware, Oketch and Mutisya (2014) explain that the teaching practices are the teacher's observable style of instructional delivery. Nonetheless, my study explored the same variables but triangulated with lesson observation and biology learners' account.

In relation to teacher qualification and student academic performance in science mathematics and technology subjects, Musau and Abere (2015) found that there was no significant difference between teacher qualification and learners' academic performance in science mathematics and technology subjects. The study further revealed that majority of the teachers of science mathematics and technology subjects were trained graduates, most of them had attended in-service or refresher courses which resulted in slight improvement in the students' performance in science mathematics and technology subjects. The teacher qualifications were categorised into Certificate, Diploma holders, trained graduate teachers and untrained graduate teachers and postgraduate teachers. The study used the ex-post-facto survey research design to determine the degree of relationship between the independent variable (teacher qualification) and the dependent variable (learners' academic performance) in science mathematics and technology subjects. This study showed that there was no significant influence of teacher qualification and experience on the learner academic performance. However, this study could not show whether there was a relationship between the teacher qualification and actual teaching and learning of science as it focused on the product rather than the process. The current study sought to examine the relationship between the teacher qualification and experience and the implementation of the biology curriculum.

2.5.2 Teacher classroom practices and curriculum implementation

The teacher classroom practices are mostly observable in the teaching methodologies, lesson time management, assessment of learners, and use of teaching materials and instructional delivery which all may be influenced by CPD activities. Teacher practices involve various methodologies that are applicable to the subject and effective in achieving learning of that subject, for instance Bryan (1948) cited the most possible teaching methods in high school biology as lecture, class discussion, problem solving, demonstration, experiments, field trip/project, research, laboratory work and drill method that encompass rote learning. It must be noted that although the teaching methods have evolved over a period of time, most of the methods cited above are still being used today in implementation of biology curriculum as noted in other studies in science education (Chifwa, 2015; Nghipandulwa, 2012; Nkoya, 2008; Su, Su & Goldstein, 1994).

The lecture method is the most commonly used in secondary school and college, because of its advantages in presenting many ideas in a short time, and ideal for large groups of learners, including assemblies, and also to present utilitarian or basic material. Lectures are usually used to introduce or conclude a lesson but in some cases may serve to introduce teacher demonstrations or laboratory exercises in the biology classroom (Bryan, 1948). On the other hand, Bryan (1948, p 180) observed that drill or rote methods are of value in some phases of biology instruction, in fixing the responses which involve learning processes acquired through repetition and recitations. He further argued regarding the importance of lecture method as follows;

Drill techniques are used to advantage in preparing for objective type tests, achievement tests or examinations. Because achievement tests play on words, frequent drills in biological nomenclature, definitions of scientific terms are worthwhile especially in such topics as cell structure, mitosis, Mendel's law of inheritance, chemistry units, and in classification of plants and animals.

The lecture and drill methods of teaching expounded by Bryan (1948) are a reflection of the schema cognitive learning theory as they both emphasise acquisition of knowledge by activation of schemata and repetitive flow of information (Cakir, 2008).

Methods like field trip, demonstration, experimental and field project are practical and more learner-centred. For instance, CDC (2013) has cited experiments, study tours, field work, group work, individual work and project work as methods that can enhance learning of biology. Regarding field trip method, Bryan (1948) noted that this method can serve as extra-curricular activity in the average high school, and that the school campus or adjacent country may be used by biology classes for tree identification, insect collections, and study of weeds, flowers, seeds and seed pods. He further argued that field trips in biology bring the forest, field, stream, farm, the local health departments, dairies, food packers, and the filtration plant as direct transfer of values to the classroom and laboratory, for discussion and practical applications. Teacher demonstration may help illustrate a concept in biology especially in an environment where the laboratory apparatus is scarce. It serves as an economical measure of conducting an experiment. Experiments on the other hand may have to involve all the learners with apparatus and tasks shared among the learners (Bryan, 1948; Nghipandulwa, 2012; Shumow, Schmidt & Zaleski, 2013).

The practical teaching methods support the socio-constructivist approach of teaching and learning biology. The field trip enables the learners to interact with their surrounding environment thereby providing a linkage between the scientific concepts and their cultural background. Experimental method also promotes collaborative learning among the learners as well as encouraging learner participation during instruction delivery (Duschl, 2008; Matthews, 1993; Matthews, 2002). Although Bryan (1948) reviewed the most important methods of teaching biology, it was not known whether these methods characterised the teacher classroom practices in implementing the biology science curriculum in the upgraded and old established secondary schools.

The choice of teaching methods by the teacher influences the learning style which may either be learner-centred or teacher-centred. For instance, Su, Su, and Goldstein (1994) compared the learning of science in American and Chinese high schools and observed that learning of science was learner-centred in the American schools while it was teacher-centred in Chinese schools. They further noted that the lessons in the Chinese schools were highly characterised by the lecture and drill methods where the teacher was the ultimate source of knowledge and whose content could not be questioned. Drill methods enable learners to memorise the formulae and concepts due to pressure of examinations. This study demonstrates that science knowledge can be acquired effectively in teacher-centred lessons characterised by lecture and drill methods of teaching. The difference in the learning styles in the American and Chinese high schools may be linked to cultural influence. Despite the remarkable findings, their study considered science curricula different from the Zambian biology science curriculum and implemented under a different education system. In addition, the school culture under Zambian education system may be different from that of the American and Chinese schools.

The choice of teaching methods for a particular lesson may be influenced by context. Gercek and Ozcan (2015) conducted a study using qualitative research design to determine biology teacher candidates' view about context based approach and found that learner-centred methods and techniques which are based on the goal of effective learning are commonly used. One of such educational approaches is context based approach towards education. Gercek and Ozcan (2015) also pointed out that research suggests that context based approach, like constructivist approach, is significant for efficient learning. Other findings of the study revealed that context based approach was important in promoting practical learning of biology since it emphasised learning by doing. However, some participants argued that not all topics in biology could be taught using context based method and that the approach required more learning time than the allocated time. This study is important because it shows the importance of context based method of learning biology as a life science subject. However, this study does not show the contexts under which the biology curriculum is implemented in upgraded and old established secondary schools in relation to socio-constructivist theory of learning.

In relation to teacher's teaching styles, Ngware, Oketch and Mutisya (2014) demonstrated that there was a linkage between teacher practices and learner performance achievement in mathematics when they investigated how school achievement was affected by different factors that ranged from teachers, curricula, learners and the school environment. The difference in learner performance in the two sets of schools under consideration were within same location and same qualified teachers from same teacher training institutions was attributed to difference in teaching practices. They further noted that rote learning through recitations in mathematics yielded positive results in terms of learner academic performance. However, this study focused on mathematics (a cognitive science) which is slightly different from biology and in addition, their study evaluated learning at primary level.

Teacher factors are known to influence teaching and learning. For instance, Haambokoma (2007) determined the nature and causes of learning difficulties in genetics in Zambian high schools by using qualitative research approach and found that some of the causes for learning difficulties were teacher based factors such as teachers' inability to explain clearly the concepts of genetics; deliberate omission of the topic by the teachers and poor lesson presentations by the teachers of biology. His findings further indicated that most teachers skipped the topic on genetics because they were not trained in genetics and therefore lacked subject content. The study however shows limitation in that its main consideration was genetics alone which is a single section in the biology science curriculum. Therefore some of the findings may not be generalised to the other topics covered in the biology curriculum. Additionally, the study does not show how biology science curriculum is implemented in the upgraded and old established secondary schools.

With respect to learning of science in Zambia, Nkoya (2008) investigated the use of learner-centred strategies by chemistry teachers and found out that teachers employed some of the learner-centred strategies despite the over enrolled chemistry classes and shortage of teaching and learning materials. He further observed that the teachers used methods such as project, laboratory work, question and answer, problem solving, class discussion and demonstrations to promote learner-centred lessons. He however, argued that teacher qualification and teaching experience were some constraints to the effective use of learner-centred strategies. As found by Nkoya (2008) use of the question and answer method enhances learners' active participation in the lessons while class discussions also promotes collaborative learning among the learners which both in turn promote constructivist approach of teaching and learning science. Nkoya's study was key in assessing whether biology curriculum implementation is characterised by learner-centred lessons in that his study was conducted in urban secondary schools which may have similar teacher characteristics to those of the schools sampled by my study.

The teaching methods used by teachers in implementing the biology science curriculum may have a bearing on attainment of the science process skills. The science process skills help to measure the learning objectives as well as enhancing knowledge acquisition in science (CDC, 2013). Constructivist based teaching methods are known to enhance attainment of most of the science process skills. For instance, Martin, Jean-Sigur and Schmidt (2005) observed that those basic science process skills such as observing; classifying; communicating; measuring; predicting; inferring; and integrated science process skills such as identifying; hypothesis testing; interpreting data; defining operationally; and experimenting can be achieved with teachers' strategies of observing learner activities, asking them questions and allowing them to enact the science lessons. It can be inferred from their study that teaching methods like question and answer, experiment; demonstration are vital in the realisation of science process skills during teaching and learning of biology.

The teaching and learning materials can influence the teacher classroom practices as earlier discussed in the previous section on teaching and learning materials. Chifwa (2015) found that the teaching practices in genetics was characterised by poor lesson presentation, limited use of teaching aids and lack of practical learning activities which were in turn attributed to the scarcity of the teaching and learning materials and poor lesson planning. Although Haambokoma *et al*. (2002) observed that most Zambian secondary schools lacked the teaching and learning materials, they argued that improvisation of materials by the teachers was inevitable. The two studies highlighted here do not show the distribution of the teaching and learning materials in upgraded and old established secondary schools and how that influences the implementation of the biology science curriculum. Chifwa's study focused on the single topic of genetics which may not be representative of other topics of the curriculum especially those that are not of abstract nature. In addition, Mansour (2013) noted that the availability of teaching materials impacted on teacher classroom practices by influencing the choice of teaching methodology as most of the teachers in Egyptian schools claimed to have used the lecture method to teach science due to the schools' poor culture of providing the teaching materials. In most cases teachers are forced to use lecture method and demonstration to economise the scarce teaching and learning materials as noted by Bryan (1948).

Conducting practical work in biology is one of the key teacher classroom practices as it has been argued that practical work promotes learning of science by the socio-constructivism (Matthews, 2002; Tsaparlis, 2001). However Mudenda (2008) and Changwe (2008) observed from their independent studies that science lessons were characterised by lack of practical work. Changwe (2008) further observed from her study that science teachers had a culture of not conducting practical lessons in science even if the materials were available. The limitation to Changwe's findings is that practical activity was restricted to use of experiment methodology. In addition, Mudenda (2008) noted that the few practical activities conducted during curriculum implementation lacked learner assessment schemes of the particular work and that the lack of practical activities during biology curriculum implementation resulted in learner difficulties during the grade 12 practical examinations. Science process skills are known to be acquired mostly through practical activities but with the lack of practical lessons the attainment of such skills in biology may be difficult.

In another study by Nghipandulwa (2012), it was also found that teachers had a poor culture of not conducting practical lessons in biology. Even with the few observed lessons characterised by practical lessons, the learners were not assessed by the teachers to measure the extent of learning. Her study is important as it established the poor teacher culture in relation to conducting of practical lessons in biology.

Teachers' conducting of practical learning activities in biology can be supplemented by the efforts of the laboratory assistants (Manda, 2012; Nghipandulwa, 2012). The laboratory assistants can help in the sourcing of the teaching and learning materials, assembling of the apparatus on behalf of the teacher which may serve on time constraint and overload on the teacher. Therefore laboratory assistants can improve implementation of biology science curriculum by helping learners conduct and monitor experiments (Manda, 2012). Hummer (1966) observed that learners of biology could be utilized as laboratory assistants to enhance their laboratory skills. This can help promote effective learning of biology as the learners can actively participate in the learning process.

2.5.3 School based CPD activities

Continuing professional development (CPD) for teachers has been cited as one of the factors that influences the curriculum implementation in the secondary schools (MESVTEE, 2013). CPD activities may involve collaborative lesson planning, review of some challenging topics and generation of teaching and learning materials among the teachers. For instance, Chifwa (2015) observed that challenges associated with teaching difficult topics on genetics could be alleviated through CPD activities. In a study conducted by Baba and Nakai (2011), it was found that the lesson study practice in the Zambian schools had a positive impact on science curriculum implementation in that there was improved lesson planning and delivery on the part of the teachers and that there was increased promotion of learner-centred science lessons. However, this study focused on science in general as opposed to specifically biology. My study looked at the CPD variable to examine how it impacted on teacher practices.

2.6 Chapter summary

In summary, literature has been reviewed on the school infrastructure and learning; teaching and learning materials; and the teacher classroom practices. Most studies show how school infrastructure impact on learner academic performance while a few show its effect on the teaching and learning of science in general. Studies on teaching and learning resources show the impact of the resources on curriculum implementation while studies on classroom practices showed that teaching methods influenced teaching practices and that most of the biology teachers do not conduct practical lessons. Knowledge gaps were identified owing to research methodologies (lack of triangulation); inability to show how particular variables impact on the actual biology curriculum implementation and lack of studies to show how schools with a perceived school infrastructure difference implement the Zambian biology science curriculum. None of the studies reviewed looked specifically at the implantation of the biology curriculum in Zambia. Therefore, my study focused on investigating whether there was a significant difference in the implementation of biology curriculum between upgraded and old established secondary schools by considering school factors namely; school infrastructure; teaching and learning materials; and teacher classroom practices.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter outlines how the study on the implementation of the biology curriculum in the upgraded and old established secondary schools was carried out. The outline of the research methodology looks at the research approach and method; study population; study sample; sampling techniques; study site; instruments of data collection and data collection procedure; instruments of data analysis and data analysis procedures; and reliability measures.

3.1 Research approach and methodology

This study was situated in the mixed research paradigm of both the Quantitative and Qualitative approaches. This approach is known to yield results of the study that are more elaborate and provides more complete explanation to the research problem than either of the two separate methods would provide (Ary, Jacobs & Razavieh, 2009). This approach was used based on triangulation and complementarity purposes. In terms of triangulation, data collected by one method was checked by the other method. In this study, qualitative data helped in complementing quantitative data especially data that could not be collected by quantitative methods. Ary, Jacobs and Razavieh (2009, p. 562) argue that 'triangulation seeks to examine the convergence of evidence from different methods that study the same phenomenon or to corroborate findings from one method by examining the findings using a different method'.

The concurrent embedded method of the mixed research approach was used in this study, as it allows for data from the qualitative method to complement data collected from quantitative method and vice-versa. This method also allows analysis of data from the two separate methods together (Ary, Jacobs & Razavieh, 2009; Creswell, 2009). The technique used was a descriptive survey design of the cross sectional survey type (Cohen, Manion, & Morrison, 2007). Descriptive survey was chosen for this study as it is concerned with phenomena that are typical of the normal conditions. For instance, Sidhu (2006) explains that a descriptive survey investigates the conditions or relationships that exist, practices that prevail, beliefs, points of view or attitudes that are held, processes that are going on, influences that are being felt and trends that are developing.

3.2 Target population

The study targeted a population of government secondary schools (Non-grant aided) of Ndola district, senior secondary school biology learners and teachers of biology. The targeted schools were day secondary schools with a mixed enrolment of both male and female learners.

3.3 Study site

The study site was Ndola district of the Copperbelt province of Zambia. The district has a total of 14 secondary schools, of which 8 are upgraded secondary schools. Two of the upgraded secondary schools are within military confinement and are grant aided. The old established secondary schools consist of six schools of which two are grant aided girls' secondary schools. One pair (UP1 & OL2) of the sampled schools are located in the southern part of the district, the second pair (UP3 & OL4) is located in the western part of the district, and the third pair (UP5 & OL6) in the northern part of the district.

3.4 Sample size and sampling techniques

Six secondary schools were purposively sampled from the target population in pairs (three upgraded and three old established secondary schools) to control for social economic factors of the target biology learners as the sampled secondary schools were assumed to draw learners from similar or same social background community. According to Ary, Jacobs and Razavieh (2009, p. 156) 'purposive sampling involves sample elements judged to be typical or representative that are chosen from the population'. The sampled secondary schools were deemed by the researcher as representative of the secondary schools in Ndola district. All the biology teachers from each of the sampled secondary schools were purposively sampled as the key implementers of the biology curriculum. In effect, respondents are selected with a specific purpose in mind, and that purpose reflects the particular qualities of the people or events chosen and their relevance to the topic of the investigation (Denscombe, 2003). From the target population of biology teachers, one teacher taking grade 11 or 12 classes was sampled using stratified random sampling method for the purpose of lesson observations in biology. This was done in order to remove biasness in the selection of the teacher for purpose of biology lesson observation. When the population consists of a number of subgroups, or strata that may differ in the characteristics being studied, it is often desirable to use a form of probability sampling called stratified random sampling (Ary, Jacobs & Razavieh, 2009).

The grade 11 biology learners were sampled using simple random sampling where each of the learners was assigned a number. Random numbers were then generated using a scientific calculator and those learners whose assigned numbers corresponded with the random numbers were sampled. This was significant because every grade 11 biology learner stood a chance of being sampled and that the sampled population was representative of the target population (Ary, Jacobs & Razavieh, 2009; Berg, 2001). With school enrolment assumed to stand at fifty (50) learners per class with five streams of grade 11 classes per school (MESVTEE, 2013), the target population from the six sampled schools was 1500 learners. At 95% confidence level with a marginal error of 5%, the sampled population of grade 11 biology learners was 626 learners as reflected in the statistical sampling table in Cohen, Manion and Morrison (2007).

3.5 Data collection instruments and procedure

The data collection instruments included the School Infrastructure and Materials Checklist (SIMC), Biology Learners' Survey Questionnaire (BLSQ), Biology Lesson Observation Schedule (BLOS), structured interview schedule, document analysis and Biology Curriculum Evaluation Questionnaire (BCEQ). SIMC was used to assess the nature and availability of school infrastructure and teaching materials respectively that are necessary for biology curriculum implementation. This followed the qualitative method of data collection; the researcher physically inspected the infrastructure and materials in the sampled schools. The BLSQ was self-administered to the sampled biology learners to assess the teaching and learning of biology owing to school infrastructure, teaching and learning materials as well as teaching practices of the biology teachers. The BLOS was used to assess teacher practices in implementing the biology curriculum. The lesson observations took the nature of non-participant and uncontrolled but structured lesson observation. The sampled teachers were observed at least in three different lessons to increase reliability of results. In terms of document analysis, biology final examination performance records for a consecutive period of 6 years (from 2011-2016) for the two sets of secondary schools was obtained from the Examinations Council of Zambia (ECZ). BCEQ was used to assess the biology curriculum implementation for all the research objectives of this study. The BCEQ consisted of both open and closed ended questions. A structured face to face interview was conducted with the staff from the Directorate of Curriculum and Standards in the MoGE as a secondary data source on the upgraded secondary schools.

Permission to conduct research in the selected secondary schools was sought from the Provincial Education Officer (PEO) of the Copperbelt Province under the MoGE. Data collection took place in the third term of the Zambian secondary school calendar of the year 2016 and the first term of 2017 school calendar year. The SIMC was used on the first visit of data collection to the selected secondary schools and further verified with the last visit of data collection to increase reliability of results. The BLSQ was distributed across the selected schools simultaneously and alongside the BCEQ and collected within ten working days. Biology lesson observations for the sampled teachers were conducted over a period of seven weeks from the commencement of the first term of 2017 school calendar.

3.6 Data Analysis

Thematic categories for commonalities was used and coding established for the qualitative data from BLOS, SMIC and responses from open ended questions of the BCEQ. Some of the data collected by qualitative method was converted into descriptive statistics and analysed together with the quantitative data in order to answer questions on the implementation of biology curriculum. Qualitative data from the structured interview was transcribed and analysed according to established themes. Both descriptive and inferential statistics were used to analyse the quantitative data from BLSQ and BCEQ. The statistics on learner academic performance from ECZ were analysed for any statistical significant differences among the sampled secondary schools using the analysis of variance (ANOVA). Both qualitative and quantitative data was analysed concurrently. Other inferential statistical methods used included the Chi-square, correlation and binomial tests. However, the raw statistical output of the statistical package for social sciences (SPSS) was not indicated but only the main statistics. The descriptive statistics was displayed inform of tables, graphs and pie charts.

3.7 Reliability and Validity measures

To promote reliability, BLOS was administered at least three times on the sampled teachers. The BLSQ internal consistency was checked by building some redundancy into the instrument such that items on the same topic were rephrased and repeated in the questionnaire to increase reliability. In order to validate the instruments, a pilot survey was conducted in a set of upgraded and old established secondary schools with similar characteristics to those of the sampled secondary schools. The survey instruments were also validated by subjecting them to expert judgement (Ary, Jacobs & Razavieh, 2009; Creswell, 2009).

CHAPTER FOUR

PRESENTATION OF THE FINDINGS

This chapter presents the findings of the study according to the research questions.

4.1 Findings to the first research question

The research question was to find out the nature of school infrastructure in the two sets of schools in relation to implementation of the biology curriculum. To answer this question, survey findings on the availability and the state of the key school facilities as well as their possible effect on the implementation of the biology curriculum are presented in the subsequent sections.

4.1.1 Survey findings on the availability and state of school infrastructure

A survey of the key school infrastructure namely science laboratories, school hall, school staffroom, computer laboratory and science departmental office showed the following:

Table 4.1 Distribution of Science laboratories by category of secondary school

Secondary school	**UP1**	**OL2**	**UP3**	**OL4**	**UP5**	**OL6**
Number of laboratory rooms present	3	3	2	1	2	3

The data above was generated using SIMC. In the category of old established secondary schools, OL4 only had a single laboratory as the other two laboratories had their inner structures raised down and converted to conventional classrooms. It was not clear however what science subject was designated for the only existing science laboratory. During field visits, all the science laboratories in the old established secondary schools were not used as conventional classrooms. In the category of upgraded secondary schools, UP1 had three laboratory rooms while UP3 and UP5 had two laboratory rooms each. The laboratories in the upgraded secondary schools were used as conventional classrooms at the time of the field visit.

Further assessment of the state of the key school physical facilities using SIMC yielded the following data as presented in Table 4.2.

Table 4.2 Availability and state of key school physical facilities

State of school infrastructure	Secondary school					
	UP1	**OL2**	**UP3**	**OL4**	**UP5**	**OL6**
School hall	NE	VG	NE	VG	NE	VG
School staffroom	S	VG	D	VG	S	VG
Computer laboratory	S	S	S	S	S	S
Science departmental office	D	VG	S	S	D	VG
Biology laboratory	D	VG	D	NE	D	S

Key: [NE-Non-existent]; [D-Dilapidated]; [S-Satisfactory]; [VG-Very good]

From Table 4.2, it can be seen that none of the upgraded secondary schools had a school hall. On the other hand, both sets of schools exhibited the same state of the computer laboratory with no significant difference. The score for biology laboratory in OL4 shows non-existent. The state of the staffroom was very good in the old established secondary schools while in the upgraded secondary schools, the state varied from dilapidated to satisfactory.

The survey of the biology laboratory measured by BLSQ showed the following frequencies regarding the laboratory usage other than for learning of biology.

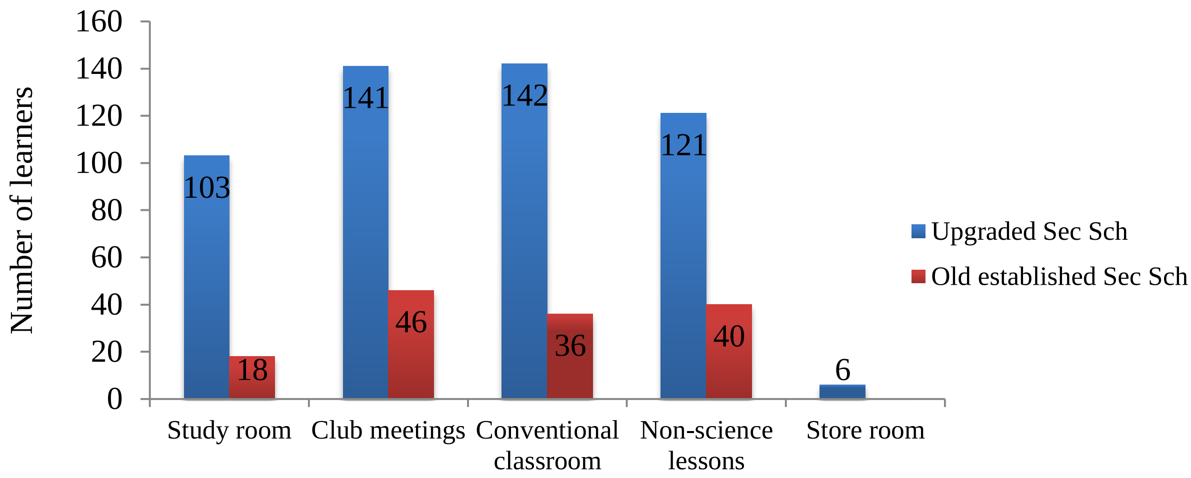

Figure 4.1 Learners' responses on other uses of biology laboratory

From Figure 4.1, it can be seen that upgraded secondary schools had the biology laboratory used for purposes other than for the learning of biology than the old established secondary schools. In addition, analysis of the number of learners that indicated either yes or no to the biology laboratory serving other purposes other than learning of biology showed a significant difference between upgraded and old established secondary schools at p=0.05, df =4, n=626 and calculated x^2= 83.23. The difference was statistically significant at calculated p (0.00) <0.05 as shown in Table 4.1.2.

Table 4.3 Chi-square test of school type against other purposes of biology laboratory

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	83.295[a]	4	.000
N of Valid Cases	626		

The teachers were also asked if the biology laboratory in their school served any other purpose and the findings in Figure 4.1.2b showed that the upgraded secondary schools had their biology laboratories used for non-science based lessons and as conventional classroom having the highest scores respectively.

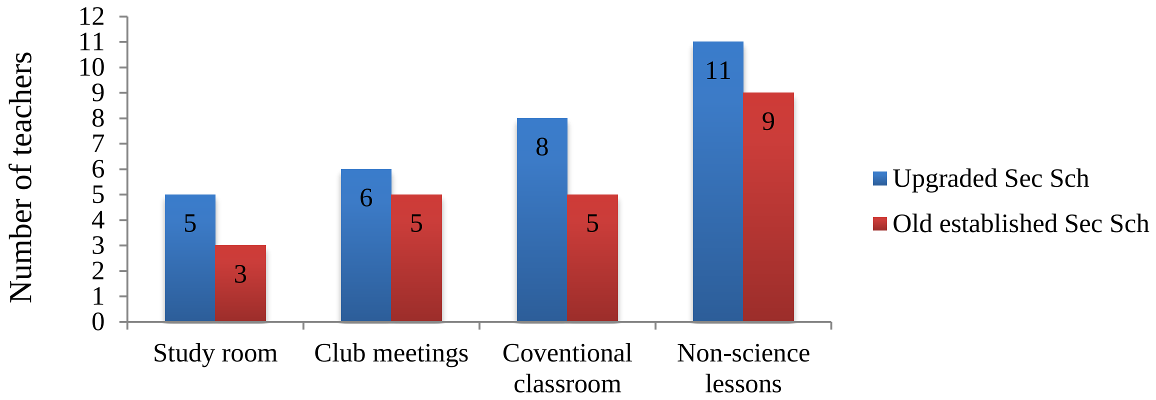

Figure 4.2 Teachers' responses on other uses of biology laboratory

It can be seen from Figure 4.2 that in both sets of schools, usage of the biology laboratories for non-science based lessons was prevalent. The use of the biology laboratories as a study room by learners was least in both school types.

Teachers were further asked to assess the state of the biology laboratory in their school and findings from BCEQ indicated that one teacher from UP1 and OL4 respectively labelled the laboratory as very dilapidated. Assessment of the biology laboratory further showed a score of very good in UP1, OL2 and OL6; although in UP1 the score of very good was repealed by the very dilapidated score since the scores were of equal strength. The frequencies are shown in Figure 4.3.

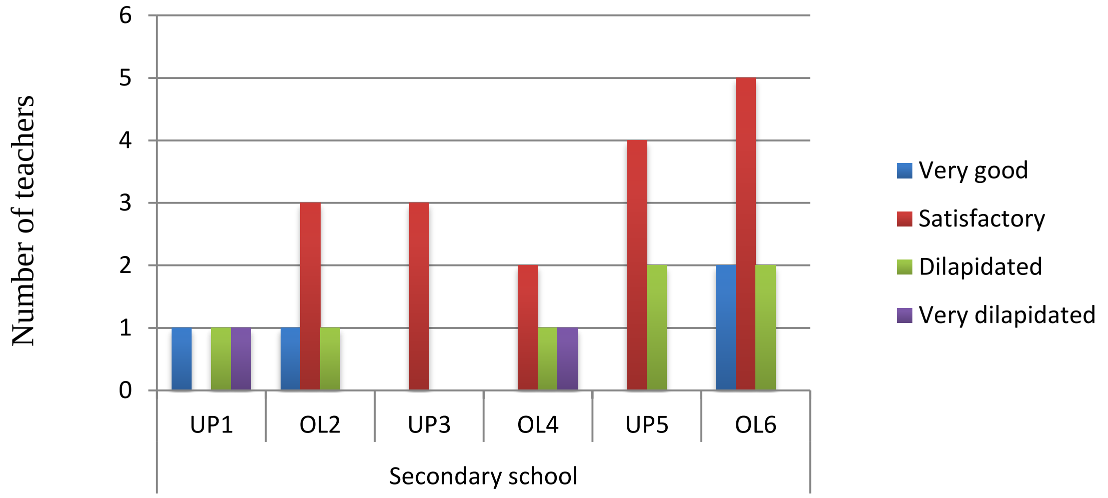

Figure: 4.3 Teachers' assessment of the state of school biology laboratory

When the learners were asked as to whether their school had a laboratory designated specifically for learning of biology, the following data were made as shown in Figure 4.4.

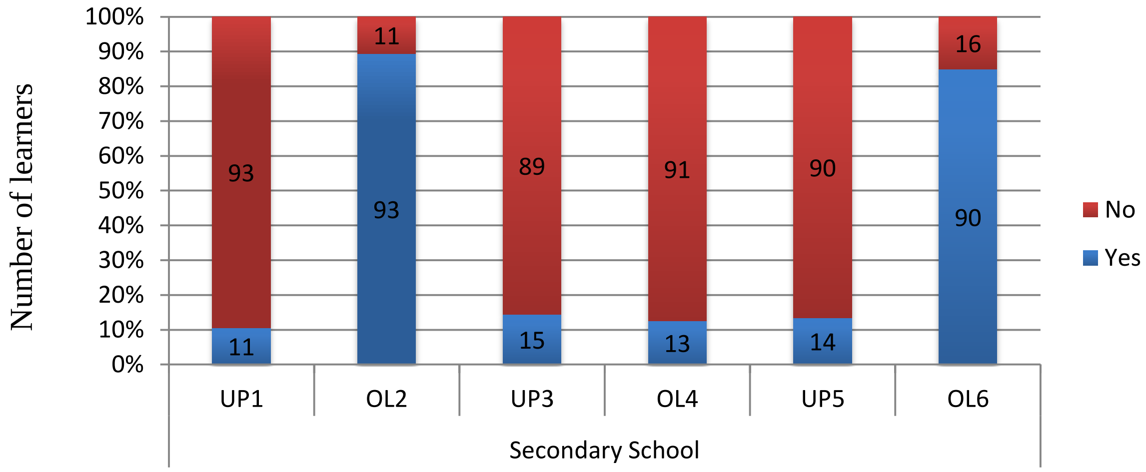

Figure 4.4 Frequencies of the availability of school biology laboratory

Data from the figure 4.4 indicate that UP1 and OL2; UP5 and OL6 recorded a significant difference in responses regarding the presence of the biology laboratory. The scores were the opposite of each other in the four schools respectively. However, scores between UP3 and

OL4 were tied in a 1:1 ratio of learners that indicated presence of a biology laboratory in their school.

Other observation of the SIMC indicated that none of the upgraded secondary schools had a science preparation room while all old established secondary schools had science preparation rooms. Physical inspection of the science laboratories showed presence of mobile laboratory units in UP5; however, the mobile laboratory units were stacked together with most of them having fallen apart. The findings on the general school environment measured by SIMC were as follows (as per secondary school category):

Upgraded secondary schools

In UP1, the science department office served as a school Tuckshop and could only accommodate the Head of department. Laboratory rooms were observed to store construction materials that were irrelevant to the learning of science. The school space was large with enough vegetation.

In UP3, the science departmental office was not large enough to accommodate all department teaching staff. The school space was limited with little vegetation. The school staffroom had inadequate space and furniture.

In UP5, the science departmental office was small and could only accommodate the Head of department. The department had a storage room for laboratory materials. The school space was limited with little vegetation. The school staffroom showed inadequate space and furniture.

Old established secondary schools

In OL2, the science departmental office was large enough to accommodate department staff. The school space was large enough with plenty of vegetation. The school had a school library for learners. Vegetation was a possible source of biology specimens of the plantae nature.

In OL4, the science departmental office was small and could only accommodate the Head of department. The science preparation room was large enough and accommodated the laboratory assistant and most of science apparatus. The school staffroom was large enough with adequate furniture.

In OL6**,** the science departmental office was small and could only accommodate the Head of department. However, the department had a large work room. A well spacious and stocked science preparation room was observed. None of the science laboratories was used as conventional classroom, however, a small number of teachers were observed preparing their lessons from the free laboratory rooms. The school staffroom was large enough with adequate furniture.

It can be seen from the above findings that there was a difference in the general school environment between the two sets of schools in that all the upgraded secondary schools had their laboratory rooms used as conventional classrooms and science department infrastructure was poor than in old established secondary schools.

4.1.2 Effect of school infrastructure on biology curriculum implementation

The adequacy and state of school infrastructure showed influence on the process of teaching and learning biology as indicated by the following findings. For instance, when the learners were asked to evaluate their teachers' use of the biology laboratory for the lessons, the following frequencies of learner responses were noted as shown in Figure 4.5.

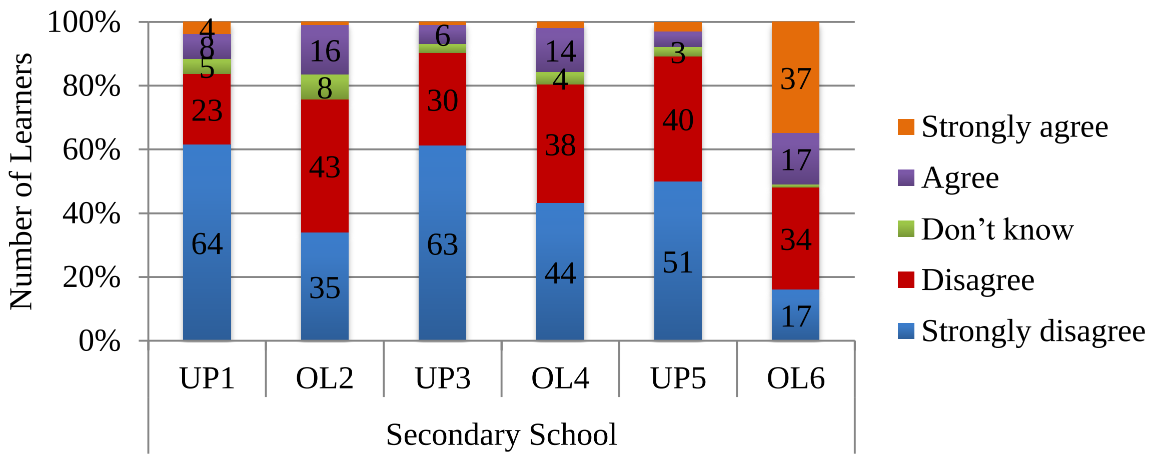

Figure 4.5 learners' evaluation of teachers' usage of the laboratory for biology lessons

In terms of those who strongly disagreed from UP1, OL2, UP3, OL4, UP5 and OL6 were distributed as 62%, 34%, 61%, 42%, 49% and 16% respectively. It can also be seen from the graph that most of learners that agreed to their teacher conducting lessons from the laboratory were more in Old established schools than Upgraded secondary schools, although the difference in frequencies between UP5 and OL6 is not large. Teachers also indicated the effect of the state of the school staffroom on their ability to prepare work such as lesson planning and marking of learner assessment tasks as shown in Figure 4.6.

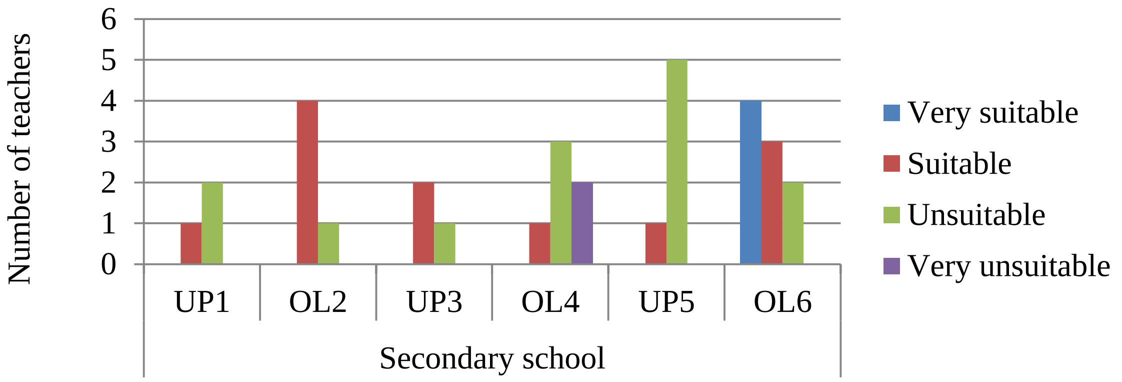

Figure 4.6 Teachers' assessment of the suitability of staffroom to support their work

It can be observed from Figure 4.1.4b that OL6 recorded the highest score of very suitable staffroom while UP5 recorded highest unsuitable staffroom. OL2 recorded highest score of suitable staffroom. Most teachers from OL4 ranked their staffroom as unsuitable and very unsuitable. The findings on OL4 are inconsistent with the findings from the SIMC where the staffroom was found to be very good. When teachers were asked to evaluate whether school infrastructure impacted negatively on their lesson delivery in biology, findings indicated many teachers from the upgraded secondary schools agreed while those from old established secondary schools disagreed with the exception of OL4.

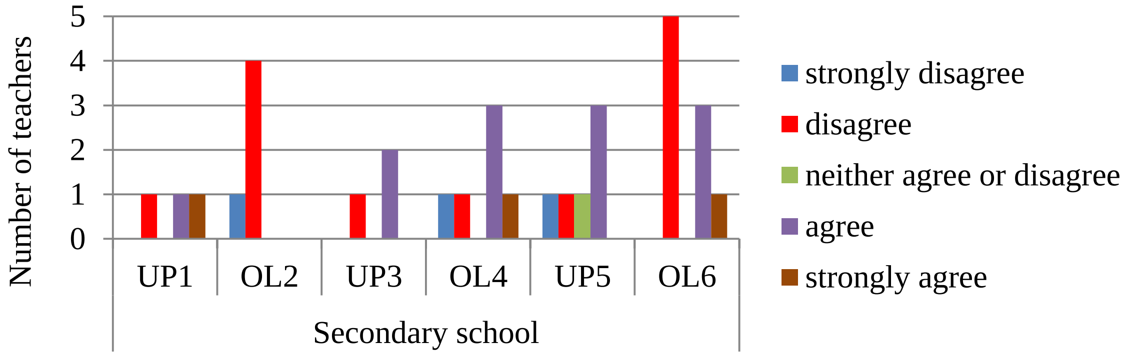

Figure 4.7 Frequencies of negative impact of school infrastructure on lesson delivery

From Figure 4.7, two teachers from UP1 agreed with the assumption that school infrastructure impacted negatively on lesson delivery. OL4 and OL6 recorded one teacher in each case having strongly agreed that their school infrastructure negatively impacted on their delivery of lessons.

However, when the teachers were asked to assess the positive influence of teachers' respective school infrastructure on their lesson delivery in biology, UP1 recorded all staff having disagreed with two disagreeing while one strongly disagreed. OL2 had 100% of the teaching staff having agreed with the assumption. UP3 and OL4 recorded three and two of the staff, respectively having disagreed with the assumption; in addition, two of the teachers from OL4 strongly disagreed.

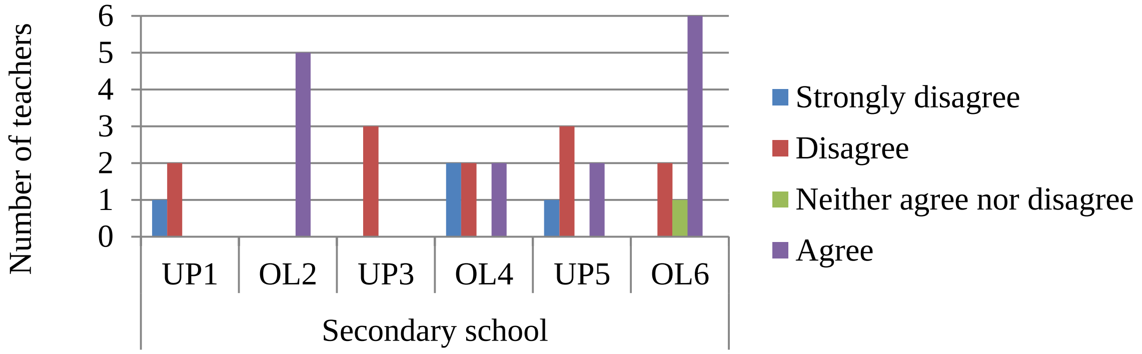

Figure 4.8 Frequencies of positive effect of school infrastructure on lesson delivery

The data from the two graphs (Figures 4.7 and 4.8) show that the school infrastructure influenced curriculum implementation through the delivery of lessons. It can be further observed that school infrastructure in the upgraded secondary schools negatively affected biology lesson delivery while school infrastructure of the old established secondary schools with the exception of OL4 promoted biology lesson delivery. This data also show consistency in the respondents' evaluation of the effect of school infrastructure.

On the other hand, teachers of biology also expressed their opinion on the effect of school infrastructure on learners' performance in the final examinations as follows;

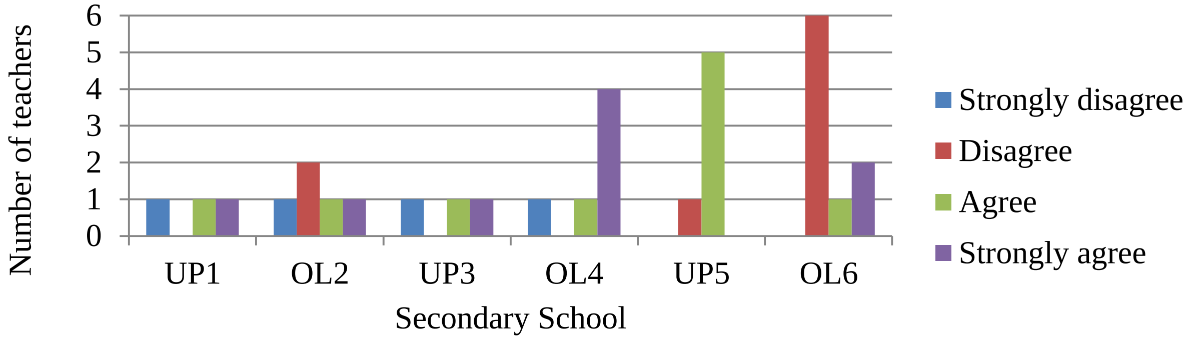

Figure 4.9 Frequencies of the effect of school infrastructure on learner performance in final examinations

The findings indicated that most teachers from OL2 and OL6 disagreed while most teachers from UP5 and OL4 agreed that school infrastructure had an effect on the academic performance of learners. UP1 and UP3 showed two against one of the teachers having agreed to the assumption as presented in Figure 4.9.

The teachers' assessment of the effect of school infrastructure on the performance of learners in the grade 12 biology final examination was cross checked with document analysis of the ECZ performance scores in biology. The data is indicated in the Figures 4.10 – 4.14.

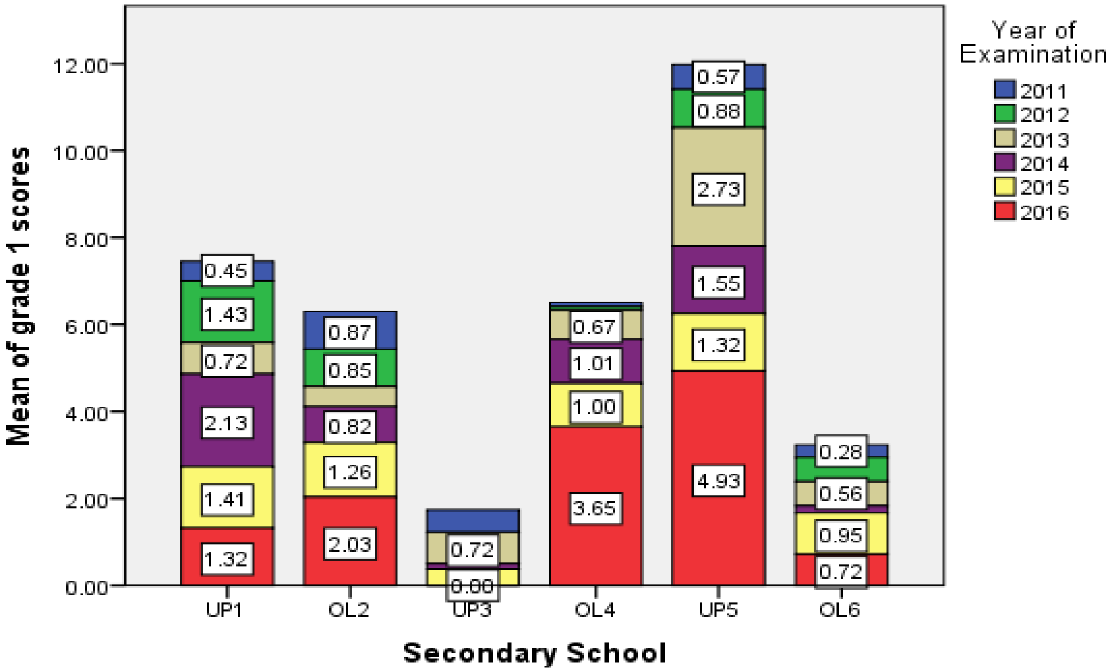

Figure 4.10 Mean of percentage distribution of grade one scores in biology final examination

Analysis of learner performance in biology from Figure 4.10 shows UP1 with a larger mean of grade one scores over OL2, UP5 equally shows a larger mean over OL6. However, the trend is reversed between UP3 and OL4. It is also worth noting that performance in grade one scores of UP1 had been increasing from the year 2011-2015 until 2016 when the performance dropped from 1.41 percent to 1.32 percent. However, the performance trend of OL2 was inconsistent. Performance trend for OL4 was consistently improving from the year 2011-2016 while in UP3 the performance was inconsistent with a record of 0 percent in the years 2012 and 2016. Performance trend for UP5 increased from the year 2011-2013 while dropping in the years 2014 and 2015, although the performance increased again in the year 2016. OL6 recorded a decline in the year 2016. In terms of the grade one performance percentage mean scores, the schools were ranked in the following descending order; UP5; UP1; OL4; OL2; OL6 and UP3. And when performance was analysed from the year 2016 in which the survey was conducted, the schools were ranked in the following descending order; UP5; OL4; OL2; UP1; OL6 and UP3. The two rankings show a difference, although the first and last schools are the same in both ranks.

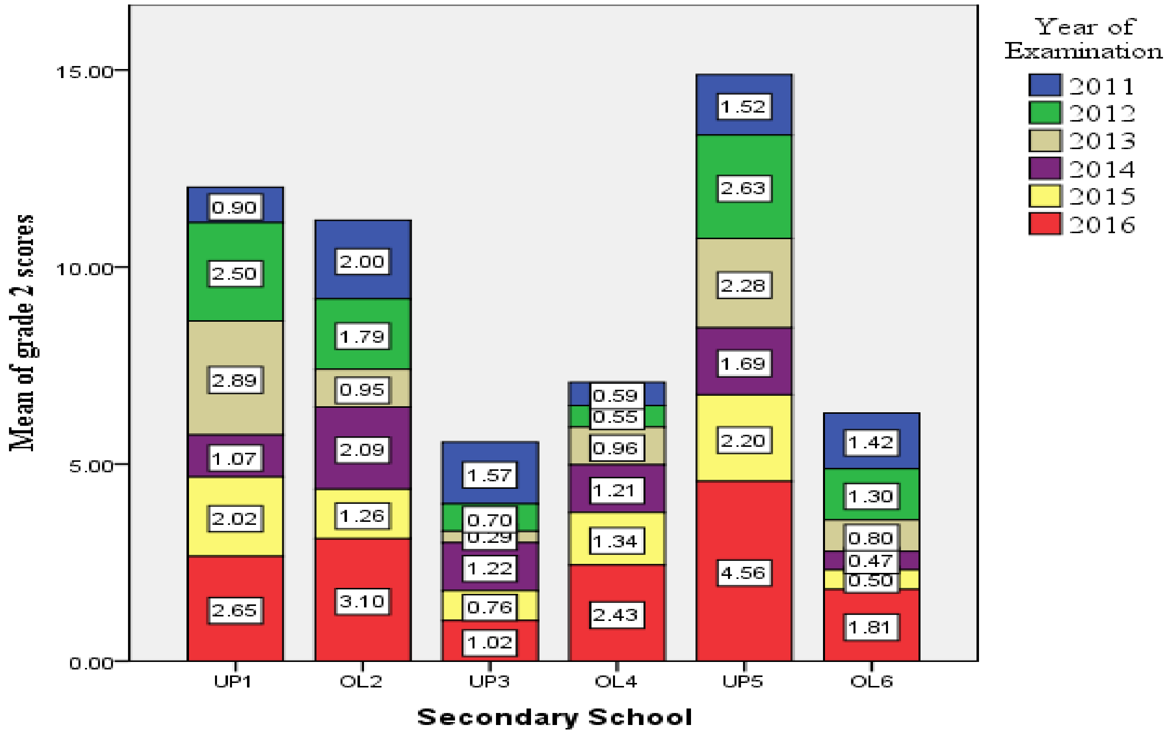

Figure 4.11 Mean of percentage distribution of grade two scores in biology final examination

Figure 4.11 shows the performance in grade two scores which is also classified as distinction, the performance trend in terms of the mean scores for the period of six years was similar to grade one score distribution with UP1 and UP5 showing larger means over OL2 and OL6 respectively. OL4 showed a larger mean score over UP3. Score percentages varied from year to year for each of the schools. The schools were ranked based on the score means in the following descending order; UP5; UP1; OL2; OL4; OL6 and UP3, while based on the year 2016 performance, the ranking was as follows; UP5; OL2; UP1; OL4; OL6 and UP3.

Analysis of the data in Figure 4.12 shows a similar performance trend of the mean distribution of percentage scores of grade one. The performance varied from year to year for each particular school. The schools were ranked in the following descending order; UP5; UP1; OL2; OL4; UP3; OL6 in terms of the grade three score means; and OL2; UP5; OL4; UP1; OL6; UP3 based on performance of year 2016 respectively.

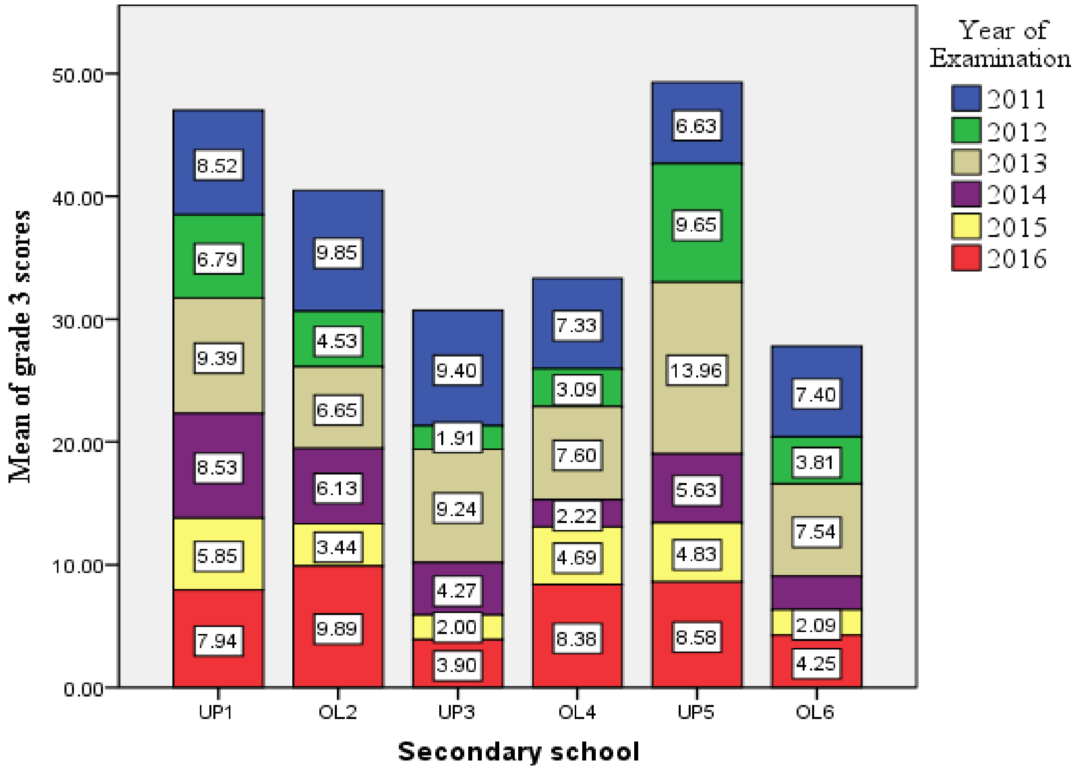

Figure 4.12 Mean of percentage distribution of grade three scores in biology final examination

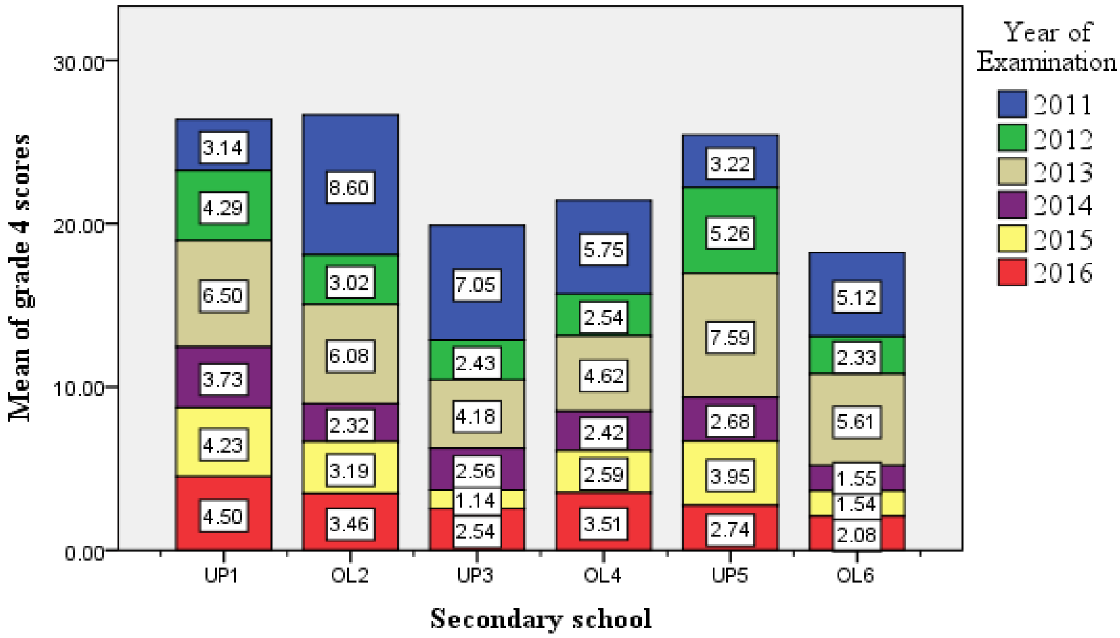

Figure 4.13 Mean of percentage distribution of grade four scores in biology final examination

Figure 4.13 also shows a slightly different distribution of the mean scores of grade four for the secondary schools, with the mean scores of OL2 greater than that of UP1 while for UP3 and OL4; UP5 and OL6 the performance trend was maintained as in the previous grade scores. Based on the six years mean scores and year 2016 performance, the school rankings in descending order were OL2; UP1; UP5; OL4; UP3; OL6; and UP1; OL4; OL2; UP5; UP3; OL6 respectively as shown in Figure 4.13.

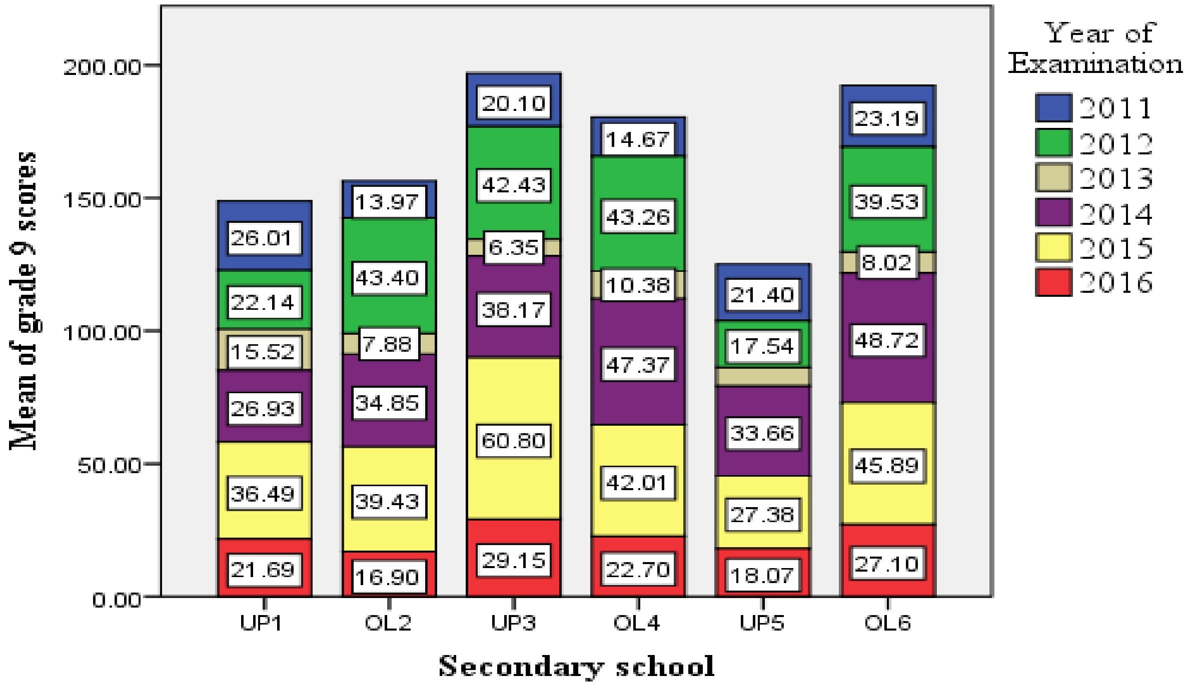

Figure 4.14 Mean of percentage distribution of grade nine scores in biology final examination

Analysis of the data in Figure 4.14 of the grade nine scores shows a reverse trend in terms of the score mean distribution, where OL2; UP3 and OL6 had greater percentage mean scores over UP1; OL4 and UP5 respectively. It can also be noted that learner performance with grade nine score varied from year to year in each school, therefore, no school showed a consistent trend in the grade nine scores over the period of six years. The grade nine score is significant as it represents the population of the learners that failed the biology final examinations. Analysis of grades seven and eight scores has been skipped as they represent the population of learners that merely attained the satisfactory score which is mainly not considered for admission in most of the Zambian tertiary institutions. Ranking the schools in descending order based on the six years score mean and year 2016 performance were UP3; OL6; OL4; OL2; UP1; UP5; and UP3; OL4; OL6; UP1; UP5; OL2 respectively. This implies that UP3 recorded the highest failure rate over the six years of biology examination as well as in the 2016 examination exclusively.

Although the data in Figures 4.10 to 4.14 show a difference in the academic performance of learners, it does not show whether there is a significant statistical difference between the two categories of secondary schools or not. Therefore, analysis of variance (ANOVA) was carried out on the academic performance data.

The test of homogeneity of variance for the two groups of secondary schools using the Levene's test, with df =1 and P =.05, showed no violation of homogeneity of variance of data since all the calculated significance (P) values for all the biology mean scores was greater than 0.05.

Analysis of variance of the mean scores distribution between the two categories at P=.05, N=36 and df=1 showed no significant difference in the means of percentage performance of learners in the final biology examinations as all the calculated P values (ranging from 0.14-0.94) were greater than the statistical P value of 0.05. Therefore, the performance trend observed in the two groups of secondary schools cannot be used to predict future learner academic performance.

In an effort to assess the effect of school infrastructure on biology curriculum implementation, teachers where asked to give a percentage estimate of how much their school environment promoted their effective teaching of biology as prescribed in the curriculum and the following findings in Table 4.1.3 where it can be noted that teacher responses from old established secondary schools with an exception of OL4 had better school infrastructure in supporting the teaching and learning of biology than the upgraded secondary. The findings are consistent with SIMC data.

Table 4.4 Teachers' assessment of school environment's effect on biology curriculum implementation

School	Estimated (%)	Teacher's explanation for the given percentage estimate
OL2	70	The laboratories are there and the materials are provided.
OL2	60	The school has a library which is well equipped with biology textbooks for pupils to use during studying.
OL4	20	There are no laboratories in which practicals are supposed to be conducted.
OL6	50	The use of the biology laboratory as a conventional classroom makes it difficult to prepare and conduct biology practical lessons.
OL6	60	There is availability of vegetation for field work studies.
UP1	40	No enough classrooms so the laboratories are used for other lessons other than science. In the laboratories there is no water and the sinks do not work.
UP5	40	The biology laboratory is used as a conventional classroom hence the class that is not in the laboratory would waste time to move to the laboratory for practical lessons. It takes a lot of time to move apparatus to go and perform a practical lesson in the conventional classroom.
UP5	30	Lack of room to prepare and conduct demonstrations and experiments in biology lessons.

4.1.3 Teacher recommendations on effective curriculum implementation in relation to school infrastructure

The following were some of the teachers' responses on how biology curriculum implementation can be effective.

From OL4;

> *School managers should ensure that schools have chemistry, physics and biology laboratories unlike the current situation of having only one laboratory; the school infrastructure should be improved to enhance effective teaching and conducting of practicals.*

From UP5;

The implementation of the biology curriculum can be effective if the laboratory is well equipped and is not used as a conventional classroom; More laboratories specific for learning biology should be constructed; Laboratories should not be used as base rooms for non-science lessons; The implementation of the biology curriculum can be effective if the laboratory is well equipped and is not used as a base room for a grade class.

4.1.4 Findings from the interview in relation to school infrastructure

When the MoGE official was asked what steps the Ministry had taken to address the challenges of lack of necessary infrastructure such as laboratories and laboratory equipment and adequate classroom space with respect to science education as highlighted by the Parliamentary committee report of 2013, the response was;

Yeah I think there about a number of steps but I will mention a few, construction of laboratories in these schools these newly upgraded schools which didn't have science laboratories and I think a number of them were constructed without science laboratories and we have also distributed science mobile labs in most of these schools and the other things we have procured are science equipment especially in 22 newly upgraded schools in each province.

However, when asked as to whether there had been any follow up to check if the distributed mobile laboratories were being used as intended by the beneficiary schools, the following response was given;

We have made follow-ups through inspection by standards officers, though they cannot replace the actual constructed laboratories they are stock up measures that we use before full-fledged laboratories are constructed so that some teaching of science can be started but seriously speaking the mobile labs are not meant to be a substitute to science laboratories.

In addition, the MoGE official mentioned that the cooperating partners especially JICA was assisting with the construction of the science laboratories in the secondary schools.

JICA comes in to help us construct science laboratories; the national science centre is being built. This is also to help better the poor infrastructure in most upgraded secondary schools.

The responses show that MoGE sees a school infrastructure difference between upgraded and old established secondary schools.

4.2 Findings to the second research question

The research question was to find out the availability and state of teaching and learning materials on the implementation of the biology curriculum in the two sets of schools. In answering this question, findings on the state and adequacy of teaching and learning materials as well as their effect on the teaching and learning process were made as presented under this section.

A survey of the key teaching and learning materials showed the following in Table 4.5.

Table 4.5 SIMC data on the distribution of key biology teaching and learning materials

Teaching and learning materials	Secondary school					
	UP1	OL2	UP3	OL4	UP5	OL6
Preserved biological specimens	×	✓	×	✓	×	✓
biological models	×	✓	×	✓	✓	✓
Prescribed learners' textbooks	✓	✓	✓	✓	✓	✓

Key:

- ✓ Present
- × Absent

From Table 4.5, it can be seen that all schools had prescribed biology textbooks while preserved biological specimens were only found in old established schools. In terms of adequacy of prescribed biology learners' textbooks, UP1 recorded fairly adequate, OL2 recorded adequate while the rest of the secondary schools recorded inadequate biology textbooks. An inspection of the adequacy of biological models indicted that OL4 and UP5 had inadequate biological models while OL2 and OL6 recorded fairly adequate teaching models. OL4 recorded inadequate preserved biological specimens while OL2 and Ol6 showed only adequate preserved specimens. Although, all sampled schools had computer laboratories, UP1 showed inadequate ICT materials while the rest of the schools recorded a fairly adequate score.

Teachers' assessment of the adequacy of teaching materials measured by BCEQ found that five against one teacher from OL4 indicated inadequacy of the teaching materials while OL2, UP1 and UP3 recorded fairly adequate materials. UP5 recorded a 1:1 ratio of fairly adequate against inadequate. OL6 recorded a 2:1 ratio of the two extremes of the adequacy of the materials as presented in Figure 4.15.

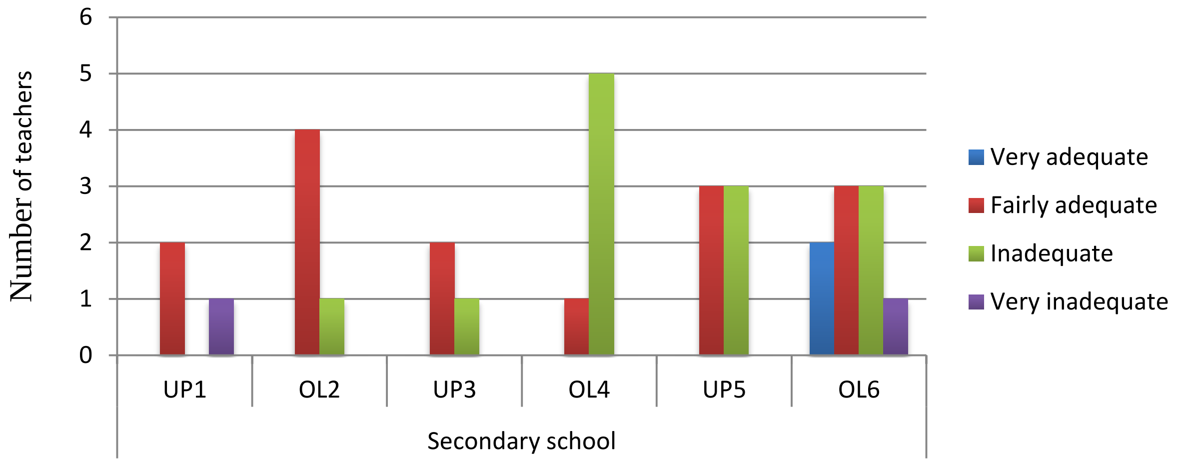

Figure 4.15 Teachers' description of adequacy of teaching and learning materials

Teachers were further asked about their accessibility to a copy of biology syllabus and it was found that all upgraded secondary school teachers had a personal copy of the document. OL2 also recorded 100 percent teacher accessibility while OL4 and OL6 showed ratio of 2:1 and 4:5 respectively of teachers who accessed against those who did not.

When the teachers were asked about the most readily available teaching materials, it was found that the charts were the most readily available materials in all schools while the live specimens were the least available. Models were found to be available in old established schools with exception of OL4 that recorded a marginal score. These teacher frequencies are presented in Figure 4.16.

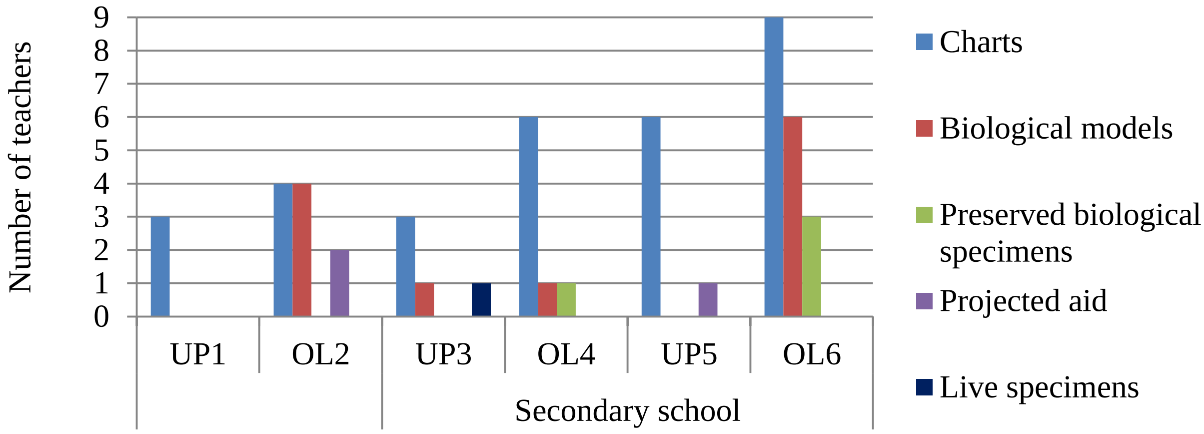

Figure 4.16 Frequency of readily available teaching materials measured by BCEQ

The frequencies on the availability of biological specimens and models from the side of the teaching staff were triangulated with the findings from the learners' perspective as presented in Figure 4.17.

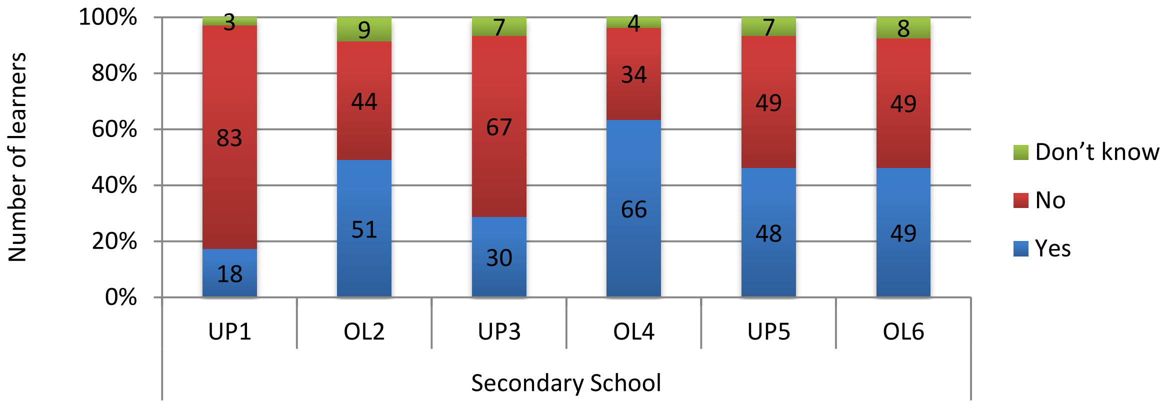

Figure 4.17 Learners' response on the presence of biological learning models in school

The data in Figure 4.17 show that the old established secondary schools had high frequencies of learners who indicated presence of biological models in school. Seventeen percent of respondents from UP1 and 29 percent from UP3 indicated that their school had biological learning models respectively. These frequencies for UP1 and UP3 are not consistent with the findings from SIMC data where an on spot inspection by the researcher showed no presence of biological models. OL4 had the highest score of the presence of the biological models and followed by OL2 while OL6 had equal number of respondents who indicated the presence and absence of the learning models. And when the learners were asked as to whether their respective schools had any preserved biological specimen, the following frequencies were recorded as shown in Figure 4.18.

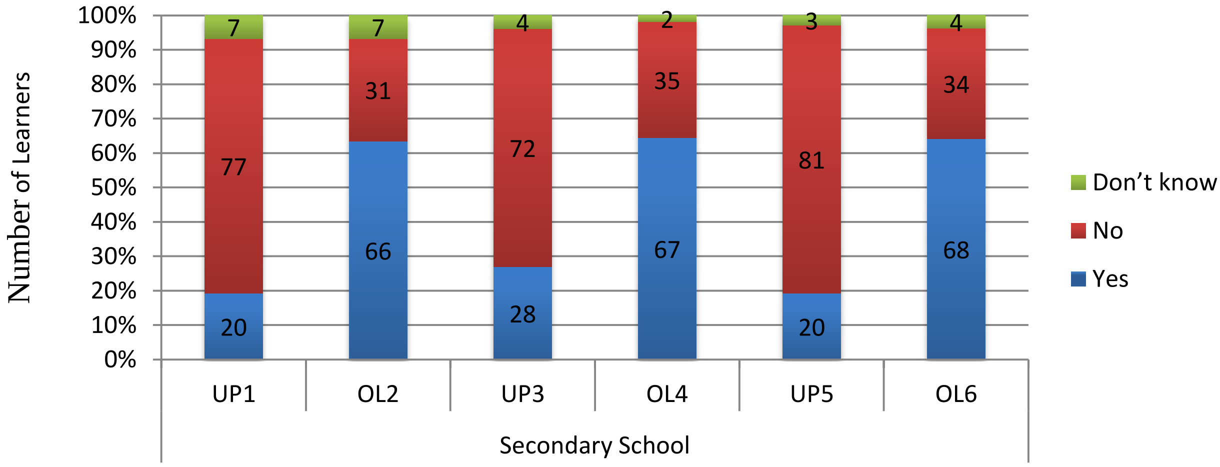

Figure 4.18 Learners' response on availability of preserved biological specimens

From the data in Figure 4.18, it can be noted that all the old established schools had over 65 percent of the respondents indicating the presence of the preserved specimens. This data is consistent with the SIMC data. All the upgraded secondary schools showed high scores of no preserved specimens. A non-parametric one sample chi-square test was run and the test showed a significant difference in the frequencies of learners that indicated presence of models and preserved specimens and those who indicated absence of these materials, in the two types of secondary schools at p=0.00<0.05, n=626 and df=1.

Learners' accessibility to the curriculum document was assessed by BLSQ and the data generated is indicated in Figure 4.19 where the analysis shows that most learners from both categories of the secondary schools had no access to the biology syllabus with the highest number of learners without access from OL6, UP3, OL2, and UP1. The ratio of those with or without access to the biology syllabus in OL4 was almost 1:1 as illustrated by the minimal difference. A comparison of the means of the two sets of schools on the learners access to the biology syllabus at *P*= 0.05, *df* =1 and *n*= 626; and calculated F value being 0.130 and P value being 0.719 showed no statistical difference between the learners' accessibility to the biology syllabus between the two sets of secondary schools.

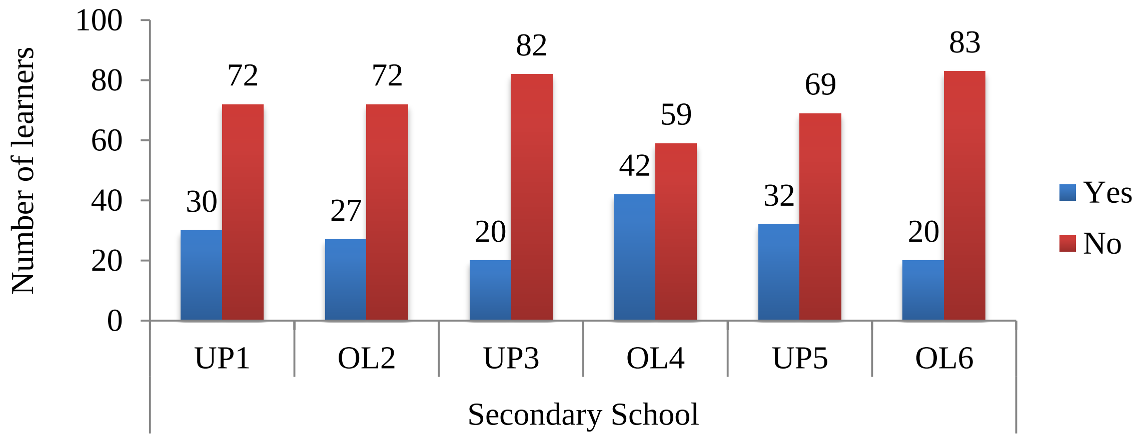

Figure 4.19 Frequencies of learners' access to a copy of biology syllabus

Data on learners' textbooks show that only UP1 and OL2 had 28 percent and 33 percent of learners as having borrowed books from the school respectively while the rest of the schools only had 10 percent each against the sampled population of 626 learners. A comparison between the pairs of the secondary schools indicates a 1:1 ratio of learners that borrowed biology textbook from the school showing no difference in learner accessibility of the textbooks as shown in Figure 4.20.

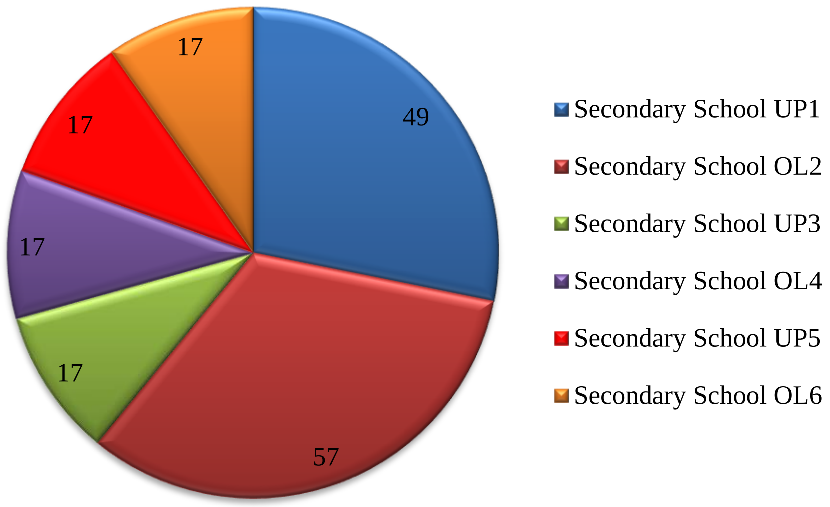

Figure 4.20 Frequency distributions of learners who borrowed biology textbooks from school

Among the 28 percent of the total sampled learners who accessed biology textbooks from their respective schools, the predominant book ratio was one textbook shared between two learners (1:2) in all the secondary schools with the worst being 1:5 ratio. Figure 4.21 shows the textbook ratio among learners that accessed this learning material.

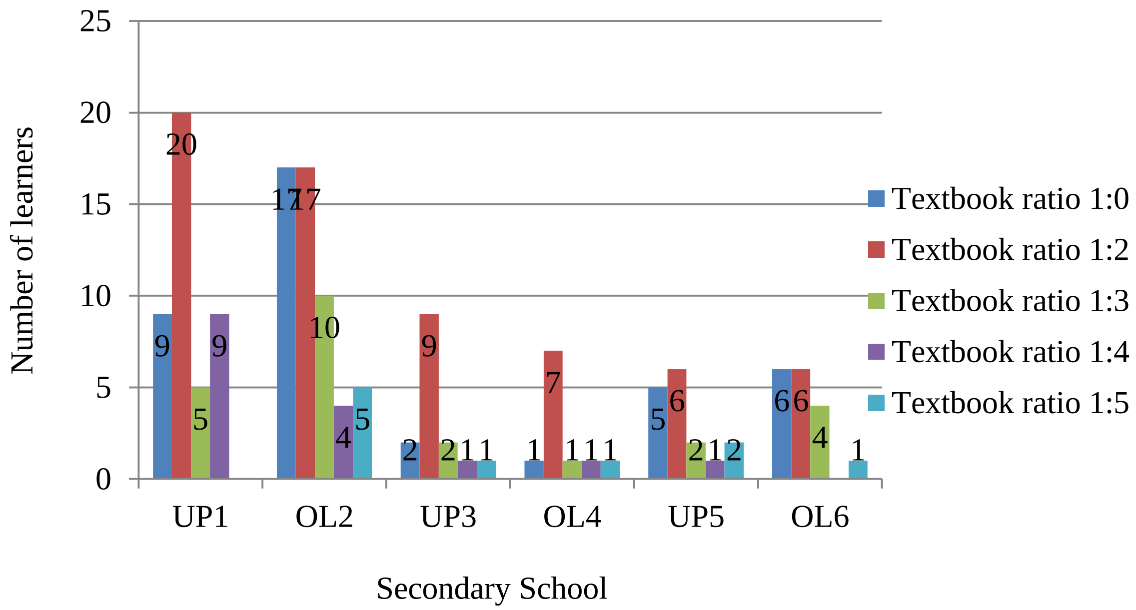

Figure 4.21 Frequencies of biology textbook sharing ratio among learners

However, the data in Figure 4.21 does not reflect the book ratio of the total sampled population of learners. The frequencies in both Figures 4.20 and 4.21 are consistent with the SIMC findings of all the secondary schools that showed inadequate number of biology textbooks with exception of UP1 and OL2 that recorded fairly adequate textbooks. A check on the retention time for the borrowed textbooks showed highest number of learners from all secondary schools having indicated the shortest retention time of less than a week which rendered the exercise of borrowing the textbook quite insignificant as shown in Figure 4.22

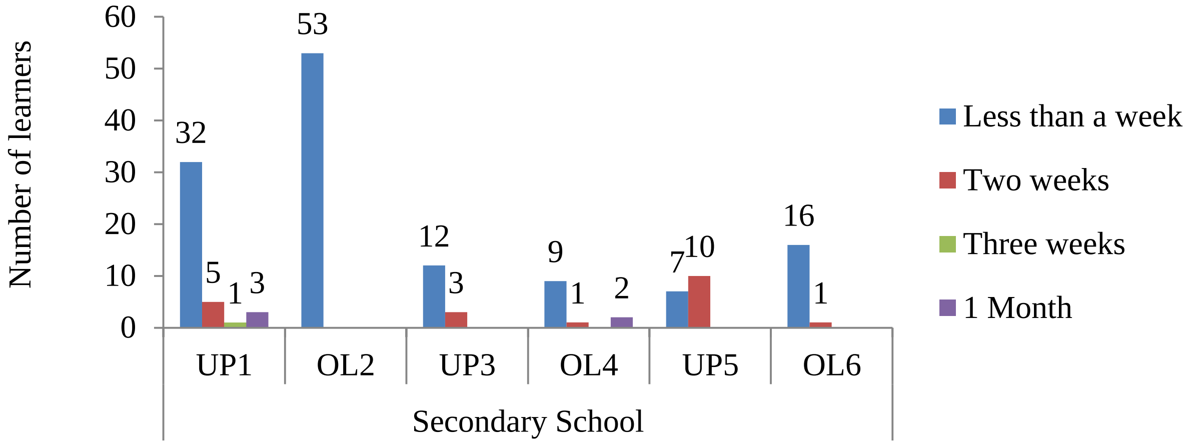

Figure 4.22 Retention time of borrowed biology textbooks

4.2.1 Effect of teaching and learning materials on curriculum implementation

The survey findings on the distribution of teaching and learning materials in the two sets of secondary schools leads to analysis of the impact of such materials on the implementation of the biology curriculum. Practical lessons reflect the importance of school infrastructure (science laboratory) but much more the use of teaching and learning materials such as specimens, models and largely laboratory apparatus.

Of the learners that indicated having experienced practical lessons in biology, a question was asked on the adequacy of laboratory apparatus during practical lessons and findings showed the ratio of inadequate against adequate laboratory apparatus during practical lessons as 3:1; 1:2; 1:1; 2:1; 5:1 and 3:1 in UP1; OL2; UP3; OL4; UP5 and OL6 respectively. It was further found that among the learners that indicated having practical lessons where they participated in, four of the schools shows learners having indicated inadequate materials while OL2 shows highest score of adequate materials. UP3 shows a 1:1 ratio which basically shows no difference, however, the number of learners that indicated having practical lessons is insignificant compared to sampled population. These findings are shown in Figure 4.23.

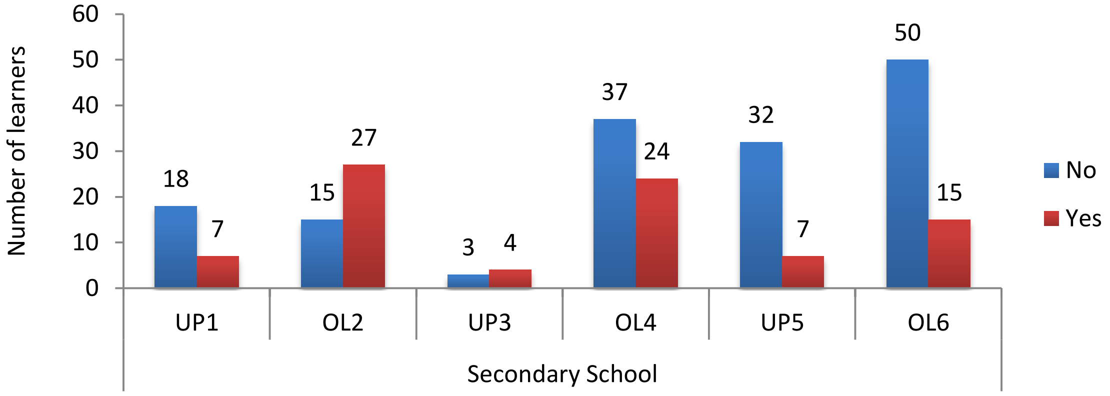

Figure 4.23 Frequencies of adequacy of laboratory apparatus during practical lesson

On assessing whether the distribution of biological specimens and teachers' use of charts, models and specimens for illustration during biology lessons were correlated, it was found that there was a weak negative correlation in both old established and upgraded secondary schools with the Spearman coefficient (rho) being -0.196 and -0.209; with n=314 and 312 respectively from the output of SPSS. The correlations were significant at 0.01 levels (2-tailed). However, the correlation coefficients from the two sets of schools were not significantly different. This shows that the distribution of biological specimens had a negative effect on teachers' use of such teaching aids.

A small positive correlation was found between the secondary school type and the teachers' usage of charts, models and specimens, rho=0.20, n=626 with correlation significant at $P<0.01$. However, there was only 4 percent of shared variance between these two variables which could not significantly explain the correlation.

When learners were asked if their teachers used any ICT materials when teaching biology, 95 percent of the learners from both sets of schools disagreed. It was also found from BCEQ that teachers did not use ICT materials in the teaching of biology.

Teachers' opinion on the impact of teaching and learning materials on the learner performance in final examinations and biology curriculum implementation showed that a few teachers from both upgraded and old established secondary schools disagreed that the teaching resources had an effect on learner academic performance. Figure 4.2.9a show that the highest number of the teachers from both secondary schools agreed that the availability of teaching and learning materials affects the performance of learners in biology final examinations and curriculum implementation respectively.

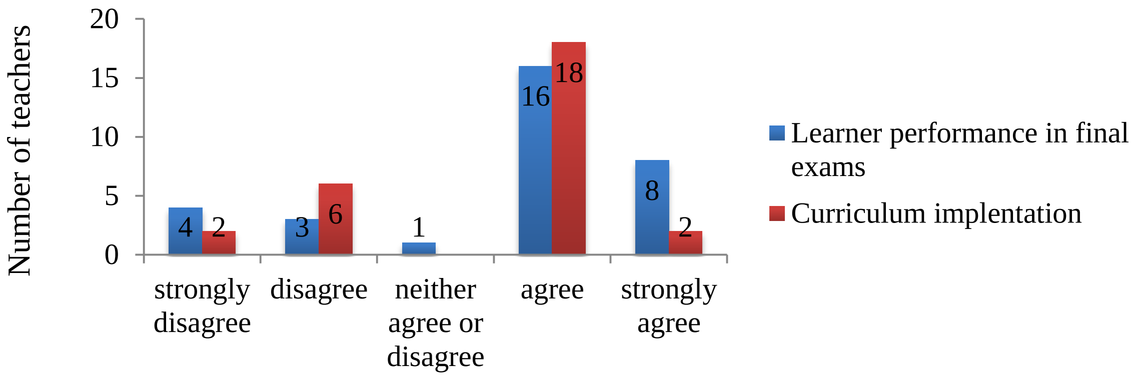

Figure 4.24 Frequencies of teachers' opinion on the effect of teaching and learning materials on learner performance in final examination and curriculum implementation

The direction of the effect of teaching and learning materials was however not shown by these frequencies. In terms of learner performance in grade 12 final examinations, the mean scores showed a difference over a period of six years between the two sets of secondary schools as indicated in the Figures 4.10-4.14. However, there was no significant difference as analysed in Section 4.1.2.

Assessment of teachers' opinion regarding procurement of laboratory apparatus yielded the following frequencies as shown in Figure 4.25.

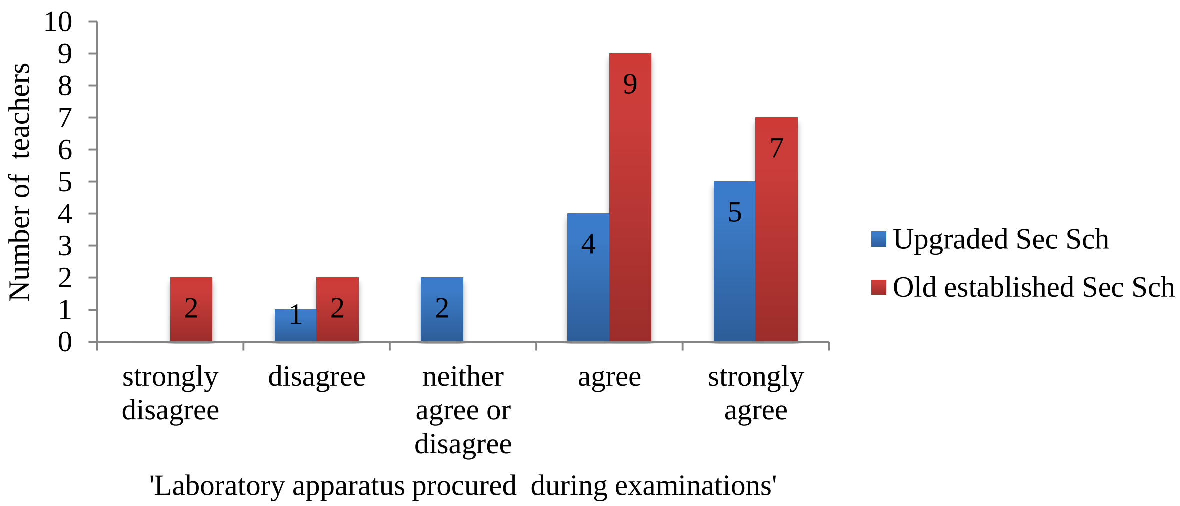

Figure 4.25 Frequencies of teachers' opinion regarding procurement of laboratory apparatus during biology examinations

Frequencies from Figure 4.25 show that teaching and learning materials are procured during examination period as indicated by most teachers. Two of the teachers from upgraded secondary schools neither agreed nor disagreed while four teachers from old established secondary schools disagreed.

Teachers were asked to assess the school's environment (a percentage estimate) in supporting their core duty of curriculum implementation and the following were some of the responses relating to teaching and learning materials.

From UP3, one teacher indicated 50% and wrote;

> *Our school lacks some of the key materials and apparatus to be used in order to enhance effective teaching.*

Another teacher from UP5 indicated 50% and wrote;

> *Textbooks for teachers to use for teaching are available but the teaching aids are not available.*

From OL2, one teacher indicated 60% and wrote;

> *Well, of late we have seen an improvement in the acquisition of teaching materials which were previously lacking, hence this improvement.*

From OL4 one teacher indicated 40% and wrote;

> *Inconsistent storage of biology specimens and models. Lack of support in terms of materials and financial aspects by the school management. Apparatus such as microscopes are not supplied by the school.*

From OL6, one teacher indicated 80% and wrote;

> *The percentage is estimated to be 80% due to the fact that sometimes the laboratories lack certain important materials that are required to conduct practicals such as reagents, hand lenses and litmus papers etc.*

Analysis of the above teacher responses from both sets of secondary schools shows that teaching materials are scarcely provided which impacts negatively on teachers' role of implementing the curriculum.

4.2.2 Teacher recommendations on effective curriculum implementation in relation to teaching and learning materials

From Upgraded secondary schools, the following were some recommendations teachers made:

Improve on teaching and learning materials in the laboratory; The Ministry of General Education should ensure they monitor all schools to make sure they purchase the required materials; Schools should be advised to scale up the budget for the procurement of adequate laboratory apparatus; Provision of teaching and learning materials during lessons; In order for the biology curriculum to be well implemented in schools as prescribed, school managers and various stakeholders should have interest and provide the necessary materials needed for it to be implemented.

From Old established secondary schools, the following were some recommendations teachers made:

The biology teacher should have access to learning and teaching materials; It is not very easy to implement the biology curriculum in that learning and teaching materials are inadequate and this makes it difficult for effective learning; The Ministry of General Education should provide enough learning and teaching materials to enhance effective learning; The school should procure more books, apparatus and other teaching materials in order to enhance learning and implement the new curriculum more effectively; The government and the school should provide more books and other teaching and learning materials; The school should procure more books and other teaching materials in order to enhance learning and also to implement the new curriculum more effectively.

Analysis of the teacher recommendations show that the lack of the teaching and learning materials impacted negatively on the implementation of the biology curriculum in both upgraded and old established secondary schools. In addition, when an official from the Directorate of Curriculum and Standards of the MoGE was asked about the highlights of the filler reports of the standards' officers, the following response was given;

> *In most cases report of standard officers does indicate that teaching and learning resources were not available in good quantities, here we are talking about books, equipment, chemicals in laboratories and so on, these were noted.*

In addition, it was found that the Ministry of General Education had taken steps to procure the necessary teaching resources and that CDC was tasked with coming up with textbooks that are in line with the curriculum objectives.

4.3 Findings to the third research question

The corresponding research question was to find out the biology teachers classroom practices in the two sets of schools in relation to implementation of biology science curriculum. To answer this question, the following findings were made as presented in subsequent sections.

4.3.1 Demographic data of teaching staff and biology learners

The teacher qualifications and their years of teaching experience were investigated using BCEQ and the data is shown in Table 4.6.

Table 4.6 Demographic data of the teaching staff distribution

Years of service/Professional qualification		Number of teachers in secondary school						Total
		UP1	**OL2**	**UP3**	**OL4**	**UP5**	**OL6**	
0-5 years	secondary school teachers' diploma	0	0	0	1	1	1	3
	Bachelors' degree	1	1	1	1	2	2	8
6-11 years	secondary school teachers' diploma	0	0	1	1	0	2	4
	Bachelors' degree	0	0	0	2	0	2	4
12-17 years	secondary school teachers' diploma	0	3	0	0	2	0	5
	Bachelors' degree	1	1	0	1	0	2	4
18-23 years	Bachelors' degree	1	1	0	0	0	0	2
24-29 years	Bachelors' degree	0	0	1	0	1	0	2

From Table 4.6, it can be seen that majority (11) teachers had teaching experience of less than five years, followed by nine teachers with experience between 12-17years. The longest serving biology teachers with experience of about 24-29 years were only two from upgraded secondary schools. The total number of teaching staff that participated in the survey was 32. Two teachers from UP3 and OL2 didn't participate on account of vacation leave and study leave respectively, while in OL2 and OL6, a single teacher from each school declined to participate in the survey on account of personal reasons. In terms of level of teacher qualification, 11 teachers had secondary school teachers' diploma while 21 were holders of bachelors' degree. Ten of the sampled teachers indicated having taught in a basic school before. However, none of the teachers moved to secondary school on secondment basis. Teacher gender distribution was also checked using BLSQ and the frequencies are depicted in Figure 4.26.

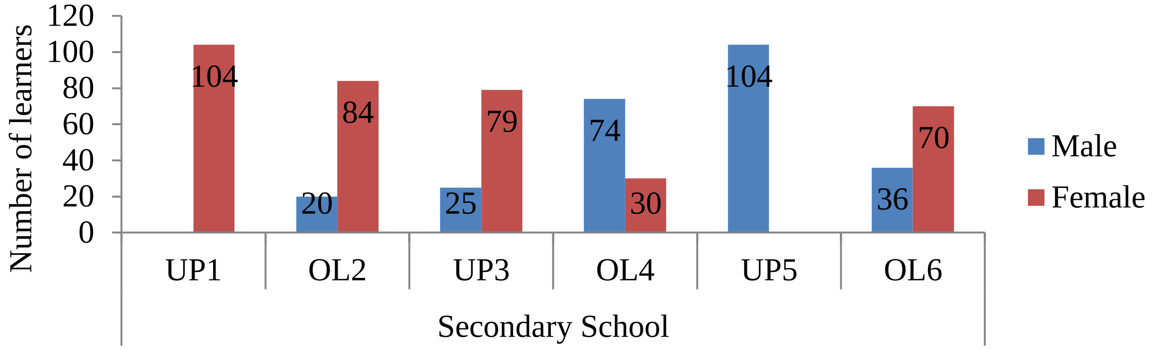

Figure 4.26 Frequency of gender of biology teachers

It can be seen from frequency distribution that most of the sampled learners were taught biology by female teachers with the exception of UP5 and OL4. Although UP5 had one female biology teacher, the entire stream of grade 11 learners was taught by one male teacher. These frequencies are quite consistent with the gender of the randomly sampled teachers for biology lesson observation, although UP3 and OL4 were exceptions with male and female teachers respectively. In total, two males and four female were sampled for lesson observation across the six secondary schools.

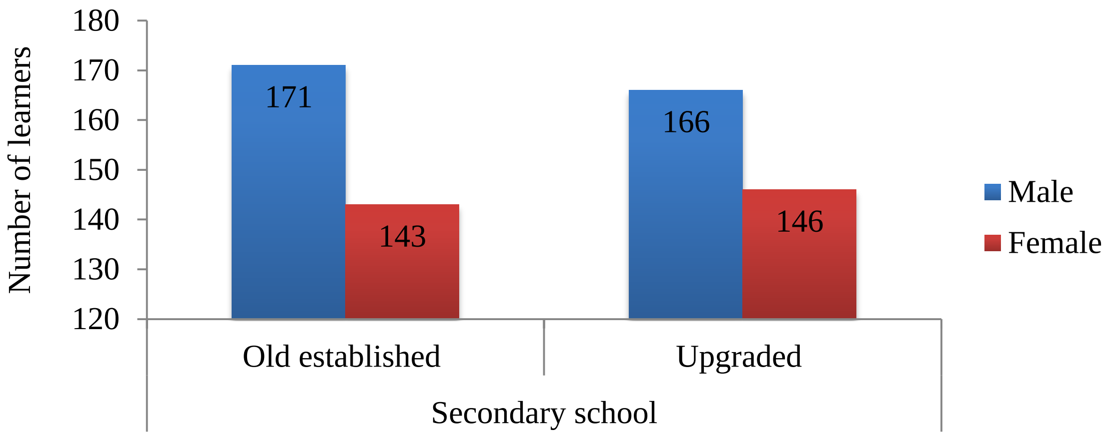

Figure 4.27 Gender distributions of the sampled learners

From Figure 4.27, it can be seen that there were more males from the randomly sampled learners. However, the difference in gender frequencies was not significant. Analysis of case by case showed that UP1 and OL4 had equal distribution of gender frequencies. OL2; UP3; UP5 and OL6 had 6; 2; 18 and 22 more males than females.

The class enrolment of biology learners was measured by BLOS and the following findings in Figure 4.28 were made.

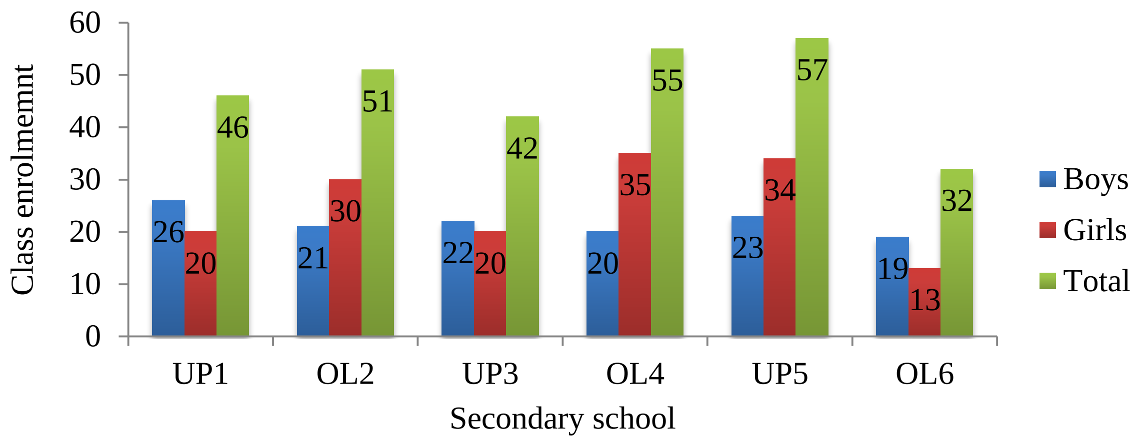

Figure 4.28 Frequencies of average class enrolment by gender

It can be noted from Figure 4.28 that the class enrolment across all observed biology lessons in all the secondary schools was 47 learners per class. However, this cannot be used as the average class enrolment per school as the sampled classes may be different from the rest of the classes. It was also learnt during research that the classes taking pure science subjects had the lowest enrolment. OL2, OL4 and UP5 had more females enrolled in the observed lessons while the rest of the secondary schools had more males over females.

4.3.2 Biology allocated lesson time and teacher teaching load

The biology lesson duration was measured by BLOS, BLSQ and BCEQ. When learners were asked to state the number of times in a week they had biology lesson/s, the findings in Figure 4.29 showed that in most of the schools, the number of times of biology lessons as indicated by the learners was twice in a week. In OL2 and UP3, the highest frequency shows learners experience as three lessons in a week. From observations of BLOS, an indication of two lessons in a week translated into four learning periods with a single lesson session taking double periods. Three times also translated into two double periods and a single period for lesson session. The frequencies indicating once and four times a week are insignificant.

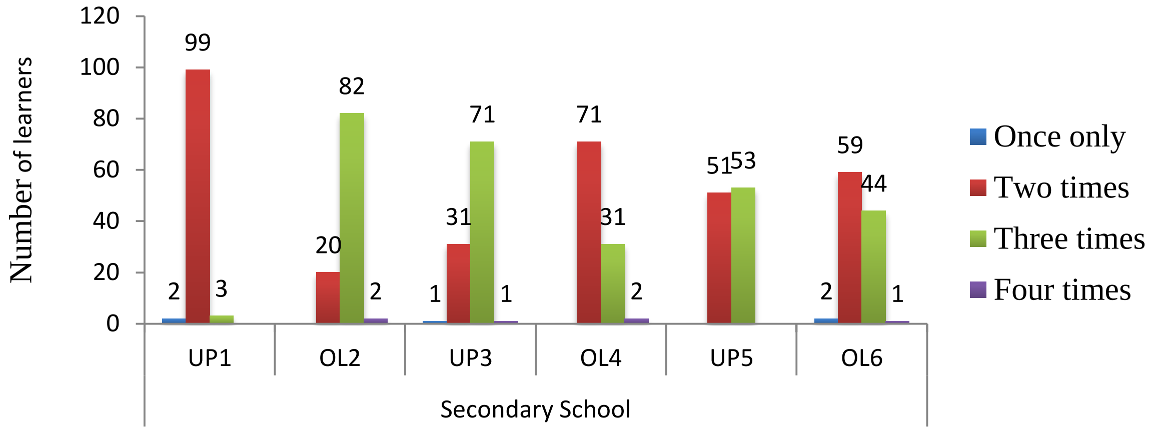

Figure 4.29 Frequencies of biology lessons in a week

However, the number of times of biology lesson in a week doesn't show the exact lesson duration. Lesson duration measured by BLOS found that UP1, UP3, OL4 and OL6 had 40 minutes allocated lesson time per period which translated into 2 hours: 40 minutes and 3 hours: 20 minutes per week for two and three lessons respectively. OL2 and UP5 had 35 minutes allocated time per period translating into 2 hours: 20 minutes and 2 hours: 55 minutes weekly learning time for two and three lessons respectively. It must be noted that there was variation in time allocation within the school type.

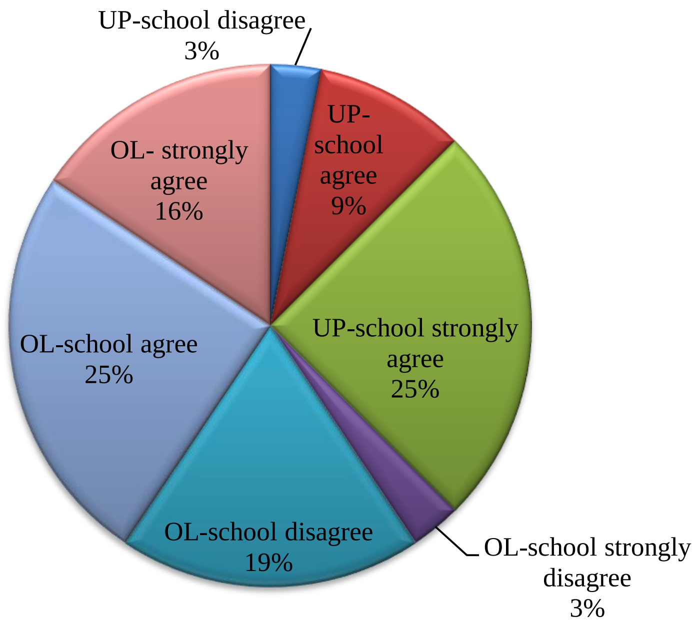

Figure 4.30 Teachers' opinion on the inadequacy of allocated biology lesson time

The frequencies of teachers' opinion shown in Figure 4.30 regarding the statement that allocated biology lesson time was inadequate, and it was found that only 19 percent and 3 percent from old established and upgraded secondary schools respectively disagreed with the statement that allocated lesson time is inadequate. Another 3% from old established school strongly disagreed. However, 75 percent of the teachers from both school types indicated that the allocated biology lesson time was inadequate.

Teachers' teaching load and its effect on curriculum implementation was also assessed using BCEQ and the frequencies are presented in Figure 4.31.

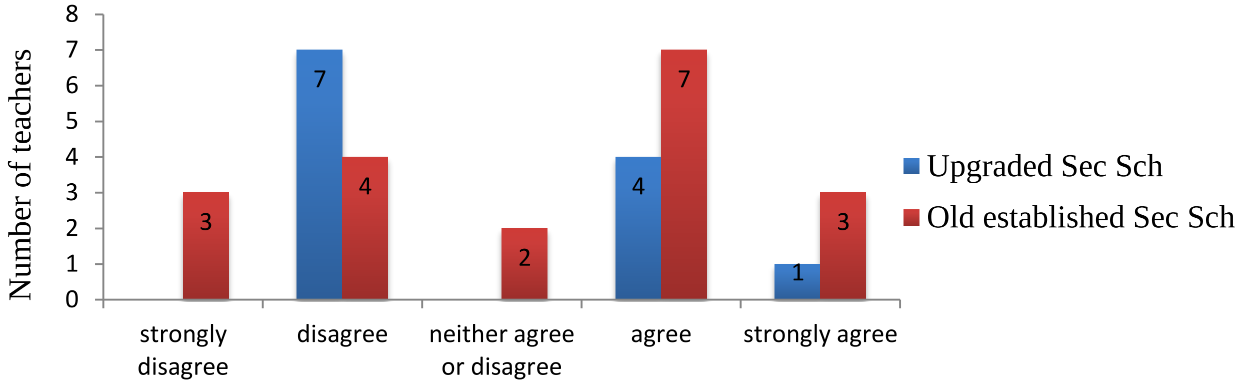

Figure 4.31 Frequencies of the negative effect of teaching load on effective curriculum implementation

Analysis of the above data show that more teachers from upgraded secondary schools disagreed that their respective teaching loads impacted negatively on curriculum implementation while 50 percent of the teachers from old established secondary school agreed with the assertion. Two of the teachers from old established schools could not assess the impact of their teaching load on the implementation of the curriculum.

4.3.3 Findings on teacher classroom practices

From the 18 lessons observed and measured by BLOS, the frequent teaching methods used by the teachers were Lecture (teacher exposition), question and answer (Socratic) with frequency of one for the demonstration, problem solving and brainstorming methods. Analysis of variance of the two frequently used methodologies showed no significant difference between the two sets of secondary schools, with P=0.05, N=18, df=1 with calculated p= 0.44 and 0.33 for lecture and question and answer methods respectively as shown in Table 4.8. The test of homogeneity of variance was observed as shown in Table 4.7.

Table 4.7 Test of Homogeneity of Variances

Variable	Levene Statistic	df1	df2	Sig.
Frequency of use of lecture method	4.894	1	16	.142
Frequency of use of question and answer method	.843	1	16	.372

Table 4.8 Analysis of variance of the most frequently used teaching methods between two sets of school

Frequently used teaching method		Sum of Squares	df	Mean Square	F	Sig.
Lecture method	Between Groups	4.500	1	4.500	.615	.444
	Within Groups	117.111	16	7.319		
Question and Answer method	Between Groups	4.500	1	4.500	1.029	.326
	Within Groups	70.000	16	4.375		

However, the findings from BLOS were quite different from data generated from BCEQ as presented in Figure 4.32 where the teachers' preferred and often used teaching methods included experimental, group discussion, project, field work, demonstration and problem solving which were either rarely observed or absent altogether during lesson observation.

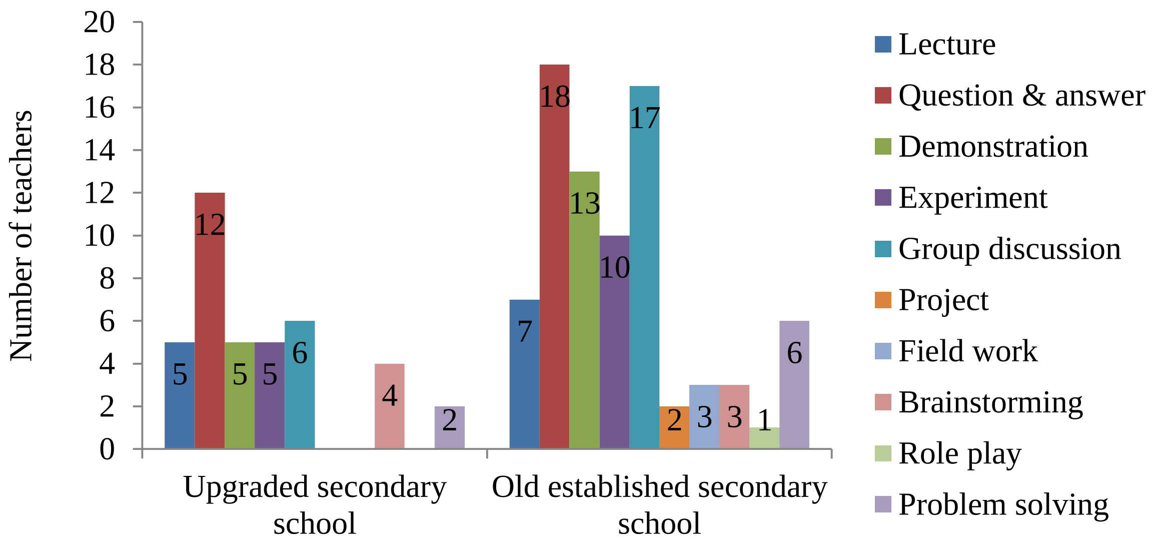

Figure 4.32 Frequency of teaching methods often used by teachers

Looking at the key teaching methods from Figure 4.32, it can be seen that the question and answer technique was the most preferred by teachers with scores of 100 and 85 percent from upgraded and old established secondary schools respectively. Group discussion was second highest with 50 and 85 percent; followed by demonstration technique with 41.7 and 55 percent while lecture method showed 41.7 and 35 percent for upgraded and old established secondary schools respectively. Experimentation was often used by teachers from old established schools with a 50 percent score. Field work and project recorded zero in the upgraded schools while in old established 10 and 15 percent of the teachers indicated use of these methods respectively.

A check on teacher response regarding field trip, none of the teachers from upgraded secondary school used a field trip while one from the old established secondary school indicated having taken learners on a biology field trip. Data from BCEQ on teaching methods claimed by the teachers were checked by the findings from BLSQ by the learners' experience of teacher usage of field work, group discussion and question and answer on a Likert scale as depicted in Figure 4.33.

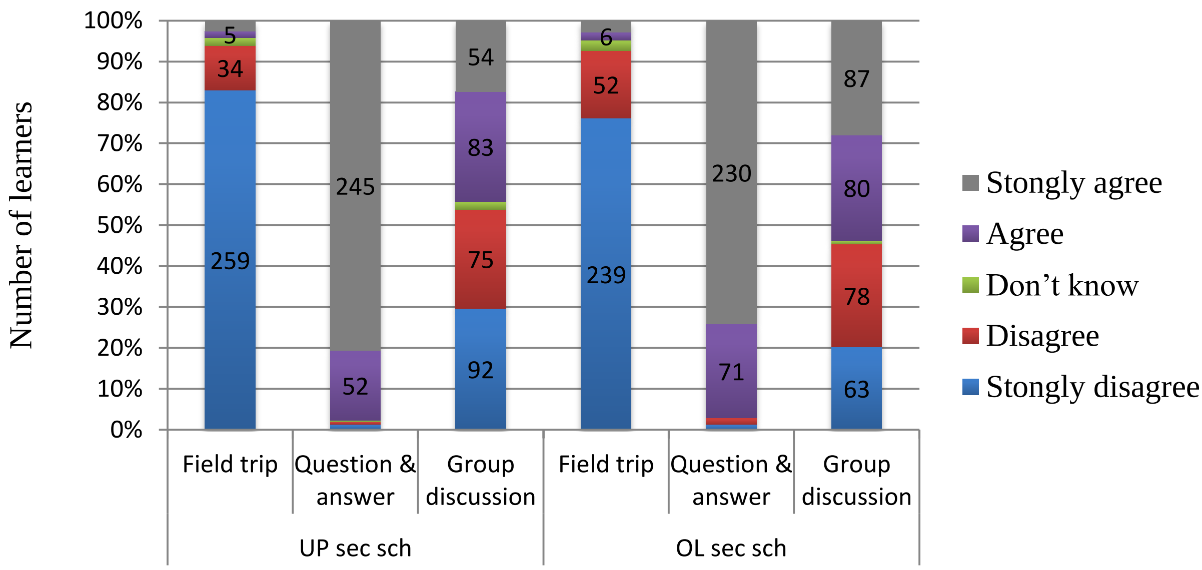

Figure 4.33 Learners' response of their learning experience in biology with respect to teacher methodology

The frequencies in Figure 4.33 indicate that field trip was not used by teachers from the learners' experience while the question and answer method was frequently used by the teachers in both sets of secondary schools. However, regarding group discussion method through group tasks given by the teacher in both sets of schools, it was found that there was a

1:1 ratio of learners who agreed against those who disagreed, although the frequency of learners that disagreed was slightly higher than those that agreed.

Analysis of the observed lessons showed that learner-centred approach was only promoted to a limited extent by teachers with isolated use of group discussion method. The frequencies of the extent to which the teacher promoted learner-centred learning are presented in Figure 4.34.

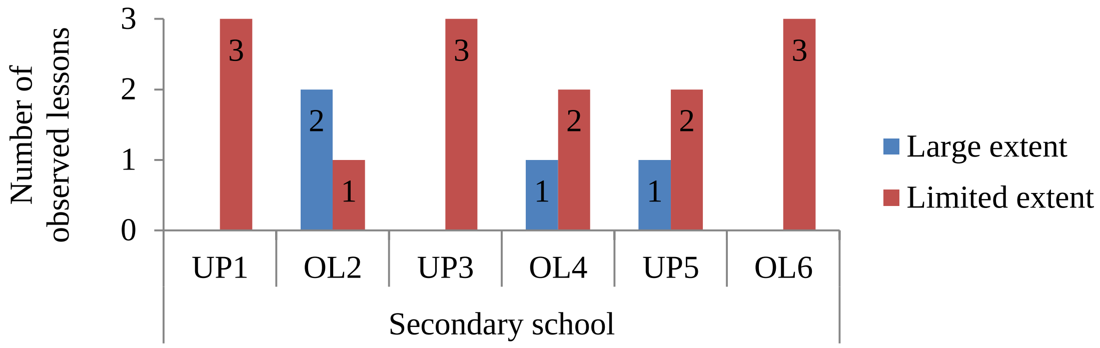

Figure 4.34 Frequency of biology lessons characterised by learner-centred approach

From the data above, it can be seen that only OL2 had the highest score of two lessons against one in which the teacher employed learner-centred approach mainly through group discussion. In OL4, one of the lessons was characterised by learners discussing the concepts and identifying labelled parts of the human reproductive system from an improvised chart.

The teachers' classroom practices were also investigated using BLOS to evaluate how they fostered attainment of science process skills in comparison to the ones prescribed in the biology syllabus and the following findings in Figure 4.35 were made.

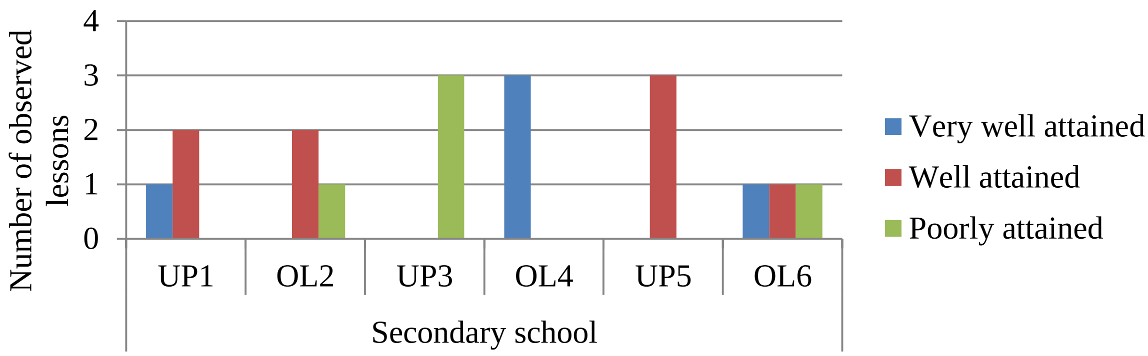

Figure 4.35 Frequency of attainment of science process skills during observed biology lesson

UP3 recorded poor attainment of science process skills in all the lessons observed while OL4 scored very well in the attainment of the process skills. The lessons that recorded poor attainment were characterised with lack of use of teaching aids and limited use of teaching methods (mainly lecture and question and answer methods).

The sitting arrangement of learners for most of the lessons observed was traditional rows with a least score of varying (traditional rows and clusters). Clusters were mostly temporal especially when the teacher employed the group discussion method. Analysis of the sitting arrangement in the two sets of secondary schools by one sample binomial test showed a significant difference at p=0.008. None of the observed lessons in upgraded schools showed a varying sitting arrangement while three of the observed lessons from old established schools were characterised by varying sitting arrangement.

4.3.3.1 Teachers' usage of teaching materials

Assessment of the teaching aids used during the observed lessons showed limited use of the teaching aids. In all observed lesson, the traditional teaching aid (chalkboard) was used by all teachers. Other teaching aids used included improvised charts, live specimens and textbooks. Textbooks were used in UP1 while live specimens of plantae nature were only used in OL6. Use of improvised charts was observed in UP1, OL4 and OL6 only. The findings are presented in Figure 4.36.

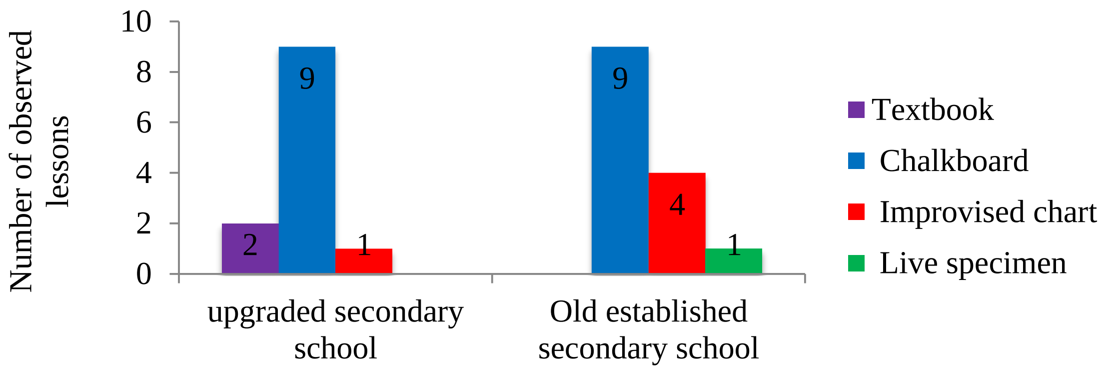

Figure 4.36 Teaching materials often used during observed biology lessons

From the nine lessons observed in each of the two school types, it was noted from two lessons under UP1, that learners were interested in the teaching materials used other than the chalkboard while under old established, in two of the lessons, learners interested and in four of the lessons, learners were very interested in the learning materials used. Teachers' innovativeness in the use of teaching aids other than chalkboard ranged from two lessons ranked innovative and one lesson very innovative in upgraded schools while five lessons ranked innovative in old established secondary schools.

4.3.3.2 Practical activity in teaching biology

When teachers were asked how often they conducted practical lessons in biology, the following frequencies in Figure 4.37 showed most teachers from the upgraded secondary schools rarely conducted practical lessons in biology. However, in UP1 and UP3 respectively, one teacher indicated having often conducted practical lessons. The highest frequency in old established secondary schools showed that teachers often conducted practical lessons. However, half the number from OL4 and two from OL6 rarely conducted practical lessons in biology. When a correlation test was run using SPSS software between teachers' teaching experience and the frequency of conducting practical lessons in biology, it was found that there was a weak positive correlation of spearman coefficient (rho)=0.10 with n=32. However, the result was not statistically significant as the calculated $p=0.61>0.05$. It was also found that there was a small negative correlation of rho= -0.19 at p=0.30 between teachers' level of qualification and ability to conduct practical lessons in biology. However, this result was not statistically significant. Figure 4.37 shows the frequencies of practical lessons as measured by BCEQ.

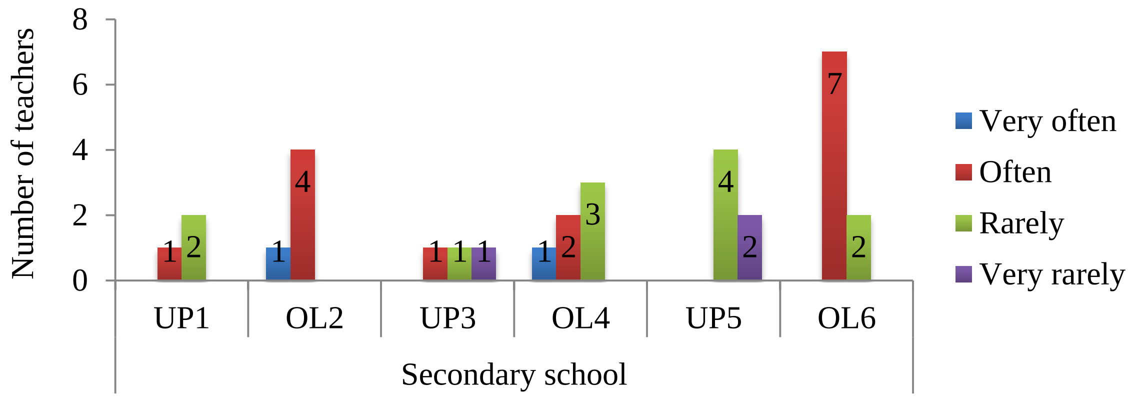

Figure 4.37 Frequency of practical lessons delivery by teachers

Frequency of practical lessons was checked against the learners' experiences as shown by the data in Figure 4.38 which indicate UP3 as the school with the least number of learners whose teachers conducted practical lessons in biology while OL2 recorded least for the old established schools. All the upgraded schools recorded high frequency of learners who had not experienced practical lessons in biology. These findings are consistent with the data in Figure 4.37 where most teachers in upgraded secondary schools indicated that they rarely conducted practical lessons in biology. Teachers' claim of how often they conducted practical lessons was verified with lesson observation by BLOS and it was found that out of the eighteen lessons observed, none of the observed lessons was characterised by practical activity. The following were frequencies on practical lessons from the learners' perspective as depicted in Figure 4.38.

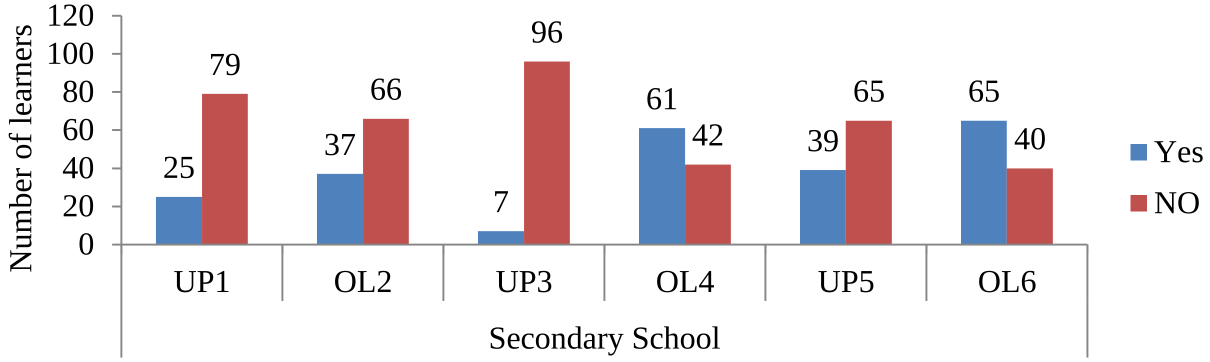

Figure 4.38 Frequencies of learners' experience of practical lessons in biology

It was further found that the highest frequency of learners who did not experience practical lessons in biology were those taught by female teachers as shown in Figure 4.39.

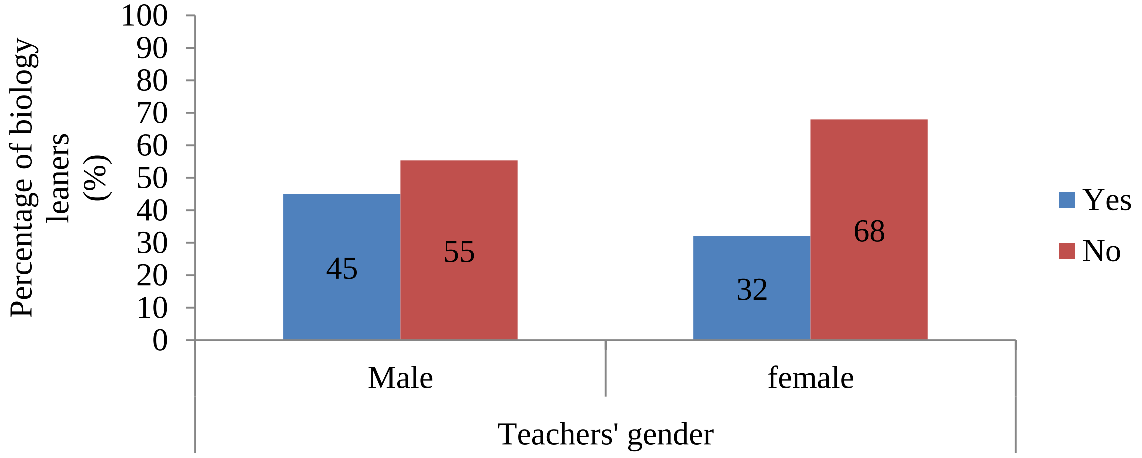

Figure 4.39 Frequencies of practical lessons against teachers' gender as assessed by biology learners

It can be noted from Figure 4.39 that the difference between the learners who responded yes or no in relation to their teacher conducting practical lessons was 36 percent for females and 10 percent for male teachers.

The presence of a laboratory assistant in the secondary schools was surveyed and it was found that UP5 had no laboratory assistant while from OL2 and OL4 two teachers indicated absence of a laboratory assistant. The findings from the two respective old established schools may imply ineffectiveness of the laboratory assistant. But an analysis of data of the teachers who indicated absence of laboratory assistant against years of teaching service, showed that the teacher from OL4 had teaching experience of 0-5 years while in OL2 the teacher had experience of 18-23years. In OL4, the teacher response may be attributed to teacher's novelty in that school environment.

Figure 4.40 shows teachers' assessment of effectiveness of their laboratory assistant where it can be seen that the laboratory assistants in the respective schools are effective in general. It can also be noted that the evaluation in old established secondary schools ranged from very effective to very ineffective, however, the extreme cases recorded the marginal scores.

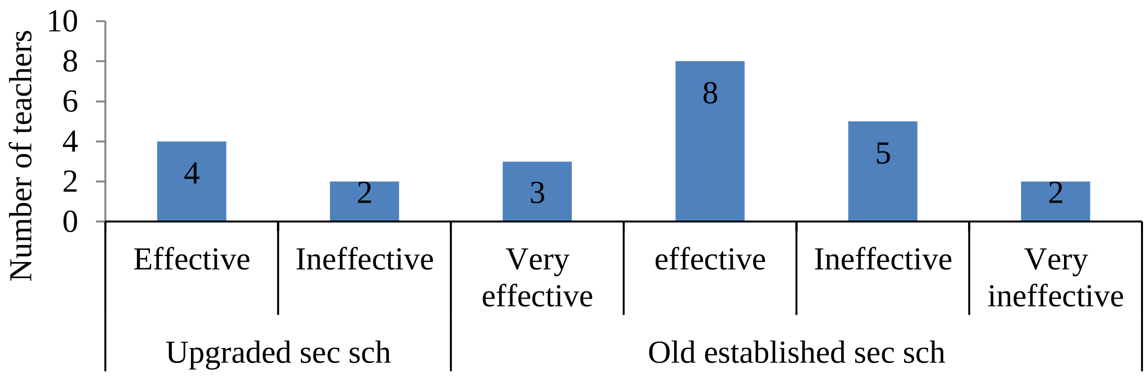

Figure 4.40 Teachers' evaluation of effectiveness of laboratory assistant

4.3.3.3 Teacher assessment of learners during biology curriculum implementation

Survey findings on the teacher classroom practices regarding teachers' assessment of the learners presented in Figure 4.41 shows that out of the 18 lessons observed only 6 lessons were characterised by teacher assessment of learners with only 1 lesson characterised by take home assessment while the remainder were written class exercises. It can also be seen from the frequency distribution that there was no significant difference in classroom teacher assessment of learners between the two sets of secondary schools.

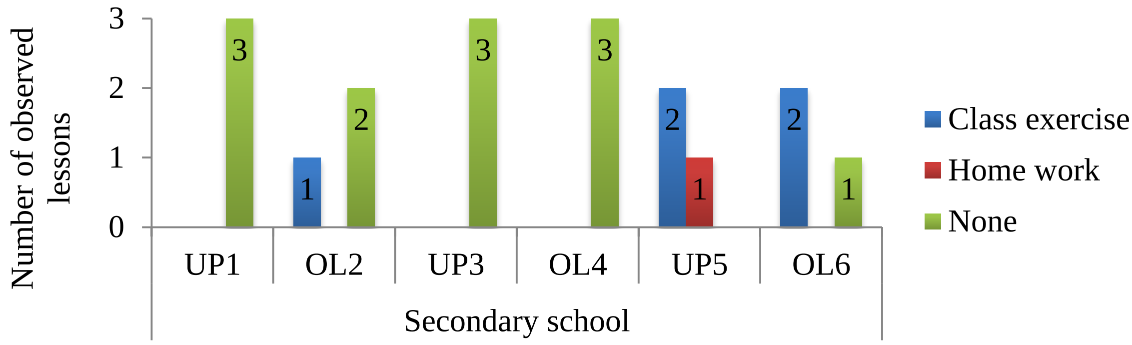

Figure 4.41 Frequency of biology learner assessment tasks in class

However, from the biology learners' perspective, the highest number of learners either strongly disagreed or disagreed with the assertion that their teachers do not give class exercise. Although about 34 and 19 percent of the learners from upgraded and old established secondary schools respectively indicated that their teachers didn't administer class exercise to them during lesson.

The assessment of the learners by the teachers in biology through monthly tests was surveyed from the learners' perspective and data is shown in Figure 4.42.

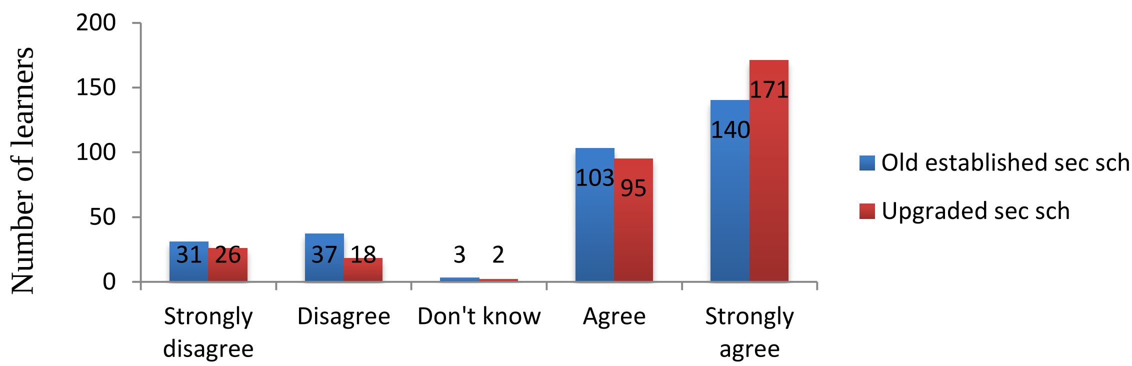

Figure 4.42 Learners' response regarding teachers' administration of monthly class tests

Analysis of the data shows 85 and 77 percent of the learners from upgraded and old established secondary schools respectively indicated having been assessed by their teachers in biology through the monthly class tests while 14 and 26 percent disagreed that their teacher administered assessment tests in biology twice every term. However, the frequency distribution shows a number of learners who disagreed were mainly from old established secondary schools, although the difference is not statistically significant at p=0.05, df=1 with calculated x^2=0.82.

4.3.3.4 Unprofessional classroom practices

Some of suspected unprofessional practices of teachers of biology such as giving notes without explaining and substituting textbooks for note taking were investigated using BLSQ and data is indicated in Figures 4.43 and 4.44.

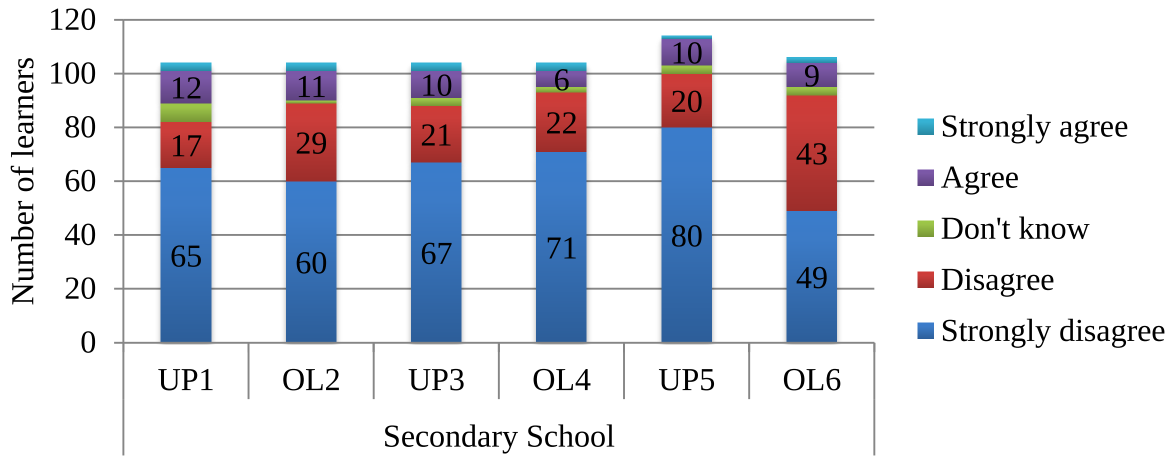

Figure 4.43 Learners' response on unprofessional classroom practices regarding note taking

It was found as depicted in Figure 4.43 that most of the learners either strongly disagreed or disagreed with the assertion that their teacher of biology often wrote notes on the chalkboard without explaining, indicating that there was no unprofessional conduct on the part of the teachers in terms of sound classroom practices. Although the highest frequencies from Figure 4.43 show that the learners disagreed with the assertion, the small frequency of those that agreed to the statement was considered carefully. However, lesson observation showed no such tendencies of teachers writing notes on the chalkboard without explaining. Therefore, the small frequencies citing teachers having exhibited the unprofessional tendency were insignificant.

Learners were also asked if their teachers often tasked them to copy notes from the textbook. The highest frequencies of the learners disagreed that their teachers asked them to copy notes from the textbooks. These findings from BLSQ were confirmed by lesson observations, however, in UP1 where use of textbook as a teaching aid was observed shows 23% of the learners having strongly agreed to the assertion that their teacher often asked them to copy notes from the biology textbook as indicated in 4.44.

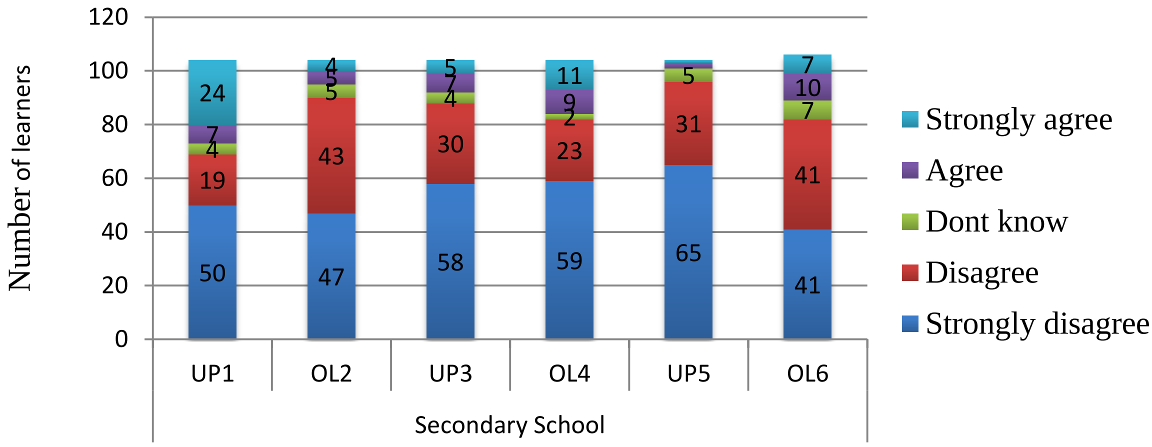

Figure 4.44 Learners' response on suspected textbook misuse regarding note taking

4.3.4 Effect of lesson study on teacher effectiveness in curriculum implementation

The study also investigated the teachers' opinion regarding continuing professional development (CPD) and curriculum implementation and the findings showed that most teachers acknowledged the importance of CPD in enhancing their effectiveness in the delivery of lessons as shown in Figure 4.45.

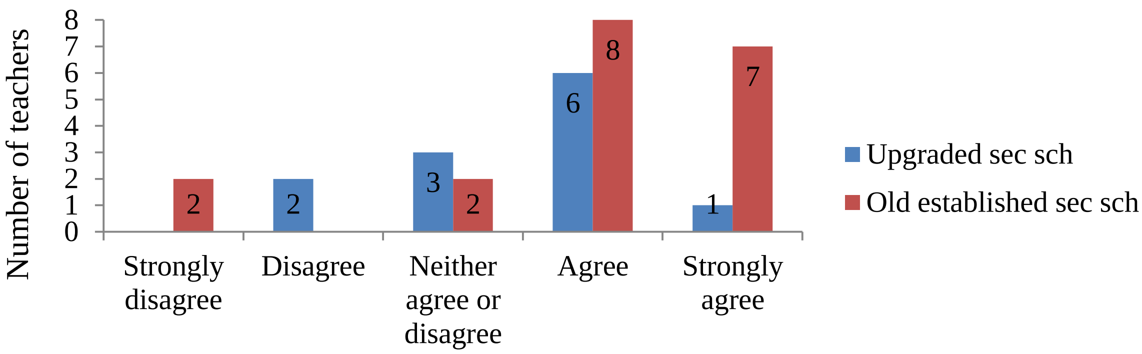

Figure 4.45 Frequencies of positive impact of CPD on biology curriculum implementation

From the graph it can also be seen that CPD was much more appreciated in the old established secondary schools. The teachers who neither agreed nor disagreed may not have experienced the CPD programme to assess its relevance to their effectiveness in implementing the biology curriculum. The MoGE official was also asked what steps the Directorate of Curriculum had taken in science curriculum development owing to the two generations of secondary schools, the response was;

> *We are encouraging CPDs amongst schools, I am sure you may have heard of lesson study approach that has been going round the provinces and are filling in the gaps.*

4.3.5 Teachers' recommendations on effective curriculum implementation in relation to classroom practices

From Upgraded secondary schools, the following recommendations were made by teachers:

The allocated time is not enough and the laboratory apparatus are scarce

Biology must be allocated more learning periods, like 6 periods per week. CPD must be taken seriously in the schools. Laboratories for biology must be improved and the school must acquire laboratory apparatus in time.

The biology syllabus is too wide; therefore, more teaching time and experiment time should be given

Reduce pupil-teacher ratio. Create room for regular practical lessons administration. The science department should have a qualified and dedicated laboratory assistant. Teachers in the department should have preparation room in order to think and try through

From Old established secondary schools, the following recommendations were made by teachers:

The implementation of the biology curriculum is not much effective to the slow learners because as a teacher needs to explain more of which the duration of the lesson can't allow

The syllabus is wide; it is difficult to complete it especially that our learners begin their examinations early.

This also affects the other learners who stop reporting for school during examinations; Teachers need more time in order to conduct the practicals in biology. Teachers need less teaching loads to have enough time to do projects in biology more effectively

More time should be allocated in order for the syllabus to be complete

It should involve all stakeholders so that more ideas are brought forward. The curriculum should include aspects of real life situations so that it is broadened

The implementation of CPD has really helped many teachers as they are able to exchange and share new ideas from the meeting. Therefore, must be encouraged.

More funding must be provided. The quality of human resource must be up-scaled. Pupil-teacher ratio must be improved.

The teacher recommendations indicate that time constraints and lack of teaching and learning materials negatively affected their practices in both sets of schools.

4.4 Chapter summary

In summary, there was a difference in the state and availability of school infrastructure between the two categories of secondary schools with old established secondary schools having better infrastructure than the upgraded schools. However, there was no significant difference in influence of infrastructure on curriculum implementation. There was no statistical significant difference in the learner performance in biology final examinations between the two sets of schools. It was also found that there was no difference in the distribution of learner textbooks and laboratory apparatus in the two sets of schools. However, the old established schools showed presence of teaching models and preserved specimens that were absent in upgraded secondary schools. There was no significant difference in terms of the effect of teaching and learning materials on curriculum implementation.

The teaching practices were characterised by limited use of teaching aids and teaching methodologies in both sets of secondary schools. The classroom practices were negatively affected by time and teaching and learning materials constraints in both upgraded and old established secondary schools which in turn had a negative impact on biology curriculum implementation. The next chapter focusses on discussing these findings.

CHAPTER FIVE

DISCUSSION OF THE FINDINGS

This chapter discusses the findings on the nature of school infrastructure; availability and state of teaching and learning materials and biology teacher classroom practices in relation to implementation of the biology curriculum in upgraded and old established secondary schools.

5.1 School infrastructure and implementation of biology curriculum

Distribution and state of school physical facilities between upgraded and old established secondary schools was different with old established secondary schools having better science laboratories, staffroom and school hall infrastructure. Laboratory rooms were present in upgraded secondary schools. Effect of school infrastructure on the biology curriculum implementation was not different between the two sets of schools as the learner academic performance in grade 12 biology final examinations was better in upgraded secondary schools although the difference was not statistically significant.

5.1.1 Distribution of science laboratories

The observed difference in the distribution of the science laboratories between upgraded and old established secondary schools is in line with the findings of the parliamentary report (MoJ, 2013) which showed that most of the primary schools that were upgraded to secondary school status lacked the necessary space and facilities fitting a junior secondary school later on a secondary school. However, the findings of my study showed presence of laboratory rooms in the upgraded secondary schools. This can be explained by the fact that a number of upgraded secondary schools had taken up the initiative of partnering with the communities through the Parents and Teachers Association (PTA) to construct the science laboratories. Additionally, an official from MoGE acknowledged that the upgraded secondary schools do not normally have the science laboratories but that the MoGE has been assisting in the construction of science laboratories as well as other interventions such as distribution of the mobile science laboratories to these upgraded secondary schools.

Findings showed only one upgraded secondary school having benefited from the mobile science laboratories project. The mobile science laboratories however, cannot replace the conventional science laboratories. For instance, an official from MoGE noted that although mobile science laboratories cannot replace the actual constructed laboratories they are stock up measures before full-fledged laboratories are constructed so that teaching of science can be started. However, this showed little contribution towards curriculum implementation as the mobile laboratories were stacked together without a sign of usage.

The case of one of the old established secondary schools (OL4) having a single laboratory where its two other laboratories had their inner structures raised down and converted to conventional classrooms depicts a school culture that doesn't value the importance of science laboratories in the teaching and learning of science. This shows that the laboratories raised down were not utilized hence the possible move to convert them to conventional classrooms. Equally, the data in Figure 4.4 of the learners' indication of whether their school had a laboratory specifically meant for learning biology depicts the schools' culture of using laboratories as conventional classrooms especially in the category of upgraded secondary schools.

The presence of science laboratory in a school is not in itself the guarantee that biology lessons are conducted from the laboratories. For instance, from the findings in Figures 4.1 and 4.2, the laboratories especially in the upgraded secondary schools were used as conventional classrooms and for non-science lessons which defeats the purpose of the science laboratories where experiments in biology can be conducted from involving participation of learners. The use of the laboratory rooms for purposes of prepping and hosting learner club meetings other than JETS shows that these rooms are not used for their sole purpose of facilitating the teaching and learning of biology such as conducting of practical lessons involving experiments. And it has been shown from the other studies that practical lessons are more likely to occur in science laboratory (Nghipandulwa, 2012). The use of biology laboratory for purposes other than teaching and learning of biology is in contradiction with the social constructivists' approach of learning science which recommends practical lesson because learners cannot easily forget what they see with their own eyes during practicals and experience reality to construct their knowledge (Driscoll, 1994).

The use of science laboratories as conventional classrooms in upgraded secondary schools was also compounded by over-enrolment of learners as one of the teachers indicated that the school environment supported biology curriculum implementation by 40 percent because the classrooms were not enough and as such laboratories were used for non-science lessons. Still another teacher indicated that his school lacked room for preparation and conducting of demonstrations and experiments during biology lessons.

Although, in the old established secondary schools the laboratories were not used as conventional classrooms. The state of these laboratories is of concern as teachers' assessment of the state of biology laboratory was either satisfactory or dilapidated as shown in Figure 4.3. This is similar to the findings by Siwale (2013) that the schools that mostly lacked science laboratories were those upgraded from basic schools while the old established secondary schools had laboratories despite these laboratories being in a dilapidated state and lacking essential apparatus, equipment, storage facilities and furniture.

5.1.2 Distribution of other key school physical facilities

The data in Table 4.2 showing the absence of a school hall in all the upgraded secondary schools further compounded the problem of using the existing science laboratories for purposes other than the learning of biology. This explains why learners use the laboratory rooms for prepping and holding of club meetings. Even though this is done after class session but its negative effect on the learning of biology is translated into failure to set up apparatus for experiments and generally the storage of the laboratory equipment that would otherwise be disturbed during the prep and club meeting activities.

School infrastructures such as staffroom and science department office were found in both sets of secondary schools. However, the state of this infrastructure was different in the upgraded and old established secondary schools where old established schools had satisfactory to very good infrastructure while in upgraded schools it was either satisfactory or dilapidated which is of concern as Durosaro (1998) argued that even if the educational curriculum is sound and well operated while the school facilities are in disrepair and badly managed, the result of the teaching and learning activities will be negative. This difference in the state of the infrastructure translates into a difference in the culture of the particular school since the school infrastructure forms part of the school culture which subsequently influences biology curriculum implementation.

5.1.3 School infrastructure effect on curriculum implementation and learner performance

While it has been noted that there was a difference in school infrastructure between the two sets of secondary schools, it is worth discussing the effect of this difference on the teaching and learning of biology as well as the learner performance in the grade 12 final examinations. In terms of the usage of the science laboratory for learning, data in Figure 4.5 showed that only half the learners from OL6 had their biology lessons from the laboratory while in the rest of the schools learners rarely had their lessons from the laboratory. These findings imply that there is very little practical activity during biology lessons as Milner, Templin and Czerniak (2011) determined from their study that constructivist teaching practices were found to occur more often in the life science laboratory than in the regular classroom. However, Njiru (2012) argues that the conventional classroom can facilitate science practical lessons especially in the absence of a school laboratory. Nonetheless, Njiru's argument cannot hold against data in Figure 4.38 which showed that majority of the learners from the schools with the exception of OL4 and OL6 did not experience practical lessons in biology. But it must be noted that the question for the data in Figure 4.5 sought to determine how often the teacher conducted biology lessons from the laboratory which may not fully determine whether practical lessons were conducted or not. Therefore, conducting of biology lessons from the laboratory does not signify practical lessons in biology.

The use of science laboratories as conventional classrooms and for purposes other than learning of biology in upgraded schools and continued lack of use of science laboratories for biology lessons in old established schools both affects negatively on the implementation of the biology curriculum. This is because the science laboratory stands as suitable learning environment of natural science subjects like biology. For instance, Hofstein and Mamlok-Naaman (2007, p. 105) observed that "over the years, many scholars have argued that science cannot be meaningful to students without worthwhile practical experiences in the school laboratory''. In addition, lack of practical learning activity through the non-use of the science laboratory deprives the learners of an opportunity of collaborative learning to arrive at shared meaning (Crawford, 1996). The non-usage of science laboratories for biology learning therefore contributes less to constructivist approach of learning biology which in turn implies that learning of biology in both sets of secondary schools is heavily dependent upon the schema cognitive theory of learning science.

Although my study did not directly measure the cause for the non-usage of the biology laboratory by the teaching staff from the old established secondary schools, the following response by one of the teachers from OL2 seems to suggest that despite the availability of the science laboratories, the constraint of learning time and class enrolments may have hampered the use of the laboratory;

The laboratories are there and the materials are provided. The challenges experienced are the large number of pupils in classes; the other challenge is time allocation. One teaching period is 35 minutes instead of 40 or more minutes.

One other observation worth noting from the above response is that the insufficient allocated lesson time makes it difficult for the teacher to make use of the laboratory as migration of a class from a conventional classroom to the biology laboratory is viewed as waste of time and therefore not necessary, this in turn makes it difficult for teachers to employ the constructivist approach during curriculum implementation. Although Roy and Sengupta (2014) argue that school infrastructure can motivate the teachers, the findings of my study do not conform to their findings as it has been noted that teachers in old established schools would not make use of the biology laboratory which they assessed to be satisfactory for the implementation of the biology curriculum because of the time constraint and high enrolment levels.

Despite the difference in the state of the staffroom and science department office between the upgraded and old established secondary schools from Table 4.2 and observations from SIMC. The perception of the teaching staff on the importance of these two key infrastructures was not different between the two sets of schools as observed from teacher responses concerning effective curriculum implementation with respect to school infrastructure. Teachers mainly focussed on the science laboratory as the only school infrastructure relevant for implementing biology curriculum. However, data in Figure 4.6 showed a relevance of the school staffroom to the teachers' work where teachers from old established schools rated this infrastructure as suitable for lesson preparation, with the exception of OL4. The lack of mention of the school staffroom and science department office but rather science laboratory in the teachers' recommendation on effective biology curriculum spells the little importance of such infrastructure on teachers' mind-set and culture in the dispensation of the science curriculum.

Although teachers from old established schools with exception of OL4 agreed while those from upgraded schools disagreed that their school infrastructure contributed positively on biology curriculum implementation as shown by data in Figures 4.7 and 4.8, it's not clear what particular infrastructure the teachers had in mind in responding to the question. Nonetheless, the teachers' opinions reflect the findings of Ayeni and Adelabu (2011) that the school infrastructure affected teacher's instructional performance. This implies that school infrastructure in old established except OL4 impacted positively on teacher instructional performance while in upgraded school infrastructure impacted negatively on teacher instructional performance.

The effect of school infrastructure on biology curriculum implementation can be reflected in learner academic performance in the final examination as is one way of interpreting the learning outcomes (Fullan & Pomfret, 1977). Despite the observed difference in distribution of school infrastructure and its effect on curriculum implementation, the data in Figures 4.10 to 4.14 of learner academic performance in national grade 12 biology final examinations are contrary to the findings by Ayeni and Adelabu, (2011); Branham, (2004); and Aladejana and Aderibigbe, (2007) whose studies showed a relationship between the state of school infrastructure and learners' academic performance. The findings of my study that showed better learner performance in upgraded secondary schools that lacked in school infrastructure compared to old established schools with better school infrastructure may be attributed to no difference in the teaching and learning style which is predominantly theoretical as supported by the schema cognitive theory in both sets of schools. Although the analysis of variance of the learner performance in biology final examinations showed no statistical significant difference between the two sets of secondary schools, some of the teachers agreed that the state of their school infrastructure affected learner academic performance in final examinations. The weakness with the data in Figure 4.9, is that the direction of the effect (whether positive or negative) was not measured. Statistically, the observed difference in learner performance can be attributed to chance and cannot be used to predict learner performance in future biology examinations.

In terms of this study's theoretical framework, the findings on learner academic performance are largely explained by the schema theory that proposes that learners can learn science effectively through the lecture method for as long as there is a connection between the new concept and old concept (Davis, 2013; Shumba, Ndofirepi & Gwirayi, 2011). This mode of learning is less or not dependent upon school infrastructure such as laboratory since the teaching and learning methods of lecture and problem solving is still effective in the conventional classroom environment. This also implies that the biology curriculum is largely implemented on the grounds of schema cognitive theory. Although the schema discourages rote learning, the findings of my study suggest learners learn biology through rote learning. However, in-depth analysis of the raw results of paper 3 (practical component) of the grade 12 biology final examinations would have helped to give a comprehensive explanation of the learner academic performance difference between the two sets of schools. For instance, Chabalengula *et al.* (2008) found that science as a way of knowing, and investigative nature of science themes received the most coverage in the biology examinations, and aims and assessment objectives sections of the biology syllabus, although it was not specifically stated which component of the biology examinations papers received the investigative nature of science literacy theme.

The information from the MoGE official that the upgraded secondary schools were prioritised over old established schools in that they received graduate teachers could have explained the difference in learner performance but this is inconsistent with the teacher demographic data in Table 4.6. Therefore, teacher distribution in the two sets of schools cannot explain the observed phenomenon in terms of the learner academic performance in biology final examinations thereby pointing to the schema theory as the basis for the same statistically performance scores.

5.2 Teaching and learning materials for biology curriculum implementation

The study considered key teaching and learning materials and found that there was no difference in the distribution of prescribed biology textbooks, ICT materials and laboratory apparatus between the two sets of schools. However, there was a difference in the distribution of the preserved specimens and biological models with the upgraded secondary schools lacking such materials.

5.2.1 Availability of biology curriculum materials

Effective curriculum implementation cannot be separated from accessibility to curriculum materials such as prescribed textbooks and the biology syllabus by both teachers and learners (Fullan, 1991). Data in Figure 4.19 which showed that most learners from both sets of secondary schools did not have access to the biology syllabus document makes it quite difficult to promote the learner-centred approach advocated for by both the constructivist theory and the curriculum designers. This is because the learners may not have the opportunity to read ahead and construct knowledge from the textbooks due to lack of advance information (from the syllabus) and as such the learners will continue to view their teacher of biology as the ultimate learning authority as opposed to him/her playing a facilitator role of the learning process (Ratanaroutal & Yutakom, 2006).

The accessibility of the prescribed learner textbooks is poor as shown by the findings in Figure 4.20. The numbers of learners that accessed the textbooks from both sets of the schools is insignificant compared to the sampled population. This impacts negatively on the teaching of biology as the learners are made to wholly depend upon their teachers for the entire learning and realisation of the curriculum objectives. Learners are not accorded an opportunity to construct knowledge from their experience with the curriculum materials (Akinbobola & Afolabi, 2010). In addition, Chabalengula *et al.* (2008) findings that the basic knowledge of science and investigative nature of science is more covered in the biology textbooks and biology syllabus content objectives is missed in a school environment where curriculum materials are scarcely provided. This entails that the learners' chance of formulating knowledge from such materials is greatly hindered thereby hampering effective biology curriculum implementation through leaner-centred approach (Lee & Zuilkowski, 2015) in both sets of secondary schools.

Although the prominent book ratio was found to be 1:2 (one textbook for two learners) as shown in Figure 4.21, the book retention time is very poor as evidenced from the data in Figure 4.22. Borrowing a book for less than a week may entail the learners are only allowed to use it for a day or during the biology lesson. The learner textbook ratio is still high as the textbooks are unavailable; this correlates with the findings by Lee and Zuilkowski (2015) that the learner textbook ratio was very high in most of the schools (inadequate textbooks) due to the high enrolment levels, although their findings are limited to primary school textbook distribution.

5.2.2 Availability and state of other key biology teaching and learning materials

Despite the difference in the distribution of biology models and preserved specimens as shown in Table 4.5 from SIMC data, there was no difference in effect on curriculum implementation between the two sets of the secondary schools. For instance, frequencies in Figure 4.17 where almost half of the learners from old established secondary schools indicated absence of biological learning models implies that their teachers do not use such materials during lessons, although this may also be attributed to the learner participants' lack of understanding of the term biological models as it can be seen from the responses from UP1 and UP3 where learners indicated presence of models when in actual fact their schools lacked those materials.

The available biological models in the old established secondary schools were mainly the skeletal system model and the human model illustrating most of the human biological systems. This is still inadequate considering the five streams for each grade in the school

(MESVTEE, 2013). This is in line with the data in Figure 4.16 in which the biological models were cited as one of the most readily available teaching materials only in OL6. The inadequacy of biological models is inconsistent with the learning by constructivist approach as the enrolment levels in the schools cannot allow the learners' manipulation of the said models. For instance, Heinich, Molenda and Russell (1989) argue that biological models may not necessarily offer the real life experiences but can greatly provide concrete experiences to the learners. From my study's findings, it can be inferred that lack of the teaching and learning materials impedes the learner-centred approach of learning biology.

In addition, the preserved specimens found in the old established secondary schools are irrelevant to the current curriculum as they were acquired mostly in the 1980s. The preserved specimens are inconsistently stored as one of the teachers from OL4 noted "*Inconsistent storage of biology specimens and models*". The lack of collection of some biological specimens such as insects and plants by laboratory assistants further compounds the problem of scarcity of these materials in both sets of schools.

Teaching and learning materials such as improvised charts, projected aid and live specimens are available in both sets of schools as measured by SIMC. However, data in Figure 4.16 from BCEQ is inconsistent with that from SIMC except for improvised charts. This can be attributed to the teachers' unawareness of their school environment where these materials like live specimens of plantae nature can be sourced. For instance, only a single teacher from UP3 indicated live specimen as one of the readily available teaching material. But specimens of plantae nature can be sourced within the school environment with the help of learners. Projected aids such as pictures and videos of biology concepts can be helpful in the absence of the actual materials but findings indicate it as one of the least cited available teaching aid among the teachers. Although each school had a computer laboratory with computers and a projector, the materials are restricted to teaching and learning of ICT at junior secondary level and therefore not accessible to senior secondary section later on learning of biology.

Distribution of laboratory apparatus was not different in both sets of schools. Although there was enough of glassware apparatus at the time of the study, there was not enough for the practical lessons in biology as indicated in Figure 4.23. This difference can be explained by the fact that glassware apparatus is normally procured during the final examinations in order to meet the current biology paper three examination requirements for the respective examination. It is some of these materials that are retained by the secondary schools after the practical examinations have been conducted. These are also the findings by Manda (2012) that the laboratory equipment is usually procured during the final examination period. The schools' culture of procuring the laboratory materials during the examinations is also evidenced from data in Figure 4.25 where teachers from both sets of the secondary schools agreed that school administrators only procure science materials during examinations. Laboratory reagents such as Iodine, mineral acids, copper (II) sulphate, biuret reagent, benedict's solution and distilled water were found lacking which further confirmed Manda's findings. This schools' culture does not support effective curriculum implementation in that the constructivist approach of learning biology as a science is not promoted. In most cases, the learners are exposed to some of the laboratory apparatus for the first time during their practical examination.

Generally, teaching and learning materials distribution in the two sets of the secondary schools is mainly from fairly adequate to inadequate as shown in Figure 4.15. This was also the finding by Haambokoma *et al.*, (2002) and Siwale, (2013). The limitation with my finding on teaching and learning materials is that the teachers were not asked to assess specific materials and as such, a teacher may have assessed the availability of chalkboard materials and charts.

5.2.3 Effect of teaching and learning materials on biology curriculum implementation

The availability of teaching and learning materials affects biology curriculum implementation. For instance, data in Figure 4.24 which showed teachers' opinion on impact of the teaching and learning materials on curriculum implementation are supported by the findings by Beyer *et al*. (2009) and Nghipandulwa (2012). The effect of the curriculum materials on teaching and learning biology is negative in both sets of schools. This is because lack of access to biology syllabus and textbooks by learners makes it difficult for them to check their learning progress against the set learning objectives before assessment by the teacher. In addition, this limits the use of learner-centred approach in learning biology as it is difficult for the teacher to play a facilitator role amidst shortage of such materials. Shortage of textbooks leads to learning biology with most of the learning time dedicated to copying notes from the chalkboard after the teacher has merely explained a few concepts by lecture method. Use of other biology textbooks that are not curriculum prescribed exposes the learners to irrelevant topics especially when there is no curriculum guide (syllabus document). The result is often rote learning because learners focus on retaining the bulky notes given to them.

Lack of access to curriculum materials by teachers further compounds the negative effect of teaching materials on teaching of biology. Some of the old established secondary schools teachers' claim that they had no access to the biology syllabus raises question as to how effective they are able to implement the curriculum. For instance, Beyer *et al.* (2009) noted that teachers often use curriculum materials to guide their planning and enactment of lessons. But how can these teachers plan their lessons without access to the curriculum document? In such cases, the content sequence of the curriculum may not likely be adhered to and there is a high chance of those teachers skipping some of the curriculum content whose effect may translate into poor learner performance in the final examinations. In addition, this may lead to poor lesson planning among such teachers.

The impact of lack of the teaching aids can be noted from the findings in Figure 4.36 where the teachers mostly used the traditional chalkboard with a few lessons characterised by use of an improvised chart, textbooks and live specimen. This limited use of teaching aids underplays learner-centred learning as a constructivist supported method. Lack of laboratory equipment and materials in both sets of schools impacts negatively on curriculum implementation, for instance, one of the teachers from OL6 estimated the school's environment support to curriculum implementation to be 80 percent and accounted for the shortfall as follows:

> *The percentage is estimated to be 80% due to the fact that sometimes the laboratories lack certain important materials that are required to conduct practicals such as reagents, hand lenses and litmus papers etc.*

The effect of the teaching materials received similar evaluation in upgraded secondary schools in which two of the teachers from UP3 and UP5 estimated school's environment to be at 50 percent because their schools lacked some of the key materials and apparatus and teaching aids respectively. The negative effect of the scarcity of teaching and learning materials is not different between the upgraded and old established secondary schools as some of the teacher recommendations on effective curriculum implementation suggest from upgraded and old established secondary schools respectively:

Improve on teaching and learning materials in the laboratory; The Ministry of General Education should ensure they monitor all schools to make sure they purchase the required materials; Schools should be advised to scale up the budget for the procurement of adequate laboratory apparatus; In order for the biology curriculum to be well implemented in schools as prescribed, school managers and various stakeholders should have interest and provide the necessary materials needed for it to be implemented

It is not very easy to implement the biology curriculum in that learning and teaching materials are inadequate and this makes it difficult for effective learning; The Ministry of General Education should provide enough learning and teaching materials to enhance effective learning; The school should procure more books, apparatus and other teaching materials in order to enhance learning and implement the new curriculum more effectively.

The above teacher recommendations clearly implies that the state and availability of the teaching and learning materials in both sets of schools has impacted negatively on the implementation of the biology curriculum by affecting teaching and learning methods. This causes the teaching staff to turn to teacher-centred style of lesson delivery where the learners have no or little chance of formulating knowledge from their own experiences. The ultimate result of this is rote learning by the biology learners especially that biology subject has a lot of concept definitions and explanations that are also reflected in paper two of the final examinations. The other consequence is lack of practical learning activities, for instance, Nghipandulwa (2012) cited lack of practical work in biology as being due to lack of teaching and learning materials. However, lack of the practical activities during biology lessons can also be attributed to teachers' lack of innovation to improvise the teaching materials as was observed from the findings of this study where teachers were unaware of the abundant natural resources around their school that are vital in teaching topics such as transport system in plants, reproduction in plants, growth and development in plants, nutrition in plants.

Lack of teacher innovation may be springing from the lack of deliberate prescription and recommendation of usage of locally available teaching materials by the curriculum designers. The problem of lack of teaching and learning materials can be reduced if the locally and readily available specimens are deliberately recommended for teaching certain topics. If some of these specimens can be sourced during final examinations at a less cost because they are inescapable requirement of the practical examination, they can also be sourced during teaching and learning with the help of the learners. And when learners are involved in sourcing the readily available learning materials from their environment, constructivist approach of learning biology would be fostered (Driscoll, 1994; Tlala, 2006).

The effect of teaching and learning materials on the learner performance in the final examinations stands neutral from data shown in Figures 4.10 to 4.14 where the learner performance was better in the upgraded schools than in the old established schools with the exception of UP3 and OL4. This differs from the findings of Mlozi, Kaguo and Nyamba (2013) that learner academic performance was poor in community schools that lacked the teaching and learning materials. Malambo (2012) also showed that learner academic performance in non-grant aided secondary schools was unsatisfactory as compared to grant aided secondary schools due to few or no teaching and learning resources. The difference between my findings and the findings by others on learner academic performance can be explained by the fact that the culture of provision of teaching and learning materials in both sets of secondary schools is very poor and that materials are usually bought for expedience of conducting the practical examinations as is the case with the findings by Manda (2012). Equally Malambo (2012) acknowledges that the provision of teaching and learning materials in non-grant aided secondary schools is a major challenge.

However, this difference in the research findings could have been explained better if specifically the learner academic performance in paper three of the final examinations was analysed as opposed to the aggregate score of all the three examination components. This is because some learners might have performed exceptionally well in papers 1 and 2 at the expense of the practical paper (paper 3). Additionally, other factors other than school infrastructure and teaching and learning materials may have been at play in the learner academic performance.

The lack of promotion of learner-centred approach due to scarcity of teaching and learning materials in both sets of secondary schools helps to explain the trend in learner academic performance observed in my study in that biology is largely learnt by the schema cognitive theory where teachers can use limited teaching methods (lecture, problem solving and question and answer) and communicate the biology concepts to the learners. However, this has adverse effect as it leads to culture where learners merely aim to pass the final examinations rather than applying the scientific concepts. Although Das (1993) argues that schema theory cannot be effective in the absence of instructional materials such as biological models and specimens, the distribution of such materials is not significantly different and may therefore not be appropriate to explain the learner academic performance observed between the upgraded and old established secondary schools.

5.3 Teacher practices and biology curriculum implementation

The teaching staff distribution in terms of the years of service and professional qualification was not different between the two sets of schools. Lesson time allocated for learning biology was not adequate and teacher classroom practices are not different between the upgraded and old established secondary schools.

5.3.1 Teacher distribution and curriculum implementation

Because teachers play the central role in the implementation of the curriculum in the classroom in both developed and developing countries, it’s important to discuss how the teacher qualifications and years of service hinge on the biology curriculum implementation. For instance, Montero- Sieburth (1992) found that the teacher’s level of training, experience and professionalism impact on curriculum implementation. My findings show most of the teachers (62 percent of sampled population) are holders of bachelors’ degree with majority of them having years of teaching service between 1-17 years. These findings are not in line with the findings by Chifwa (2015) in terms of the professional qualifications in that Chifwa (2015) indicated that most biology teachers were diploma holders. This difference in the findings may be attributed to the fact that many of the biology teachers have upgraded their qualification through the Fast Track programme of the MoGE. Additionally, the increased number of graduate biology teachers may be as a result of teacher recruitment by MoGE as echoed by its official. In terms of teacher gender as shown in Figure 4.26, most biology teachers are females in line with the findings by Chifwa (2015).

Although Chifwa (2015) argues that the teachers with bachelors’ degree qualification taught better than those with college diploma qualification, my study didn’t fully establish the relationship between teacher practices and teacher qualification as the teachers observed for biology lessons were not asked about their level of qualification. However, findings showed no effect of teacher qualification on teaching of biology because of the same classroom teacher practices in the two sets of secondary schools. This can be explained by the findings by Cronin-Jones (1991) that teachers’ perceptions and beliefs play a critical role in the curriculum implementation process. In addition, Musau and Abere (2015) showed that there was no significant difference between teacher qualification and students' academic performance in science mathematics and technology subjects. The teacher qualification impact on curriculum implementation may have been shadowed by other factors as my study looked at the prevailing conditions other than the cause and effect.

Teacher gender shows some influence on teaching of biology from the data in Figure 4.39 where a larger percentage (45%) of learners taught by male teachers indicated that their teachers conducted practical lessons compared to 32 percent of those taught by female teachers. This is in line with the number of female teachers sampled for lesson observation which was four out of six teachers, and of the 12 out of 18 biology lessons taught by the female teachers there was no practical activity. This may be attributed to perceptions that biology is mostly learnt by rote learning as it is bulky and best suitable for females. For instance, Mansour (2013) noted that one of the female science teachers from his study confessed having taught science by use of lecture method until she was exposed to another culture.

5.3.2 Biology lesson allocated time and teaching load

The data in Figure 4.29 show that the allocated learning time for biology subject is inadequate contrary to the curriculum prescription (CDC, 2013). The allocated lesson time is different in each secondary school; however, there is no significant difference between the upgraded and old established secondary schools. The variation in lesson time allocation in each secondary school is as the result of the overall school enrolment where schools with exception of UP1 operated afternoon classes for the senior secondary (MoE, 1996). The findings in Figure 4.29 are consistent with the findings in Figure 4.30 where 75 percent of the teachers indicated that the allocated biology lesson time is inadequate. The 25 percent of the teachers that disagreed may be those teachers that taught their respective classes three times in a week (translated into five teaching periods per week) which is close to the curriculum prescription of six teaching periods in a week. In summary, the teaching and learning time for biology as allocated by the individual secondary schools falls short of the time allocation prescribed by the curriculum designers. There is no difference in the allocated teaching and learning time between the two sets of secondary schools.

The effect of the inadequate biology lesson time on curriculum implementation is negative as can be seen from some teacher classroom practices. For instance, out of the lessons observed, all the lessons were conducted within the allocated time although some were not concluded. The implication of this finding is observed from the small number of the lessons observed where learner-centred approach was promoted to a large extent and from data in Figure 4.34, only four out of eighteen lessons were characterised by learner-centred approach. This suggests that teachers are not keen to use methodologies and teaching activities that are learner-centred for fear of failing to cover much of the topics in the syllabus for the final examinations. This is also what Scott (1994) noted that time constraint and pressure of examinations impact negatively on teachers' role of implementing the curriculum. For instance, one of the teachers had to say the following concerning allocated biology lesson time in relation to the biology curriculum; "*The biology syllabus is too wide; therefore, more teaching time and experiment time should be given".* Another teacher from one of the old established schools wrote "*The biology curriculum is so wide such that it is not always easy to complete the syllabus in good time in preparation for the final examinations"*.

The result is use of the lecture method that is teacher-centred and this falls short of the effective teaching and learning of science but fostering learning of science by the schema cognitive theory.

The negative effect on curriculum implementation due to lack of adequate lesson time is also observed from the poor teacher tendencies in assessing learners for each lesson as shown in Figure 4.41 where most of the observed lessons (12) were characterised by lack of learner assessment tasks. There is hardly time to assess the learners especially when the teacher can hardly conclude the lesson within the allocated learning time. Nonetheless, the teachers can still give home work when the lesson time is inadequate. The lack of deliberate effort on the part of teachers to give assessment tasks to learners such as group work tasks falls short of the constructivist approach of enabling learners to fully participate in the learning process through collaborative learning. Even in cases where a class exercise was administered, there was no evidence of teacher marking the learners' work. This is still attributed to the limited allocated lesson time. The effect of teaching and learning time on learner class assessment is not different between the upgraded and old established secondary schools. One of the positive effects on the curriculum implementation is that the teachers are able to assess learners through monthly tests where most of the learners agreed that their teachers administer two tests in a term. This was also confirmed during the time of lesson observation.

The effect of teachers' teaching load on curriculum implementation is positive in upgraded while negative in the old established secondary schools as shown by findings in Figure 4.31. This is based on the teachers' opinion; however, a look at the teaching time tables of the teachers that were sampled for lesson observation showed that the teaching loads were within the normal stipulated loads of 28 teaching periods per week for each teacher in both sets of the secondary schools. The difference in the teachers' opinion on their teaching loads between the two sets of secondary schools can be attributed to overall school enrolments in which case the old established schools enrol more learners for each grade stream, although the teacher staffing levels is also high in the old established schools. Additionally, the teachers' opinion from the old established secondary schools may also be due to the bulkiness of the biology syllabus thereby teachers thinking completion of the syllabus content would be possible if more time was allocated and few classes allocated to them. For instance, one of the teachers from OL2 in suggesting for effective curriculum implementation wrote, "*The syllabus is wide; it is difficult to complete it especially that our learners begin their examinations early".* These words depict the bulkiness of the biology syllabus. But it's also worth noting that the teachers who teach biology also teach other science subjects such as chemistry and integrated science at junior secondary level. Nonetheless, the teaching load is within the prescribed limits of 28 teaching periods in a week for each teacher in both sets of secondary schools.

5.3.3 Influence of teacher classroom practices on curriculum implementation

A look at the findings on teacher methodology shows no difference between the upgraded and old established secondary schools as indicated in Figure 4.32 where question and answer; group discussion; demonstration; experiment as the most readily used methods by the teachers in the descending order. The lecture method was cited as used by a few teachers. However, from the 18 lessons observed, the most frequent teaching methods were lecture and question and answer in both sets of schools with no difference. Demonstration, problem solving and brainstorming were rarely observed. This difference between the methods that teachers claimed to have used often and the actual methods observed suggests that the teachers are aware of the methods that are effective in teaching biology as a science through promotion of the learner-centred approach and practical learning activities.

But it is still wondered as to why the teachers were not observed to use some of the methods they indicated in Figure 4.32 as the ones often used during lesson delivery? This can be explained by the fact that some of the topics taught during lesson observation did not necessarily require use of some methods like experiment. For instance the lessons observed in OL4 were on human reproduction which rendered some teaching methods out of context. This is also evidenced in the attainment of science process skills shown in Figure 4.35 where some of the prescribed science skills were attained very well with the use of limited teaching methods. Although some methods were not applicable to some of the lesson topics considered, the group discussion method which is learner-centred could have worked effectively. But the use of teaching methods could have been influenced by other factors, for instance, one teacher from OL4 wrote in relation to the school environment supporting curriculum implementation; "*The teacher pupil ratio makes it difficult for effective teaching in that the number of pupils in class is high and as such group discussion is hampered*". Another teacher echoed the same sentiments; "*There are so many pupils in class as a result group discussion becomes difficult*".

Although class enrolment is cited by some teachers as having hindered use of some teaching methods especially those that are learner-centred, Nkoya (2008) found that teachers were able to employ learner-centred methodologies in chemistry lessons despite the high class enrolment numbers. In addition, the average class enrolment in Figure 4.28 suggests a possibility of employing a group discussion method. For instance, in UP5 with highest class enrolment of 57 learners, 10 groups with an average of 5 learners per group could be formulated and supervised effectively. However, the limitation to the class enrolment (as shown in Figure 4.28) is that the sampled teachers for lesson observation may have taught the pure science class (class taking pure sciences) which in most cases has the least enrolment in the stream as is the case with class in OL6. Other factors limiting use of some teaching methods include time constraints, resources availability and infrastructure as discussed in the previous sections and in line with other studies by Beyer *et al.*, (2009); Haambokoma *et al.*, (2002); and Milner, Templin & Czerniak, (2011). Overall, the choice and use of teaching method is in most cases teacher-bound as found by Cronin-Jones (1991), that teachers do not often implement the curriculum as prescribed by the curriculum designers but often change implementation to suit their style of teaching. This is the case with my findings on teacher methodology as teachers choose particular methods that suit their conditions owing to school infrastructure, availability of teaching and learning materials as well as the type of learners.

In relation to promotion of learner-centred learning by teachers, most learners from both sets of secondary schools indicated question and answer method as used during lessons. This is consistent with the data in Figure 4.33. However, half of the learners from both sets of schools disagreed that their teachers gave them group discussion tasks. Field trip is not used in the teaching of biology despite its prescription in the biology curriculum as a way of promoting learner-centred lessons and constructivist approach (CDC, 2013).

The continued use of limited teaching methods (lecture and question and answer) during biology curriculum implementation from my findings and as noted by Chifwa (2015) has a negative effect. The negative effect is observed in the non-promotion of learner-centred lessons as observed. Although Nkoya (2008) found that teacher qualification and experience as well as teaching materials as constraints to use of learner-centred approach, this is not the case with my findings in that methods such as question and answer and group discussion as cited by Nkoya (2008) as some of the learner-centred methods do not require complex learning materials such as laboratory apparatus. But the influence of teacher experience and qualification may hold except to a limited extent due to no difference in the observed teacher classroom practices.

The monotonous use of the lecture method points to the fact that the constructivist approaches such as collaborative learning and practical learning activity that would enable learners construct knowledge from their classroom experiences is hampered and as such learning of biology is largely supported by the schema cognitive theory. This poses a negative influence on curriculum implementation as the schema theory is misconstrued when learners resort to rote learning. As observed during the lessons, when the lecture method was used continuously during lesson delivery, the learners became increasingly passive or merely took notes. This observation clearly implies that constructivist principle of learners actively participating during a lesson is obscured by perpetual usage of lecture method (Ratanaroutal & Yutakom, 2006).

From the lessons observed in relation to classroom teacher practices, there was limited use of teaching aids with highest use of the chalkboard and minimal usage of improvised chart, textbooks and live specimen as shown in Figure 4.36. This exerts a negative influence on the curriculum implementation especially on the lack of use of specimens that can help learners identify with their environment. However, teachers' innovativeness in the use of teaching aids other than the chalkboard exerted a positive influence on curriculum implementation as the learners' participation was encouraged and learners showed interest in the materials used as this is also supported by findings of Akinbobola and Afolabi (2010) that use of teaching aids facilitates attainment of science process skills. For instance, the use of the textbooks during one of the lessons in UP1 helped in the full realisation of the prescribed science process skills as shown in Figure 4.35, although some of the science process skills such as 'communicating' are largely attainable even in the absence of a teaching aid other than the chalkboard.

The classroom teacher practices in terms of practical activities during biology lessons showed that teachers from old established secondary schools conducted practical lessons often while teachers from upgraded secondary schools rarely conducted practical lessons as indicated in Figure 4.37. However, a triangulation of the finding from the learners' perspective showed learners from old established schools except OL2 having experienced practical lessons in biology while most of the learners from upgraded secondary schools did not experience practical lessons in biology as shown in Figure 4.38. The two findings are consistent as they show a difference between the two sets of secondary schools. The trend shift observed in OL2 may be attributed to an aspect of time constraint as this is the only old established school with least lesson time per period as can be seen from the statement of one of its teachers who wrote;

> *The laboratories are there and the materials are provided. The challenges experienced are the large number of pupils in classes; the other challenge is time allocation. One teaching period is 35 minutes instead of 40 or more minutes.*

The difference in the classroom teacher practices in terms of practical activity between upgraded and old established secondary schools may be attributed to teacher experience and qualification as found by Shamsudeen (2015) that teacher qualification and experience affect his/her ability to use laboratory equipment in biology practical work. However, findings of this study showed a very weak correlation between teacher experience and frequency of practical lessons which in any case was not statistically significant and a weak negative correlation between teacher qualification and practical work which was also not statistically significant. Additionally, there was no significant difference in teacher qualification and years of experience between the two sets of secondary schools to support the findings by Shamsudeen (2015) that teacher qualification and experience influence delivery of science practical activities by the teacher.

Despite the findings discussed in the previous paragraph, none of the 18 lessons observed was characterised by a science practical activity. This agrees with the findings by Chifwa

(2015) that the teachers of biology do not use practical learning activities when teaching genetics. This difference in findings from the teachers' and learners' perspective and the observed lessons in relation to practical activities can be explained by the time of lesson observation which was the first term of grade 12 academic year which may have mounted pressure on teachers to structure lessons in such a way that the scheduled grade 11 work was completely covered before transitioning to grade 12 scheme of work. For instance, one teacher from old established secondary school wrote in relation to curriculum implementation, "*With our bulky syllabus of biology, it is difficult to manage to do all the experiments in the syllabus*". This impacted negatively on the curriculum implementation as the teachers' merely focus on syllabus completion at the expense of normal teaching that can promote constructivist learning activities.

Even if the teachers claimed to have conducted practical lessons, from the lesson observations, learning of biology in the schools is characterised by lack of practical activities which mostly promote teacher-centred approach in both sets of secondary schools. This falls short of the constructivist approach of learning biology. However, the context also exerts an influence as Gercek and Ozcan (2015) found that context based approach was important in promoting practical learning of biology since it emphasised learning by doing. My findings can also be attributed to pedagogical content knowledge of teachers in biology. For instance, Chapoo, Thathong and Halim (2014) argued that pedagogical content knowledge of science teachers helps them to create constructivist classrooms and provides the opportunity for their students to learn science through an inquiry approach. This however, cannot be relied upon, as my study neither focused on the training of teachers of biology nor assessing their content knowledge which can adequately address the question on pedagogical content knowledge.

The role of the school laboratory assistant may also influence the teachers' ability to conduct practicals like experiments. This can especially help alleviate the challenge of the time constraint and shortage of biology specimens in school, as the laboratory assistant can set up laboratory apparatus for an experiment in advance for the teacher and help in the collection and preserving of the specimens respectively. From the data in Figure 4.40, most teachers from both sets of schools rated their laboratory assistants as effective. However, in upgraded secondary schools where the laboratories are used as conventional classrooms and lacking science preparation rooms, the role of the laboratory assistant may be rendered ineffective. The role of the laboratory assistant in the implementation of biology curriculum is negligible as none of the observed lessons had the input of the assistant especially in relating to conducting of practical lessons.

Findings on absence of unprofessional classroom teacher practices in terms of writing of notes on chalkboard without explaining and asking learners to copy notes from the text book as shown in Figures 4.43 and 4.44 respectively, impacts positively on the curriculum implementation. However, an indication of 30 percent learners from UP1 that their teacher asks them to copy notes from the textbook may be very possible as this is the school where use of the textbooks as teaching aid was observed. But this could be fully confirmed if the learners' note books were checked and notes compared to those in the textbooks.

5.3.4 Effect of CPD on curriculum implementation

Most teachers from both sets of the secondary schools agreed that the programme of lesson study cycle has contributed to their effectiveness in implementing the biology curriculum as shown in Figure 4.45. In addition, an official from MoGE indicated that the Ministry was encouraging CPD programme in the upgraded secondary schools to fill up the gaps generated by the infrastructure difference. CPD facilitates the exchange of knowledge among the teachers of biology on how best they can teach a particular topic and sharing of teaching materials such as improvised charts and personally acquired biological models. This has improved teaching of biology through improved lesson planning and delivery. For instance, one of the teachers in relation to suggestions on effective curriculum implementation wrote; "*The implementation of CPD has really helped many teachers as they are able to exchange and share new ideas from the meeting".* CPD also exerts a positive influence by facilitating effective interpretation of the curriculum aims and objectives collectively by teachers. However, it's not clear how easy it is to hold CPD meetings amidst the cited time constraint in both sets of secondary schools.

5.3.5 Teaching staff and learner academic performance

The teacher qualification and teaching experience distribution between the upgraded and old established secondary schools helps to explain the learner academic performance in grade 12 final examinations which showed no statistical significant difference between the two sets of schools as this confirms the findings by Musau and Abere (2015) that showed no significant difference between teacher qualification and students' academic performance in science, mathematics and technology subjects. However, in-depth statistical analysis could have helped explain the observed difference in the learner academic performance mean scores of the schools.

The same classroom practices observed between the two sets of secondary schools also explains the lack of significant statistical difference in the learner academic performance in the final examinations. For instance, Lederman (1999) observed that years of teaching experience caused clear differences between the classroom practices of teachers. But my findings show no significant difference in the distribution of teachers between upgraded and old established schools based on teaching experience. The teacher practices are the means of instructional delivery and because quality of instructional delivery determines the extent to which teaching practices have an impact on learners' academic achievement (Stevens, 1996; as cited in Ngware, Oketch & Mutisya, 2014), this explains the difference in the observed learner academic performance. The learner socio-economic factors have not been analysed in relation to academic performance as such factors were controlled through purposive sampling and subsequent pairing of the secondary schools.

CPD implementation in upgraded secondary schools can help explain the difference in the learner academic performance in the grade 12 final examinations as Musau and Abere (2015) observed that majority of the teachers of science, mathematics and technology subjects were trained graduates, most of them had attended in-service or refresher courses which resulted in slight improvement in the students' performance in science mathematics and technology subjects. In addition, intervention by MoGE to intensify CPD in upgraded secondary schools also helps explain the difference in learner performance. The limitation however is that my study didn't establish how effective the upgraded secondary schools implemented the CPD programme in comparison to old established secondary schools.

5.4 Chapter Summary

In summary, effect of school infrastructure on biology curriculum implementation showed no difference between the two sets of schools owing to some interventions taken by upgraded secondary schools and the MoGE at large. Better learner academic performance in upgraded schools is attributed to the fact that biology is most learnt theoretically in both sets of schools. Effect of teaching and learning materials on curriculum implementation is negative in both sets of schools owing to schools' culture of only procuring materials during final examinations. The teacher classroom practices showed no difference in both sets of schools due to same teacher characteristics, time and materials constraints.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusions on the findings of the study in line with the research objectives and questions. Recommendations to the Ministry of General Education, Curriculum planners, school administrators and teachers; and recommendations for further research are also presented in this chapter.

6.1 Conclusions

There is no significant difference in implementing biology curriculum between upgraded and old established secondary schools. The biology curriculum implementation is largely supported by the schema cognitive theory as opposed to constructivist theory of learning. Therefore, the teaching and learning and subsequent biology curriculum implementation in both sets of secondary schools is the same and not effective.

It can be concluded that teaching and learning of biology is the same in both sets of secondary schools despite old established secondary schools having better school infrastructure than the upgraded secondary schools. This is due to dilapidated laboratories in old established secondary schools and continued use of laboratories as conventional classrooms in upgraded secondary schools. Presence of laboratory rooms in upgraded secondary schools is as the result of the school management’s intervention alongside the community to upgrade the existing primary infrastructure to that of secondary school status. School infrastructure has negatively affected biology curriculum implementation resulting in teaching and learning biology that is theory based and not practical based.

It can be further concluded that the school infrastructure has had no effect on learner academic performance in the grade 12 final examinations since the teaching and learning process is not different in both sets of secondary schools. The implication of this is that the schema theory is effective in the learning of biology irrespective of the school infrastructure.

In both sets of secondary schools, lack of adequate curriculum materials was compounded by high learner enrolment levels. Laboratory apparatus are fairly adequate but inadequate to support teaching and learning of biology because of the schools’ culture of mostly procuring these materials for examination purposes. Old established secondary schools are stocked with biological models and preserved specimens which are inadequate and outdated respectively while upgraded secondary schools lack these materials altogether. The effect translated in lack of practical lessons in biology. Although both upgraded and old established secondary schools have some ICT materials, their usage is restricted to teaching and learning of ICT at junior secondary level and therefore teaching and learning of biology has not utilised ICT.

The lack of teaching and learning materials and non-usage of some of the available materials in both sets of secondary schools impacts negatively on the implementation of the biology curriculum as it makes learning by constructivist approach difficult as reflected by biology lessons' lack of practical learning activities. The schools' culture of procuring laboratory materials and some specimens for the expedience of conducting final examinations also impacts negatively on curriculum implementation in both sets of secondary schools as learning largely takes place by schema cognitive means at the expense of the constructivist approach due to lack of learner-centred lessons.

Regarding teaching practices in the classroom, it can be concluded that there is no difference in terms of qualification and teaching experience of biology teachers between sets of schools. Biology is mostly taught by female teachers. Time allocated for teaching and learning biology is inadequate in both sets of secondary schools. The implication of this being difficulties in covering whole curriculum content by teachers and learners and predominant use of teacher-centred techniques during lesson delivery.

The teacher classroom practices that range from teaching methodology, usage of teaching aids and conducting of practical lessons in biology are not different between the sets of secondary schools. Teacher methodology negatively affected biology curriculum implementation due to teacher-centred lessons emanating from perpetual usage of the lecture method. Limited use of teaching aids and non-practical based biology lessons has had a negative influence on the curriculum implementation as learners are predisposed to rote learning as a result of misconstruing of the schema cognitive theory of learning science.

The role of the school laboratory assistant is negligible due to poor stock of preserved specimens and lack of practical activities in biology. The CPD programme has had a positive effect on teacher classroom practices through improved lesson planning and delivery in both sets of secondary schools. Teaching experience and teacher qualification had no impact on learner academic performance in both sets of secondary schools.

6.2 Recommendations

Based on the research findings the following recommendations have been made to the respective stakeholders.

6.2.1 Recommendation to the Ministry of General Education

The Government should review its policy of upgrading some basic schools to secondary schools by ensuring that the school infrastructure is first upgraded before upgrading the school status. This may result in improved education standards through competitive provision of science education between upgraded and old established secondary schools.

The Ministry of General Education should consider restructuring school inspectorate and standards section to extend its mandate to conduct research studies as opposed to routine reports from inspections.

The Government should review the role of laboratory assistants in schools and subsequently recruit more for the lacking secondary schools.

6.2.2 Recommendation for curriculum planners

The Curriculum Development Centre should consider prescribing teaching and learning materials (specimens) that are readily available in regions of the country where the respective schools are located to reduce on the challenge of material scarcity.

The curriculum planners should prioritise the situational analysis stage of biology curriculum formulation and review by involving as many teachers as possible. The designers should review content of the current curriculum with respect to available learning time as this may make biology learning more pragmatic.

6.2.3 Recommendations for school administrators and teachers

The school administrators should procure and ensure proper use and storage of the teaching and learning materials for effective biology curriculum implementation. Teachers should endeavour to use the locally available teaching materials and subsequent improvisation of some of the lacking materials. School administrators should strengthen the CPD activities and facilitate any opportunities of in-service training for science teachers as this may motivate the staff and enhance their instructional delivery skills.

6.3.4 Recommendation for further research

Further research can be conducted to investigate biology curriculum implementation in grant aided secondary schools to ascertain the link between school enrolment and learner academic performance in practical examinations. Studies can also be conducted to investigate how effective upgraded secondary schools implement the CPD programme in science in comparison to old established secondary schools.

Future studies can also look at how teachers of biology are trained to ascertain their preparedness for practical based biology lessons and pedagogical content knowledge.

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APPENDIX A

BIOLOGY CURRICULUM EVALUATION QUESTIONNAIRE (BCEQ)

RESEARCH TOPIC:

IMPLEMENTATION OF BIOLOGY CURRICULUM: A COMPARISON OF UPGRADED AND OLD ESTABLISHED SECONDARY SCHOOLS IN NDOLA DISTRICT OF ZAMBIA

SCHOOL TYPE: ……………………………………………… BCEQ CODE: ………….

Dear Sir/Madam,

This questionnaire is designed to collect data on the biology curriculum implementation in upgraded and old established secondary schools in Zambia. The data collected will help the researcher compile a report which is a requirement for the completion of this study. You are also assured that the information you provide will be treated with the greatest confidentiality it deserves, therefore your honesty responses will greatly help. I would also like to assure you of <u>No risk</u> in participating in this study.

Thank you for accepting to complete this questionnaire.

Part A: Demographic Information

Please **tick [√]** to indicate your response to the question.

1. Indicate your level of professional qualification.
   Primary school teachers' certificate [ ]
   Secondary school teachers' diploma [ ]
   Advanced secondary school teachers' diploma [ ]
   Bachelor's degree [ ]
   Postgraduate degree [ ]
2. For how long have you been teaching (in-service)?
   0-5 years [ ]; 6-11 years [ ]; 12-17 years [ ]; 18-23 years [ ]; 24-29 years [ ]

3. Have you taught in a primary or basic school before?
   Yes [ ] No [ ]

4. If yes to question 3, did you move to your current post in this secondary school on secondment basis?

   Yes [ ] No [ ]

B. Teaching experiences relating to school infrastructure and teaching and learning materials

5. Are there science laboratories in your school?

   Yes [ ] No [ ]

6. If yes, how many laboratories are there? Indicate the number in the box.
7. How do you describe the state of the biology laboratory in your school?

   Very Good [ ]; Satisfactory [ ]; Dilapidated [ ]; Very Dilapidated [ ]
8. Does the biology laboratory in your school serve purposes other than teaching of biology? Yes [ ] No [ ]
9. What other purposes does the Laboratory serve? The laboratory is;

   Used for other lessons that are not science based [ ]

   Used as the prep/ study room [ ]

   Used for club meetings other than JETS meetings [ ]

   Used as a conventional classroom [ ]
10. How often do you conduct biology lesson/s from the laboratory?

    Very often [ ]; Often [ ]; rarely [ ]; Very rarely [ ]
11. Do you have a workroom in your department? Yes [ ] No [ ]
12. How suitable is the school staffroom in supporting your work preparations?

    Very suitable [ ]; Suitable [ ]; unsuitable [ ]; Very unsuitable [ ]
13. How do you describe the adequacy of biology teaching and learning materials in your department?

    Very adequate [ ]; fairly adequate [ ]; Inadequate [ ]; Very inadequate [ ]
14. Has the school provided you with a personal copy of the biology syllabus? Yes [ ] No [ ]
15. Has the school provided you with the prescribed biology textbooks?

    Yes [ ] No [ ]
16. How often do you conduct biology practical lesson/s?

    Very often [ ]; Often [ ]; rarely [ ]; Very rarely [ ]; Not at all [ ]

17. Of the following list of teaching materials, tick (√) the ones that are readily available in your school for teaching biology?

Charts [ ]; Biology models [ ]; preserved biological specimens [ ]; projector [ ] Live specimens [ ]

18. From the following list of teaching methods, which one/s do you often use when teaching biology? Tick the applicable ones.

1. Lecture [ ]; 2. Question & answer [ ]; 3. Demonstration [ ]; 4. Games [ ]

5. Experimental [ ]; 6. Group discussion [ ]; 7. Project [ ]; 8. Field work [ ];

9. Brainstorming [ ]; 10. Role play [ ]; 11. Problem solving [ ]; 12. Case study [ ]

19. To what extent does the school environment promote your effective teaching of biology as prescribed in the biology syllabus?

Give an estimate in percentage form [**%**]

20. Give a brief explanation for your given estimate?

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21. Have you ever taken your biology learners on a field trip? Yes [ ] No [ ]
22. Do you know of any colleague in your department who has ever taken his/her biology learners on a biology field trip? Yes [ ] No [ ]
23. Do you a have a laboratory assistant in your school?

Yes [ ] No [ ]

24. If yes, evaluate the role of the laboratory assistant in the effective implementation of biology curriculum.

Very effective [ ]; Effective [ ] Ineffective [ ]; Very ineffective [ ]

Part C: Respondent's views on the biology curriculum implementation

Please **circle** only one response that you think is the most appropriate to each of the given statements about biology curriculum implementation.

Statement about curriculum implementation	**Strongly agree**	**Agree**	**Neither**	**Disagree**	**Strongly disagree**
25. The state of the school infrastructure negatively affects my lesson delivery.	5	4	3	2	1
26. The state of the school infrastructure positively impacts on my lesson delivery.	5	4	3	2	1
27. The time allocation for teaching biology is inadequate.	5	4	3	2	1
28. The availability of teaching materials in the school affects the implementation of biology curriculum.	5	4	3	2	1
29. My teaching load hinders effective implementation of biology curriculum.	5	4	3	2	1
30. The state of school infrastructure affects the performance of learners in biology final examinations.	5	4	3	2	1
31. The availability of teaching and learning materials affects the performance of learners in biology final examinations.	5	4	3	2	1

Statement about curriculum implementation	**Strongly agree**	**Agree**	**Neither**	**Disagree**	**Strongly disagree**
32. Laboratory apparatus and materials are only procured by the school during biology examinations.	5	4	3	2	1
33. CPD has improved my effectiveness in implementing the biology curriculum.	5	4	3	2	1

34. What comments or recommendations can you give regarding the implementation of the biology curriculum?

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THE END

THANK YOU!

APPENDIX B

BIOLOGY LESSON OBSERVATION SCHEDULE (BLOS)

RESEARCH TOPIC:

IMPLEMENTATION OF BIOLOGY CURRICULUM: A COMPARISON OF UPGRADED AND OLD ESTABLISHED SECONDARY SCHOOLS IN NDOLA DISTRICT OF ZAMBIA

SCHOOL TYPE: ………………………………………………… BLOS CODE: ………….

ATTENDANCE: Boys [ ], Girls [ ] LESSON DURATION: …………………….

GENDER OF TEACHER: [ ] LESSON VENUE: ………………………………….

LESSON TOPIC: ……………………………………………………………………………

A. Teaching methodologies

1. What teaching methods are being used by the teacher and what is their frequency during the lesson delivery? <u>Assign tally marks</u>.

   Lecture [ ]; Question & answer [ ]; Demonstration [ ]; Games [ ]
   Experimental [ ]; Group discussion [ ]; Project [ ]; Field work [ ];
   Brainstorming [ ]; Role play [ ]; Problem solving [ ]; Case study [ ]
   Other/s (specify); ……………………………………………………..

2. What is the sitting arrangement of the learners?

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

3. Is there a recap from the previous lesson/s?

   Yes [ ] No [ ]

4. To what extent are the learners engaged during the lesson?

   Very actively participating [ ] actively participating [ ]
   Fairly active [ ] Less active [ ]

5. Describe learners' activity during the lesson development stage?

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

…………………………………………………………………………………………

…………………………………………………………………………………………

6. Is there any form of assessment given to the learners?

   Yes [ ] No [ ]

7. If yes, what type? ………………………………………………….

B. Practical activity used during lesson delivery

8. Is there any practical activity?

Yes [ ] No [ ]

9. What type of practical activity is done during the lesson?

Illustrative [ ]; Procedural [ ]; Investigative [ ]

10. Are learners participating? Yes [ ] No [ ]

11. Estimate the percentage of the class that is participating in the practical activity[%]

12. Is the teacher supervising the practical activity? Yes [ ] No [ ]

13. Has the teacher improvised materials needed for the practical activity?

Yes [ ] No [ ]

14. Has the practical activity been conducted within the allocated time?

Yes [ ] No [ ]

C. Teaching and learning materials

15. What teaching aids are being used during the biology lesson?

    Chart [ ]; Model [ ]; Live specimen [ ]; Projected aid [ ]; laboratory apparatus [ ] improvised chart [ ] Chalkboard [ ] Textbook [ ] improvised apparatus [ ] preserved specimen [ ]

    Other/s (specify); ………………………………………………………….

16. Describe the learners' interest in relation to the teaching aid/s being used other than the chalkboard?

    Very interested [ ] Interested [ ] Less interested [ ] Not interested [ ]

17. Describe the teachers' innovativeness in the use of the teaching aid/s other than the chalkboard?

    Very innovative [ ] Innovative [ ] Less innovative [ ] Not innovative [ ]

D. **Science process skills observed against the ones prescribed in the syllabus for the topic under consideration**

18. Which of the following science process skills have been observed during the lesson, what is the relationship in comparison to the prescribed process skills on the topic of consideration?

Science process skills	Observed	Prescribed	Comment
1. Observing			
2. Classifying			
3. Measuring			
4. Hypothesis formulation			
5. Making inference			
6. Making predictions			
7. Controlling variables			
8. Interpreting of data			
9. Defining operationally			
10. communicating			
11. performing calculations			
12. Using space/time relationship.			
13. Experimenting			

E. Researcher's reflection on the observed lesson

19. To what extent has the teacher promoted learner–centred approach?

Large extent [ ] limited extent [ ] Not at all [ ]

20. To what extent has the teacher exhibited teacher-centred approach?

Large extent [ ] limited extent [ ] Not at all [ ]

21. How has the teacher managed the allocated time for the lesson?

Well [ ] fairly well [ ] with difficult [ ]

22. Any other comments about the observed lesson?

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END OF OBSERVATION

APPENDIX C

BIOLOGY LEARNERS' SURVEY QUESTIONNAIRE (BLSQ)

RESEARCH TOPIC:

IMPLEMENTATION OF BIOLOGY CURRICULUM: A COMPARISON OF UPGRADED AND OLD ESTABLISHED SECONDARY SCHOOLS IN NDOLA DISTRICT OF ZAMBIA

SCHOOL TYPE: ………………………………………………… BLSQ CODE: ………….

Dear Respondent,

This questionnaire is designed to collect information on the biology curriculum implementation (teaching and learning) in upgraded and old established secondary schools in Zambia. The information collected will help the researcher compile a report which is a requirement for the completion of this study. You are also assured that the information you provide will be treated with the greatest confidentiality it deserves, and that it is meant for understanding the teaching and learning of biology science.

Thank you most sincerely for accepting to answer this questionnaire.

Part A: Demographic Information

Please **tick [√]** to indicate your response to the question.

1. Indicate your Gender. Male [ ] Female [ ]
2. Indicate Gender of your biology teacher. Male [ ] Female [ ]
3. For how long have you been enrolled in this secondary school?
   Less than 1 year [ ]; 1-2 years [ ]; 3-5 year [ ]

Part B: Learning experiences in biology in relation to school infrastructure

4. How many <u>science laboratories</u> are this school?
   None [ ]; One [ ]; Two [ ]: Three [ ]; More than three [ ]

5. How many <u>Times</u> do you have biology lesson/s in a <u>Week</u>?
   Once only [ ]; Two times [ ]; Three times [ ]; Four times [ ]
6. How many <u>Times</u> in a <u>Week</u> do you have your biology lesson/s from the Laboratory?
   None [ ]; Once only [ ]; Two times [ ]; Three times [ ]; Four times [ ]

7. Is there a laboratory in your school that is specifically meant for learning of biology?
   Yes [ ] No [ ]
8. If yes, does the biology laboratory in your school serve any purposes other than learning of biology? Yes [ ] No [ ]
9. If yes, what other purposes does the Laboratory serve? The laboratory is;
   Used for other lessons that are not science based [ ]
   Used as the prep/ study room [ ]
   Used for club meetings other than JETS meetings [ ]
   Used as a conventional classroom base for a grade class [ ]
   Others (specify): …………………………………………………………………………..

Part C: Learning experiences in biology in relation to teaching and learning materials

10. Do you have Practical lessons in biology? (If no, skip questions 11 and 12)
    Yes [ ] No [ ]
11. How often do you have Practical lesson/s in biology?
    Very often [ ]; Often [ ]; Not often [ ]
12. When you have biology practical lesson/s, are the laboratory apparatus and other necessary materials enough for all pupils in class?
    Yes [ ] No [ ]
13. Have you ever borrowed any biology textbook from your school?
    Yes [ ] No [ ]
14. If yes to question 13, with how many pupils do you share the biology textbook? Indicate number in the box; [ ]
15. For how long are you allowed to retain (Use) the borrowed biology textbook?
    ……………………………………………………………………….
16. Are there any biology learning models in your school?
    Yes [ ] No [ ] Don’t know [ ]
17. Are there any preserved biological specimens in your school for learning biology?
    Yes [ ] No [ ] Don’t know [ ]
18. Do you have access to a copy of the biology syllabus?
    Yes [ ] No [ ]

Part D: Respondent's views on the biology teacher practices in curriculum implementation

Please circle only **ONE** response that you think is the most appropriate to each of the statements about your biology teacher.

Statement about your biology teacher.	**Strongly Agree**	**Agree**	**I don't know**	**Disagree**	**Strongly Disagree**
19. Our teacher conducts practical lessons in biology.	5	4	3	2	1
20. Our teacher often conducts biology lessons from the laboratory.	5	4	3	2	1
21. Our teacher has in the past taken us out on an educational tour to learn biology.	5	4	3	2	1
22. Our teacher often gives us group work tasks when learning biology.	5	4	3	2	1
23. Our teacher uses charts (drawn diagrams), specimens and models for illustrations during biology lessons.	5	4	3	2	1
24. Our teacher allows us to ask questions during biology lessons whenever we are not clear.	5	4	3	2	1
25. Our teacher often writes notes on the board without explaining.	5	4	3	2	1

Statement about your biology teacher.	Strongly Agree	Agree	I don't know	Disagree	Strongly Disagree
26. Our teacher gives us two class tests in biology every school term.	5	4	3	2	1
27. Our teacher always asks us to copy notes from the textbook.	5	4	3	2	1
28. Our teacher makes use of computer projector when teaching us biology.	5	4	3	2	1

THE END

APPENDIX D

INTERVIEW SCHEDULE GUIDE FOR MoGE OFFICIAL

RESEARCH TOPIC:

IMPLEMENTATION OF BIOLOGY CURRICULUM: A COMPARISON OF UPGRADED AND OLD ESTABLISHED SECONDARY SCHOOLS IN NDOLA DISTRICT OF ZAMBIA

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1. When was the policy of upgrading some basic schools to secondary schools start?
2. What are the reasons that led to the generation of this policy?
3. Has the Ministry of General Education conducted any research to evaluate the performance of the upgraded schools?*
4. If so, what were the findings?
5. What measures does the Ministry take/consider before upgrading a basic school?
6. The parliamentary committee report of 2013 highlighted that most of the upgraded schools lack necessary infrastructure such as laboratories and laboratory equipment and adequate classroom space. What steps has the Ministry taken to address the challenges noted with respect to science education?*
7. What steps has the directorate of curriculum taken in science curriculum development owing to the two generations of secondary schools?
8. I would also like to find out if CDC consults this directorate when coming up with a curriculum?
9. Are there any co-operating partners assisting with the policy of upgrading basic schools to secondary schools in relation to science education? If so, what is their contribution?

*****Depending on the response to the question, a follow up question was asked.

End of Interview

APPENDIX E

SCHOOL INFRASTRUCTURE AND MATERIALS CHECKLIST (SIMC)

RESEARCH TOPIC:

IMPLEMENTATION OF BIOLOGY SCIENCE CURRICULUM: A COMPARISON OF UPGRADED AND OLD ESTABLISHED SECONDARY SCHOOLS IN NDOLA DISTRICT OF ZAMBIA

SCHOOL TYPE: ……………………………………………… SMIC CODE: ………

DATE: …………………………..

A. **SCHOOL INFRASTRUCTURE**

1. Are there any conventional science laboratories? Yes [ ] No [ ]
2. How many laboratories are present? One [ ] Two [ ] Three [ ]
3. If yes, is there a biology laboratory? Yes [ ] No [ ]
4. Is there a science preparation room? Yes [ ] No [ ]
5. What is the state of the school infrastructure present in school as ranked by the following scale:

   Very Good = 4, Satisfactory =3, Dilapidated = 2, non- existent = 1

School infrastructure	**Very Good**	**Satisfactory**	**Poor**	**None**
School hall	4	3	2	1
School staffroom	4	3	2	1
Computer laboratory	4	3	2	1
Science departmental office	4	3	2	1
Biology Laboratory	4	3	2	1

B. TEACHING AND LEARNING MATERIALS

6. Are there any preserved biological specimens? Yes [ ] No [ ]

7. If yes, describe the adequacy?

   Very adequate [ ] Adequate [ ] fairly adequate [ ] Inadequate [ ]

8. Are there any teaching models? Yes [ ] No [ ]

9. If yes, how adequate are they?

   Very adequate [ ] Adequate [ ] fairly adequate [ ] Inadequate [ ]

10. Has the department got the prescribed biology textbooks Yes [ ] No [ ]

11. If yes, how adequate? Very adequate [ ] Adequate [ ] Fairly adequate [ ] Inadequate [ ]

12. Describe the ICT materials?

    Adequate [ ] fairly adequate [ ] Inadequate [ ] None [ ].

13. What other observations have been made on the school infrastructure; teaching and learning materials and school's physical environment?

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END OF OBSERVATION