DISCOURSE PATTERNS OF LESSONS ON TOPICS PERCEIVED TO BE DIFFICULT IN BIOLOGY IN SELECTED SECONDARY SCHOOLS OF LUAPULA PROVINCE, ZAMBIA

By

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A thesis submitted to the University of Zambia in fulfillment of the requirements for the degree of Doctor of Philosophy in Science Education.

The University of Zambia

Lusaka

2020

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DECLARATION

I, KAMBI MANDA, declare that this thesis

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APPROVAL

This thesis of KAMBI MANDA has been approved as fulfilling the requirements for the award of the degree of Doctor of Philosophy in Science Education by the University of Zambia.

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ABSTRACT

This study explored classroom discourse patterns of perceived difficult topics in biology such as classification of living organisms, mitosis and meiosis at senior secondary level in selected secondary schools of Luapula Province in Zambia. A collective case study design was used and data was obtained from students and teachers, using observation schedules and interview guides. Purposive sampling was used to select the sample of schools from the target population of Luapula Province of Zambia. Data collected was analysed using discourse analysis and thematic analysis. The study found out that three discourse patterns were used during lessons on topics perceived to be difficult. These three discourse patterns are: Pupil to pupil discourse pattern, teacher- led discourse pattern and teacher-explanation discourse pattern. The choice of discourse patterns by teachers hinged on the following: non availability of teaching and learning aids, desire to cover more content, need to relate lessons to real life situations, nature of the topic to be taught, skill in managing groups, classroom environment and pupil participation. The effects were two fold; lack of understanding and enhanced understanding of stages of cell division and biological names of living organisms. The observed causes of lack of understanding included the following: Experiments on cell division were not conducted because they usually took a lot of time to be concluded. Classification was not taught practically as a result pupils connected classification with the task of memorising a list of biological names. Most teachers used inappropriate group activities and allocated inadequate time to cell division and classification of living organisms as these topics were taught around examination time. Furthermore, the study revealed that many teachers of biology taught perceived difficult topics in biology by following prescribed Zambian textbooks instead of the syllabus. This made them leave out important aspects of the syllabus and taught kingdoms and phyla not found in the syllabus. Among the causes of enhanced understanding, were mind capturing introductions, properly organised group work, clear explanations from the teacher and all inclusive questioning techniques by the teachers. Some of the recommendations made by the researcher were that: Teachers should combine the three discourse patterns namely; teacher-explanation, teacher-led and pupil to pupil discourse patterns when teaching biology because these patterns proved effective when used together during the lesson observations. Teachers should avoid using one discourse pattern during lessons on topics perceived to be difficult because it is monotonous and does not usually bring about effective learning. Workshops and seminars should be organised internally by schools for teachers to enable them acquire skills of teacher-explanation, teacher-led and pupil to pupil discourse patterns for teaching biology. Biological terms must be explained to pupils in a clear way by using the teacher-explanation discourse pattern so that pupils can understand them clearly. Pupils should be encouraged to draw diagrams on cell division during pupil to pupil discourse pattern in order for them to understand stages of cell division. Teachers must use real life examples of living organisms to help classify them into different kingdoms, phyla/divisions, classes, orders, families, genus and species during the teacher led discourse pattern.

Key words: *Discourse pattern, classification, mitosis, meiosis, biological terms, cell division, practical activities.*

DEDICATION

This Thesis is dedicated to my parents, my father Mr Happy Kambi and my mother Mrs Belita Chifumbe Kambi, who together struggled with meagre resources, at their disposal, to send me to school, and to my wife Charity Mutale Kambi and my daughters Claire, Bertha and Theresa who sacrificed with very little resources while I undertook this study.

ACKNOWLEDGEMENT

This Ph.D. research study could not have been possible without the tireless efforts of my well informed supervisors Dr C. Haambokoma and Dr K. Nachiyunde

I want to thank the lecturers from the Department of Mathematics and Science Education, in the School of Education, at the University of Zambia for their constructive criticism and advice during my oral presentations at both Departmental level and Hiroshima/UNZA research dissemination seminars. Particular thanks go to Dr P.P. Nalube, Dr G. Kaulu, Dr P. Malambo, Dr Z. Ndhlovu, the late Dr P. Shanyinde (May his soul rest in peace), Dr S. Mbewe and Dr B. Nkhata. Finally, I want to thank Mr M. Kanyinso from UNZA Press for editing this thesis and my friend Mr Chibwe Pandwell, for providing money at short notice which was used to print this thesis, may God richly bless him.

TABLE OF CONTENTS

CHAPTER TWO: REVIEW OF RELATED LITERATURE

CHAPTER THREE: METHODOLOGY

CHAPTER FOUR: FINDINGS

CHAPTER FIVE: DISCUSSION OF FINDINGS

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS

ATP Adenosine Triphosphate

CPD Continuous Professional Development.

CDC Curriculum Development Centre

DEBS District Education Board Secretary

DEIBC Discourse engagement in biology classrooms

DNA Deoxyribonucleic Acid

ECZ Examinations Council of Zambia.

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

MoE Ministry of Education.

MOGE Ministry of General Education

PEO Provincial Education Officer.

UNZA University of Zambia

OPERATIONAL DEFINITION OF TERMS

Discourse analysis is a long and serious treatment or discussion of a subject in speech or writing (O'Leary, 2012). In this study it refers to a process of assigning codes to the textual material in order to discover patterns and broad areas in the study.

Discourse pattern is used here to mean a communication pattern during lessons used to pass information from the teacher to the learner or simply teacher-pupil talk pattern in the classroom.

Teacher-explanation discourse pattern is used here to mean a teacher-pupil talk pattern which is characterised by a straight forward instruction or a mini lecture, with little or no pupil participation.

Teacher-led discourse pattern is used here to mean a teacher-pupil talk pattern which involves the teacher asking questions to pupils and pupils providing answers. The teacher initiates and guides classroom talk.

Pupil to pupil discourse pattern is used here to mean a talk pattern where pupils talk with their peers in groups to solve a common problem. The teacher divides the class into small groups then after a discussion group representatives are asked by the teacher to present group findings.

Learner is used here to mean individuals receiving instructions. In this study this term is used inter- changeably with pupil or student.

Learner-centred lesson is used here to mean the type of lesson where the pupils do most of the activities in a lesson. The pupil assumes the responsibility for learning while the teacher is responsible for facilitating the learning. Thus, the power in the classroom shifts to the pupil.

Teacher-centred lesson is used here to mean the type of lesson where the teacher does most of the talking and activities while learners passively receive information.

CHAPTER ONE

INTRODUCTION

1.1 1ntroduction

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

1.2 Context and background to the study

Luapula province is one of the 10 provinces in Zambia. The province was named after the Luapula River and is inhabited by the Lunda, Kabende, Aushi, Chishinga and Bemba speaking people. The provincial capital is Mansa. Figure 1.1 shows the geographical position of Luapula Province on the map of Zambia.

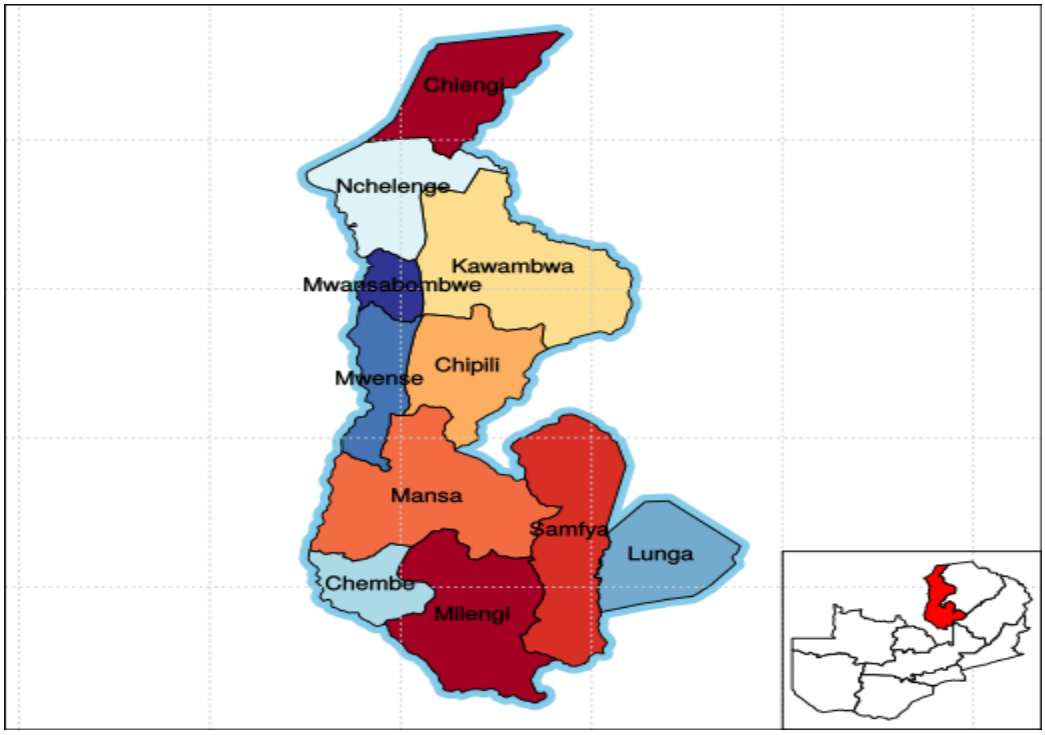


Figure 1.1: Geographical position of Luapula province (Source: Maphill.com, 2016)

Fishing is the main occupation for people in this province. During the fish ban, between December and March, most of the fishermen leave their fishing camps in the swamps and go to their villages on the upper land where they practice subsistence farming. They mainly grow cassava, millet, sorghum, groundnuts and maize. During the fishing period, pupils' attendance in schools is adversely affected by fishing activities at all levels since they accompany their parents to go and catch fish during lesson time.

Administratively, Luapula province is divided into 12 Districts namely; Chienge, Chipili, Chembe, Kawambwa, Lunga, Mansa, Milenge, Mwansabombwe, Mwense, Nchelenge, Chifunabuli and Samfya. The educational structure in Luapula Province, like in other provinces of Zambia, starts with preschools then primary schools, secondary schools and finally colleges, as shown in Figure 1.2.

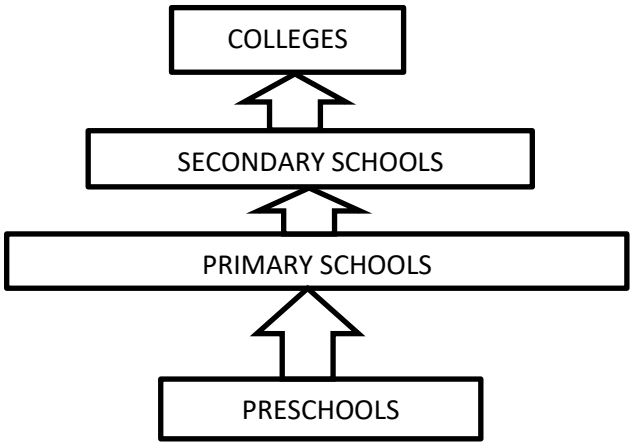


Figure 1.2: Educational structure for Luapula Province (Source; PEO Mansa, 2016)

The sizes of boxes in Figure 1.2 indicate that there are very few preschools and colleges in the province. The highest number of schools are primary schools followed by secondary schools (PEO Mansa, 2016).

The Junior Secondary School Curriculum is a two year course that covers grades 8 and 9. It forms the basis for the acquisition of basic knowledge, skills and values needed for learning

in subsequent formal studies at senior secondary school. The curriculum at this level also equips learners to either continue with the academic education or pursue pre-vocational and life skills (MESVTEE, 2013). The goal at grades 8 and 9 is to produce a learner with basic competences in communication skills, mathematical skills, information and communication technology skills, scientific skills and pre-vocational and life skills. A practical component has also been included in the grade 9 integrated science examination which covers 2 questions, one question is on biological content and the other one is on the physical sciences content (CDC, 2014). This level is taught by teachers who either degree holders or diploma holders in science education.

There are two career pathways at grade 8 and 9 secondary level namely; academic and vocational. The academic pathway is meant for learners with passion for academic subjects such as integrated science and desire to pursue careers in sciences. The vocational career pathway is for learners with ambitions and interests in technical and practical subjects such as woodwork and metalwork. The curriculum provides practical skills to such learners starting at grade 8 through to grade 12. In the provision of this curriculum, schools closely collaborate with trade institutes and other key stakeholders in various areas of specialisation (MESVTEE, 2013). However, these two systems are not being implemented effectively in Luapula Province due to lack of sensitisation of pupils on the two career pathways by school managers. Furthermore, in most schools the facilities for the vocational pathway are not available (PEO Mansa, 2013).

Senior Secondary education is provided from grades 10 to 12 leading to the School Certificate Ordinary Level Examinations. It is expected that senior secondary learners are adequately prepared for tertiary education and the labour market. It is also highly desired that entrepreneurial skills, through business studies, are acquired by all learners to contribute positively to the development of the nation and to take up adult roles. The content, structure

and process of teaching at senior secondary school level and the range of co-curricular activities are all directed towards developing a learner who is accountable, well-educated and capable of communicating effectively in both speech and writing (MESVTEE, 2013). It is argued that senior secondary school pupils must understand, interpret and apply mathematical, scientific and technological concepts in real life (MESVTEE, 2013). This will slowly be achieved as stakeholders implement the new curriculum. This is because from grades 8 to 12, leaners will be required to take at least one practical subject. Since the practical subjects will provide sufficient practical skills to prepare learners for subsequent training or entry into the labour market, the curriculum should provide leaners with opportunities for hands-on practical experience which is the essence for all the practical subjects (MESVTEE, 2012).

The secondary schools, at senior level, in Luapula province offer biology as a compulsory subject together with science (coded as 5124) which comprises physics and chemistry. These subject combinations are adequate for the preparation of pupils for university education in science related fields because they are also offered at college and university level. However, in 2014 the permanent secretary of the Ministry of Education, Science, Vocational Training and Early Education issued a circular instructing all old secondary schools with science laboratories to select Natural Sciences career pathway to ensure that they harnessed the critical nation's human resources from the learners (MESVTEE, 2014). This would be spearheaded by Senior Education Standards Officers for science. In this circular, the permanent secretary reminded secondary schools that the revised curriculum required secondary schools to choose two academic pathways from the three provided and two vocational pathways from the five provided for senior secondary schools. The permanent secretary observed, with great concern, that very few schools had chosen the Natural Sciences academic pathway which comprised pure physics, pure chemistry and pure biology.

This meant that gifted learners in science would greatly be disadvantaged and that the nation would be deprived of would be engineers, doctors and other science based professionals that stem from learning pure sciences in secondary schools (MESVTEE, 2014). Schools have been avoiding to offer pure sciences due to the cost involved in conducting practical examinations (PEO Mansa, 2013).

Science occupies an important place at various levels of the educational system in Zambia (MoE, 1996). However, allocation of resources to science teaching such as chemicals and apparatus does not show this importance. At lower and middle basic school level pupils are exposed to integrated science which aims at helping them develop scientific skills, knowledge and altitudes (CDC, 2003). The integrated science syllabus requires teachers to use activity based approaches that enhance pupils' creativity, analysis and problem solving in and outside the classroom (MoE, 2000; CDC, 2003). These approaches are not actually used, but are merely recommendations on paper (Kambi, 2012). This is due to lack of monitoring by standard officers because of inadequate funding. The integrated science is usually taught by non-specialist teachers who have been trained to teach all the subjects at lower and middle primary school. These teachers lack scientific methods of teaching.

At upper primary level, pupils learn integrated science. The specific aims of the curriculum at upper primary level are to develop the pupils' ability to think reflectively, logically, scientifically and critically (CDC, 2014). However, this will be difficult to achieve in the absence of resources to engage pupils in scientific inquiry which involves the use of practical activities. The major topics taught at lower and middle primary school levels include; the human body, health, the environment, plants, animals, materials and energy. The major topics taught in integrated science at junior secondary school level include; the human body, health, environment, plants and animals, materials and energy. At senior secondary school level pupils study physics, chemistry, biology and agricultural science for three years. Out of these

sciences offered at senior secondary school, biology is offered in all the senior secondary schools in Zambia, and quite a good number of pupils both boys and girls take biology (MoE, 2004). The popularity of biology as a subject in schools has also been reported as far back as the 1980s (Meyer, 1988). This popularity of biology is due to misconceptions that biology is easier to pass than chemistry and physics. Secondly, pupils feel that there is little or no mathematical calculations in the subject which makes the subject easier to pass (Nwachukwu & Nwosu, 2007). The current situation is that at least all secondary schools with science laboratories in Zambia have been asked to offer pure chemistry and pure physics to at least one class of pupils for each level. For example, in Luapula province only four schools had been offering pure physics and pure chemistry while biology was being offered by all the secondary schools by 2013. However, all the schools now are offering pure chemistry and pure physics (MESVTEE, 2014). This directive has been issued so that pupils can be adequately prepared for university education in science related courses. It is slowly being implemented despite challenges associated with it like lack of funds for procurement of laboratory apparatus. The study of biology is essential to pupils for many reasons. For instance, pupils study biology to obtain a certificate and to go on and train for jobs that need the knowledge and the practical skills acquired through the study of biology. The study of biology also helps people live healthier and happier lives because it enables them to understand their bodies, other living organisms and the environment (CDC, 2000). It also reveals the importance of nutrition and hygiene to communities. High school biology is not merely intended to increase a pupil's knowledge but also to develop and encourage scientific attitudes relevant to biology such as concern for accuracy and precision, objectivity and integrity. High school biology also encourages pupils to be open minded in asking questions by assisting in the development of the skills of enquiry and to be objective and accurate in

interpreting results (CDC, 2000). However, this depends on how they are taught in class. If they are poorly taught they will not achieve the scientific attitudes given above.

According to a survey conducted by the Senior Education Standards Officer for Natural Sciences in Luapula province in the first term of 2013, it was discovered that there were very few graduates teaching science in the province (PEO Mansa, 2013). Biology is taught mainly by diploma holders who are only qualified to teach grade 8 and 9 Integrated Science. Most of these teachers lack confidence when teaching biology to senior secondary school pupils. Lack of confidence by diploma holders was also observed by Mwiya (2015), who looked at the classroom performance of graduate and non-graduate biology teachers in selected secondary schools in Lusaka.

At the end of grade 12, pupils sit for the school certificate biology examination. This examination consists of 3 papers namely 1, 2 and 3. Paper 1 contains 40 compulsory multiple choice questions, paper 2 contains two sections. Section 'A' of paper 2 has short answer type questions while Section 'B' has essay type questions where candidates are expected to answer 3 essay type questions out of 5 questions. Paper 3 has 2 compulsory practical questions. These examinations are intended to assess pupil's competences in interpreting scientific phenomenon (CDC, 2000).

Although biology is supposedly the easiest of the science disciplines, research on student learning has shown that even high calibre, high achieving biology students at elite institutions taught by universally admired academics fail to build a scientifically conceptual and contextual foundation in biology (Ross, 2011). Perhaps because learning, teaching and assessment strategies in the discipline of biology have become ritualised (Ross, 2011). Biology examination papers usually cover a wide range of topics providing for a wide coverage of syllabus content. The papers usually include questions on recall of factual

knowledge as well as questions on application and synthesis (CDC, 2000). The performance of candidates in the 3 biology examination papers in Zambia has not been good (ECZ, 2016). This underachievement by pupils in biology is not new. Table 1.1 shows countrywide biology school certificate results for 1992 and 1993.

Table 1.1: Countrywide biology school certificate results for 1992 and 1993.

Year	Grades 1 and 2 Distinction	Grades 3 and 4 Merit	Grades 5 and 6 Credit	Grades 7 and 8 Pass	Grade 9 fail	Total
1992	371	2037	3404	6420	6139 (33%)	18370
1993	510	2048	3580	6811	6113 (32%)	19062
Totals	881(2.3%)	4085(10.9%)	6984(18.6%)	13231(35%)	12252(32.5%)	37432

Source: MoE 1994

It is clear from Table 1 that 67.5% of the candidates, in the two years given above, barely passed or failed biology. In 2002, the picture remained the same as that of 1992 and1993. In this year, 9975 (52.5%) pupils failed biology out of a total of 19000 registered candidates. In 2003, 11890 (58%) pupils failed biology out of a total of 20500 registered candidates (ECZ, 2004).Table 1.2 shows country wide school certificate biology results for the period 2005 to 2012.

Table 1.2: Countrywide biology school certificate results (2005-2012)

Year	1 and 2 Dist.	3 and 4 Merit	5 and 6 Credit	7 and 8 Pass	9 Fail	Total Sat
2005	788	3002	5819	21997	38986(55%)	70592
2006	1358	4551	7614	28946	34700(48%)	77169
2007	2138	6342	11940	34608	32073(37%)	87101
2008	2514	6843	11563	35380	32214(36%)	88514
2009	1208	5808	15730	30928	36039(40%)	89713
2010	2375	9640	20062	37510	33664(33%)	103251
2011	3474	12128	22290	41221	35857(31%)	114970
2012	4036	12504	26320	47285	42129(32%)	132274
Total	17891	60818	121338	277875	285662	763584
Average	2236(2%)	7602(7.6%)	15167(15.9%)	34734(36.4%)	35708(37%)	95448

Source: ECZ Data base (2013)

As can be seen in Table 1.2, on average 37% of the candidates failed biology during the period 2005 to 2012, while 36.4% barely passed. Figure 1.3 shows countrywide biology school certificate results for 2015.

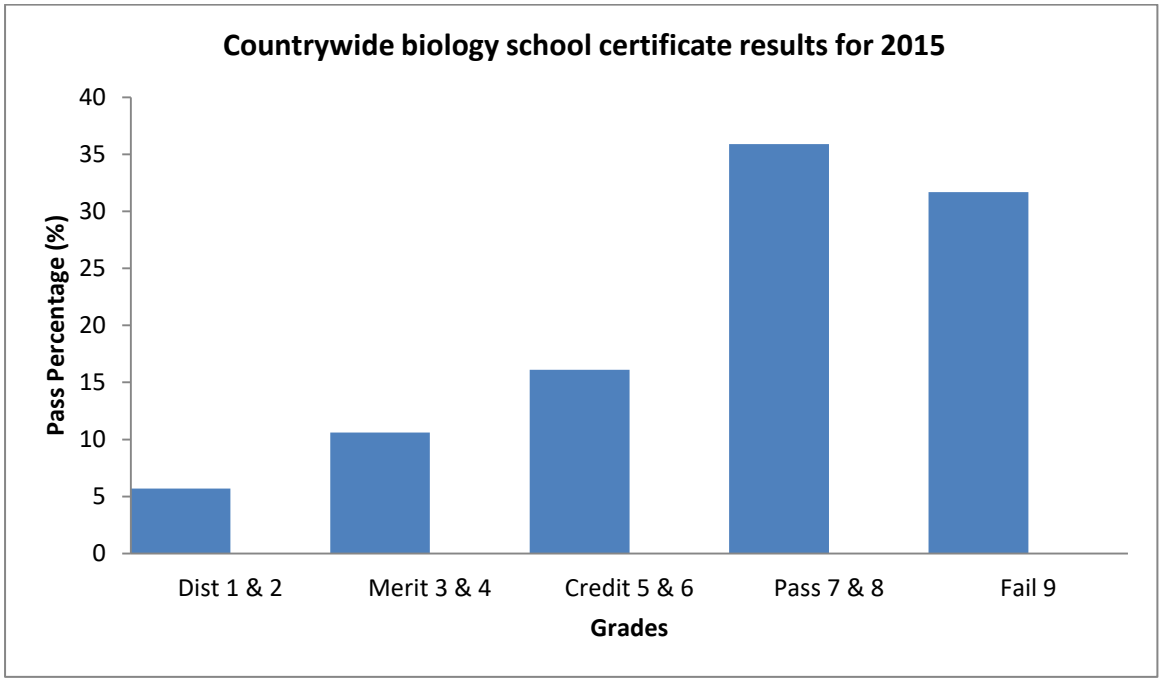


Figure 1.3: Countrywide school certificate biology results for 2015 (ECZ, 2016)

As can be seen in Figure 1.3, on average 35.9% of the candidates barely passed and 31.7% failed biology.

This poor performance of pupils in biology is said to be caused by ill-prepared pupils writing biology examinations due to inadequate learning (ECZ, 2016). The implication of this poor performance is that very few pupils will go on to study science related courses at university and college level.

The Ministry of General Education has taken a number of steps to improve the situation. One of them is by upgrading diploma holders, teaching science in secondary schools, to degree level by introducing the fast track teacher training programme being implemented by the University of Zambia.

With respect to Luapula province, which is the focus of this study, the school certificate results in biology for 2015 in 24 secondary schools were as shown in Table 1.3.

Table 1.3: Luapula Province school certificate biology results for 2015

No	Name of School	1&2 Distinction	3&4 Merit	5&6 Credit	7&8 Pass	9 Fail	Total Sat
1	Chembe	1	7	17	48	73	146
2	Ponde	10	33	64	157	66	330
3	Chipili	0	1	6	19	37	63
4	Musonda Girls	9	29	15	15	1	69
5	Chimpempe	8	33	64	158	65	328
6	Kawambwa Tea	4	5	12	23	27	71
7	KawambwaTech	16	24	39	76	76	231
8	Ngona Day	4	14	25	105	89	237
9	St Marys	22	28	22	6	2	80
10	Bahati Seminary	4	4	-	-	-	8
11	Kabunda	4	13	35	88	44	183
12	Mansa	8	13	24	85	77	207
13	Lwela	2	8	17	45	41	113
14	Milenge	1	7	16	36	26	86
15	Kazembe	0	2	15	61	36	114
16	Mable Shaw	7	23	44	53	4	131
17	Lukwesa	6	24	47	82	64	223
18	Mambilima Special	6	4	7	16	20	53
19	Mwense	8	34	40	86	52	220
20	Nchelenge	21	57	79	264	276	697
21	Kasaba	1	7	15	57	53	133
22	Lubwe	5	12	28	44	33	122
23	Samfya	12	38	89	211	282	632
24	Twingi	1	5	5	23	29	63
	Totals	160(3%)	425(9%)	725(15%)	1757(38%)	1473(32%)	4540

Source: PEO Mansa (2016).

As can be seen from Table 1.3, a total of 1473 (32%) candidates failed biology while 1757 (38%) barely passed biology in Luapula province in 2015. With regard to the year 2016, the picture is similar to that of 2015. Figure1.4 shows Luapula Province school certificate biology results for 2016.

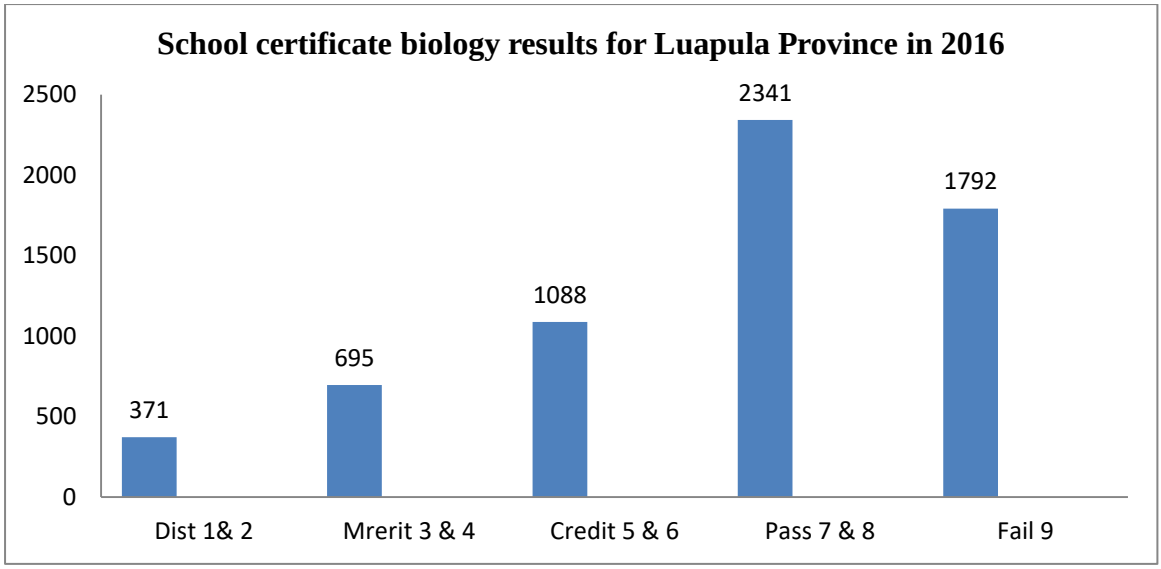


Figure 1.4: School Certificate biology results for Luapula Province in 2016 (PEO, Mansa 2017).

As can be seen from Figure 1.4, 2341 (37.2%) candidates barely passed and 1792 (28.5%) candidates failed biology in Luapula Province. For 2017 the picture remained the same as can be seen in Figure 1.5.

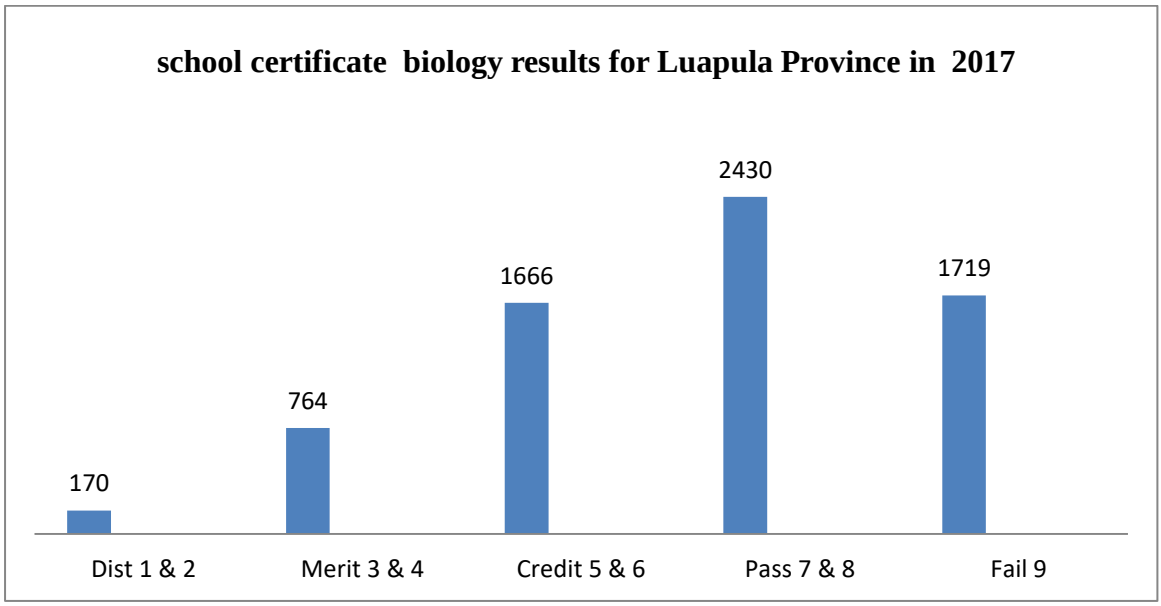


Figure 1.5: School Certificate biology results for Luapula Province in 2017 (PEO, Mansa 2018).

As can be seen in Figure 1.5, 2430 (36%) candidates barely passed and 1719 (25.5%) failed biology in Luapula province.

This underachievement in science at school certificate level reflects deficiencies at school level, such as the facilities, resources and teaching (MoE, 1996). As a result of the general poor performance of pupils in the biology school certificate examinations, a number of studies have been undertaken to identify some issues which contribute to this. Some of these studies focused on establishing topics considered to be difficult to both teachers and pupils which in turn affect their teaching and learning. For example, Abimbola (1998), in Nigeria, identified the following topics; photosynthesis, meiosis and cellular respiration. Cimer (2012), in Turkey, identified endocrine systems, aerobic respiration, cell division, genes and chromosomes as the most difficult topics to learn for pupils in biology. While Musonda (2013), in Zambia, identified genetics, mitosis and meiosis, DNA synthesis, skeletal system, genes and chromosomes, evolution and ecology as topics perceived to be difficult in biology by pupils.

Other studies focussed on determining issues which contribute to poor performance in biology practicals. For example, Haambokoma (2007) investigated errors pupils make in biology practical tests in the school certificate examinations which eventually result in poor performance. He discovered that pupils were failing to calculate magnification of the drawings, were giving similarities not seen on the specimen provided and inability to state differences properly, failure to carry out food tests using correct procedures and to interpret observations correctly.

Another study undertaken by Chocha, Namayanga and Ndhlovu (2014) examined teacher's competences in the preparation of materials for practical work. They established that many Zambian biology teachers did not even know how to prepare reagents like Benedict's

Solution, Iodine Solution and Biuret Reagent to be used in biology practical sessions. It was further reported that many teachers did not have the skill of handling science laboratory apparatus like beam balances and of correctly relating the apparatus to their use and the subjects where they were commonly used.

Some studies focused on how certain biological topics were taught. For example, Chifwa (2015) studied the teaching of genetics in selected secondary schools in Kitwe District of Zambia and discovered that teachers used teacher-centred methods when teaching genetics. As a result pupils' understanding of the genetics topic was compromised resulting in them performing poorly in examination questions in this topic.

1.3 Statement of the problem

Although researchers (e.g Abimbola, 1998; Haambokoma et al, 2002; Cimer, 2012; Musonda, 2013; Chocha, Namayanga & Ndhlovu, 2014, Chifwa, 2015) have identified topics perceived to be difficult in biology, for both teachers and learners, no studies have been conducted in Zambia to document knowledge and understanding of classroom discourse patterns during biology lessons on these perceived difficult topics in secondary schools in Luapula Province. Hence there is no knowledge on the issue of classroom discourse patterns which needed investigation.

1.4 Purpose of the study

The main purpose of this qualitative study was to document knowledge and understanding of classroom discourse patterns during lessons on topics perceived to be difficult in biology at senior secondary school level in selected secondary schools in Luapula Province of Zambia.

1.5 Research objectives

The objectives of the study were as follows:

1. To analyse the classroom discourse patterns during lessons involving topics perceived to be difficult in biology.
2. To investigate how teachers of biology arrive at the choice of discourse patterns they use for teaching topics perceived to be difficult in biology.
3. To assess the effects of discourse patterns used by teachers on pupils' understanding of topics perceived to be difficult in biology.
4. To explore what could be done to improve the teaching and learning of topics perceived to be difficult in biology in order to facilitate pupils' understanding.

1.6 Research questions

The study was guided by the following questions:

1. What are the discourse patterns during lessons involving topics perceived to be difficult in biology?
2. How do teachers of biology arrive at the choice of discourse patterns they use for teaching topics perceived to be difficult in biology?
3. What effects do discourse patterns used by teachers have on pupils' understanding of topics perceived to be difficult in biology?
4. What could be done to enhance the teaching and learning of topics perceived to be difficult in biology in order to facilitate pupils' understanding?

1.7 Significance of the study

There are no studies, to the researcher's knowledge, which have been undertaken to analyse classroom discourse patterns during lessons involving topics perceived to be difficult in biology and what underpins the choice of the discourse patterns used to teach topics

perceived to be difficult in biology in Luapula province. This study is, therefore, important in many ways; firstly it has generated new knowledge which will help to understand classroom discourse patterns during lessons involving topics perceived to be difficult in biology.

Secondly, this study has generated empirical evidence which could be used by various stakeholders as a basis for making informed decisions regarding improvement of biology education in secondary schools, colleges and universities.

Furthermore, information generated from this study will assist science teacher educators involved in the preparation of teachers of biology in possible improvement in pedagogy. Heads of Science Departments will be helped in allocating more time to perceived difficult topics when preparing schemes of work. School Administrators will be assisted when soliciting for teachers of biology. Textbook writers will be helped to simplify their work as they develop textbooks for pupils and teachers. Science Standards Officers will be helped on how to advice teachers of biology as they monitor them. Curriculum Developers will be helped to pay attention to perceived difficult topics as they develop biology materials for teachers and pupils and the Examination Council of Zambia will be able to consider perceived difficult topics when preparing final examinations.

Other researchers may find the knowledge which has been generated to be important as a source of information for further research.

1.8 Theoretical frameworks

This study was informed by two theoretical perspectives, namely; Expectancy Value Theory (Eccles *et al*, 2002) which has some relevance on choices people make and the Transactional Model of the teaching and learning process developed by Huitt (1995) which explains the factors affecting teaching and learning.

1.8.1 Expectancy- Value Theory

According to the Expectancy – Value Theory, choices which people make are influenced by two beliefs which are the expectancy of achievement belief and the task value belief. According to this theory, teachers choose particular discourse patterns where they expect to enjoy and be successful. Their choices also depend on important, useful and cost effective discourse patterns (Stuart & Whaley, 2005).

Figure 1.6 is a modified diagrammatic representation of Eccles et al, (2002) Expectancy-Value Theory.

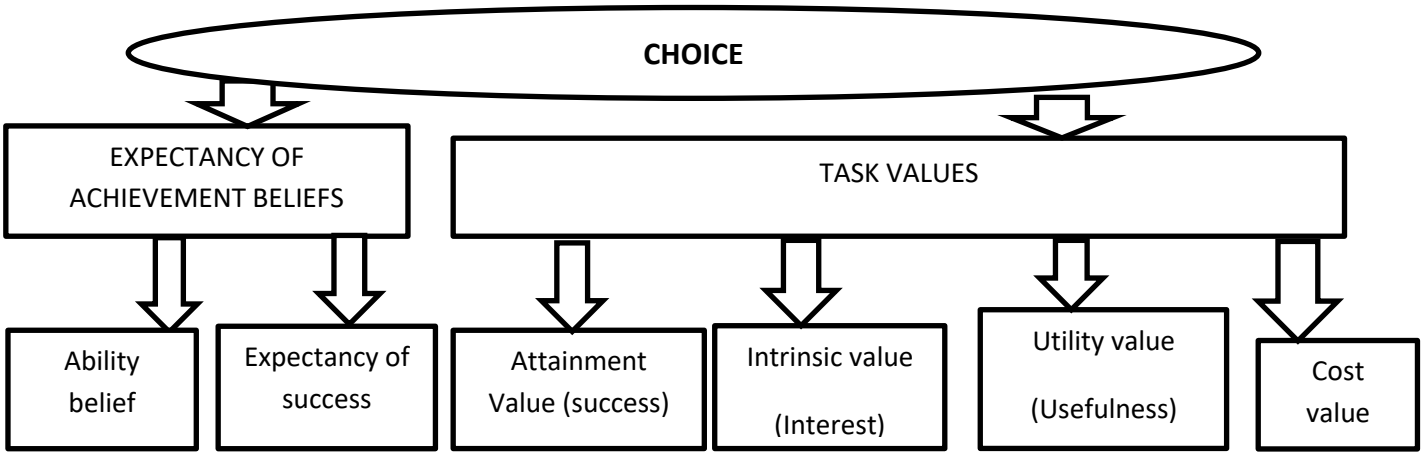


Figure1.6: Expectancy – Value Theory as adapted from Eccles *et al* (2002)

The two beliefs of the Expectancy- Value Theory are explained in Table 1.4.

Table 1.4: Expectancy- Value Theory beliefs

Expectancy of achievement beliefs	**Ability beliefs-** The ability to perform a task
	Expectance of success- A person's belief about how well he or she will perform an upcoming task
Task values	**Attainment value** (success)- Importance of succeeding on a task
	Intrinsic value (interest)- The pleasure a person derives from participating in an activity
	Utility value (Usefulness)- The benefits a person will derive from performing an activity
	Cost value- The savings a person will realise by participating in an activity.

Source: Eccles et al (2002)

The Expectancy- Value Theory was initially used to understand why there are few females in science related careers (Eccles, *et al*, 1990; Eccles, *et al*, 1999). It has also been used to study choices pupils make to study mathematics in high school and beyond high school (Wigfield, 1994). It has further been used to study decisions people make in taking certain subjects such as physical education (Xian et al, 2003) and to study enrolment decisions people make in science courses (Barnes, *et al*, 2005). Haambokoma (2015) also used this theory to study what motivated girls to get involved in Junior Engineers Technicians and Scientists (JETS) activities in selected Zambian schools. One strength of this theory is that it is based on extensive empirical studies undertaken in different countries of the world. However, one limitation is that this theory emerged from studies conducted in the developed parts of the world. Therefore, the factors affecting the choice of discourse patterns in the Zambian classrooms may be different from those of advanced nations. Nevertheless, the beliefs highlighted by this theory will be used to discuss the choice of discourse patterns used by teachers during lessons on topics perceived to be difficult in biology because they are similar.

1.8.2 Transaction Model

The Transaction Model developed by Huitt (1995), classified factors affecting output (which is pupils learning achievement) into three categories namely; context, input and classroom processes. Context covers all the factors outside the classroom that might influence teaching and learning such as social economic status and state policies. Input covers those qualities or characteristics of teachers and students that they bring with them to the classroom experience such as previous knowledge about the subject matter. Classroom processes include teacher and student behaviours in the classroom as well as some other variables such as classroom climate and teacher and student relationships (Huitt, 1995).

The role of the teacher in terms of facilitation of learning by specifying the lesson objectives, selecting groups of pupils and their roles in groups and in monitoring the effectiveness of the groups was the focus of the open ended questionnaires and interview schedules. The use of learners' own responses also guided the analysis and interpretation of the findings.

According to the transaction model, the factors affecting learning can be classified into four categories as shown in Table 1.5.

Table 1.5: A Transaction Model of the Teaching and Learning Process

Context	All those factors outside of the classroom that might influence teaching and learning such as social economic status and state policies
Input	Those qualities or characteristics of teachers and students that they bring with them to the classroom experience such as previous knowledge about the subject matter
Classroom Processes	Teacher and student behaviours in the classroom as well as some other variables such as classroom climate and teacher/student relationship.
Output	Measures of student learning like examination results.

Source: Huitt, (1995)

The transaction model has weaknesses because it ignores the variations which exist between different subjects and it is also based on studies done outside Zambia. The most important

category on the transaction model is output because once that has been defined it explains the importance of the variables in the other categories (Huitt, 1995). For example, if the desired outcome measure is a score on a standardised test of basic skills, the instructional method most likely to positively impact that measure is the direct or explicit instruction (Rosenshine, 1995). However, if the desired outcome is creativity and independence, then the teacher led instruction may be a better alternative (Giaconia & Hedges, 1982). Alternatively, if a better relationship among diverse students is the goal, the cooperative learning would appear to be the better instructional method (Slavin, 1995). Although the transaction model has some weaknesses which are given above, it was useful to this study in that it provided some guidance on what influences classroom discourse patterns during biology lessons. The transaction model was also used by Mwiya (2015) in his study when he was looking at the classroom performance of graduate and non- graduate biology teachers in selected secondary schools in Lusaka district of Zambia.

Below is the diagrammatic representation of the modified transaction model (Figure 1.7).

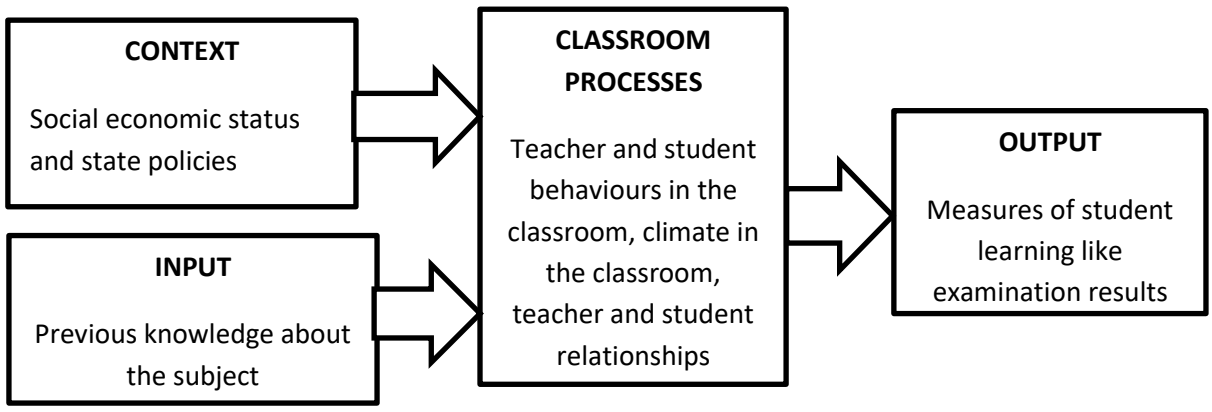


Figure 1.7: Transaction model as adapted from Huitt (1995)

Other researchers who have used more than one theoretical perspectives include; Kaulu (2015) whose study on student misconceptions in physics education was informed by two

cognitive constructivist theories of learning as interpreted and applied to science education by Kelly (1966), and Von Glasersfeld (1995) because they had common premises which guided the research. Another study by Haambokoma (2015) on influences of female pupils decision to join the Junior Engineers Technicians and Scientists (JETS) clubs in Zambia was informed by three theoretical perspectives namely, the Feminist Theory, the Self-Efficacy Theory and the Expectancy-Value Theory because they had some relevance on decisions or choices people make. Therefore, it was appropriate to use the two theoretical perspectives because they guided the current study on classroom discourse patterns.

1.9. Conceptual framework

Knowledge development by students themselves in class is mainly demonstrated by verbal means through classroom discourse. However, students' verbal expression of their views depends on teacher questions or statements that elicit either answers or responses from students (Beccles, 2012). This study is underpinned by the view of teaching and learning as a relationship between an individual learner, the instruction, lesson content, the learning outcome and the teacher (Figure 1.8).

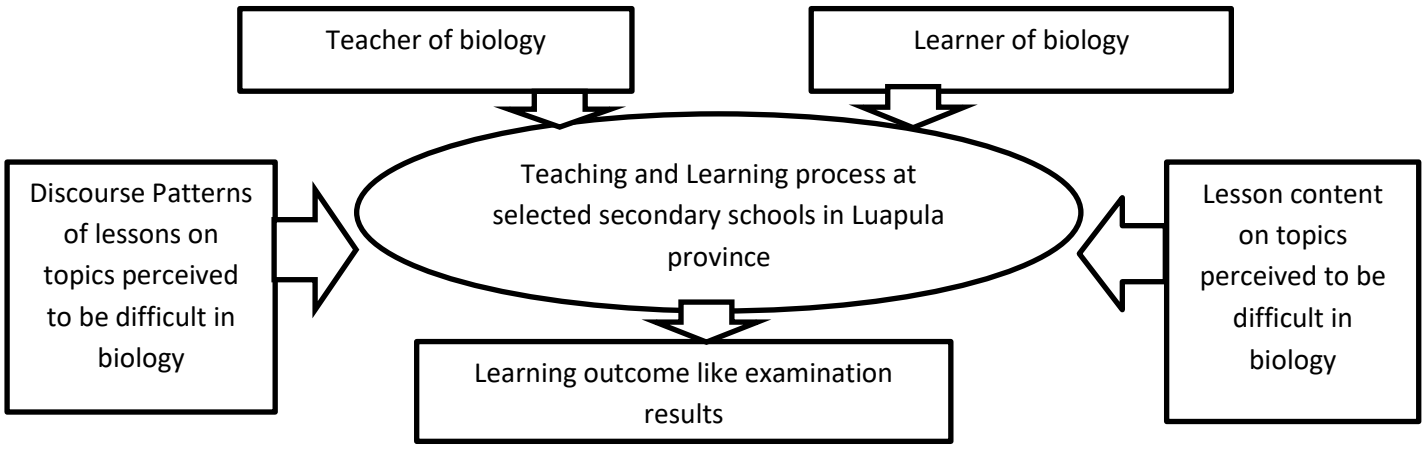


Figure 1.8: Conceptual framework

1.10. Delimitations of the study

The study was conducted in four secondary schools only, despite having many schools in Luapula province that offer biology to senior secondary school pupils. This was due to the fact that the four schools studied had poor grade 12 results in 2015.

1.11. Limitations of the study

The study was qualitative and required a relatively small sample of schools and respondents. However, the researcher took care to choose participating schools which had similar characteristics with other schools in Luapula province and in the nation as a whole, so that it was possible to understand the findings of the study beyond the immediate research settings.

1.12 Structure of the thesis

This thesis is structured into six chapters as follows:

Chapter One is an introduction to the study. It gives the context and background to the study, the statement of the problem, purpose of the study, research objectives and research questions, significance of the study, theoretical frameworks, conceptual framework, delimitations and limitations of the study including operational definitions of terms.

Chapter Two discusses review of related literature, structured into broad themes as follows: Classroom discourse patterns, perceived difficult topics in senior secondary biology, patterns of science lesson presentation, teachers' choice of discourse patterns used for teaching biology topics perceived to be difficult, challenges of teaching perceived difficult topics in biology and practices which enhance the teaching of biology.

Chapter Three presents research paradigms, design and methodology of the study. It starts by describing and justifying the research paradigms and the design which were used. It then describes the broad methodological approach that was adopted. It also includes a description

of the research sites, study population, study sample, sampling procedure, research instruments, pilot study, data collection procedure, trustworthiness of the study, data analysis and ends with ethical issues.

Chapter Four presents findings which were meant to answer the four research questions. Findings on the classroom discourse patterns on topics perceived to be difficult in biology answered the first research question which reads 'What are the classroom discourse patterns of lessons on topics perceived to be difficult in biology?' This chapter also presents data provided by participants with respect to the three subsequent research questions; How do teachers of biology arrive at the choice of discourse patterns they use to teach topics perceived to be difficult in biology?, What are the effects of discourse patterns that teachers use on topics perceived to be difficult in biology?, What could be done to improve the teaching and learning of topics perceived to be difficult in biology in order to facilitate pupils' understanding? The chapter ends with a summary.

Chapter Five discusses the findings of the study. It starts by discussing the classroom discourse patterns during lessons involving topics perceived to be difficult in biology. This is followed by a discussion of choice of discourse patterns used in teaching topics perceived to be difficult in biology. The third discussion is on the effects of discourse patterns on pupils' understanding of topics perceived to be difficult in biology. The last section discusses proposals for improving learning of some perceived difficult topics in biology and the innovation emerging from the study. A summary has also been provided at the end of this chapter.

Chapter Six presents the conclusions and recommendations arising from the study. This chapter also presents areas for further research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter reviews literature related to the study and covers the following areas: Classroom discourse patterns, topics perceived to be difficult t in senior secondary biology, patterns of science lesson presentation, teachers' choice of discourse patterns used for teaching biology topics perceived to be difficult, challenges of teaching topics perceived to be difficult in biology and practices which enhance the teaching of biology.

2.2 Classroom discourse patterns

Classroom discourse is the oral interaction that occurs between teachers and pupils and among pupils in the classroom (Dysthe, 1993; Liu & Le, 2012). It is the language that teachers and pupils use to communicate with each other in the classroom. Talking or conversation is the medium through which most teaching takes place. So the study of classroom discourse is the study of the process of face to face classroom teaching. Through their interactions with each other, teachers and pupils construct a common body of knowledge, understanding of their roles and relationships and the norms and expectations for their classrooms.

Nystrand *et al* (1997) clustered discourse patterns into two types namely: monological and dialogic. In a monological discourse the teacher initiates most of the questions and already knows the answers. This type of interaction is similar to what Mehan (1979) coined as the teacher initiates, student responds and teacher evaluates (IRE) pattern. Authoritative classroom interactions in which the teacher focuses the discussion on one meaning or point of view most frequently occur through an IRE Pattern (Scott, *et al;* Yu, 2009). This traditional pattern of discussion in science classrooms places teachers in a position of power in which

they control the topic, the direction of the conversation, who participates in the conversation and what contributions count as legitimate (Lemke, 1990; Skidmore, 2000). Traditional science discourse patterns such as the IRE are not appropriate as the sole discourse pattern in inquiry-oriented classrooms, because they are based on teacher driven instruction and known answers to questions (Polma & Pea, 2001). The issue of asking questions by teachers in the classroom was also investigated by Matsubara (2010) when he was looking at the learning process of children. He developed tangible methods that would help teachers visualise student-centred teaching. His two lesson analysis system of the category and the coding unit focussed on students' responses during classroom discourse. The coding unit used in this lesson analysis system consisted of a set of teachers' questions and students responses to the questions. However, Matsubara's lesson analysis system did not look at teacher-centred methods which are very common in Zambian schools.

Another type of discourse pattern which engages students in a more open form of instruction with greater student involvement is the dialogic discourse pattern. This involves exchange of ideas since students are given the opportunity to freely express their views or opinions on a given problem (Anton, 1999; Aggrawal, 2002). This suggests that science classrooms should include opportunities for students to engage in classroom discussions in which students practice talking science, challenging each other's ideas and influencing the direction of the discourse (Norman, 1992; Yerrick & Roth, 2005). The verbal discourse is a two- way action between the teacher and students which may affect learning depending on the clarity of the message (Umeano, 1999, Krat & Kratcoski, 2004).

Viiri and Saari (2006) classified discourse or teacher student talk pattern into six types. These six discourse patterns are: Teacher Presentation Discourse Pattern, Teacher –Guided Discourse Pattern, Authoritative Discourse Pattern, Dialogical Discourse Pattern, Peer Discourse Pattern and some patterns categorised as 'others'.

Teacher-Presentation Discourse is characterised by a straight forward instruction, a mini lecture with little or no student contribution. The students remain passive as the teacher talks to them in the classroom (Viiri & Saari, 2006). In the teacher–guided discourse pattern the teacher directs and guides the students in a classroom discussion on a specific problem which may help to increase students' interest in a lesson (Widdowson, 1984; Numan, 2001; Virri & Sarri, 2006).

The Dialogical Discourse Pattern involves exchange of ideas since students are given the opportunity to freely express their views or opinions on a given problem (Aggrawal, 2002). This discourse pattern is democratic in nature since it involves free dialogue. The Peer Discourse Pattern enables students to talk with their peers in groups to solve a common problem (Viiri & Saari, 2006). The peer discourse pattern is a cooperative learning strategy in which students work collaboratively with their classmates in small groups to solve a common problem (Okebukola, 2004). The Authoritative Discourse Pattern is autocratic in nature because authority is centralised around the teacher (NTI, 2000). The Authoritative discourse pattern is teacher dominated because students are inhibited from sharing ideas with the teacher, instead they are expected to comply with commands or orders from teachers without questioning (Ugwuadu, 2011). The discourse pattern classified as others are characterised by teacher's talk not having relationship with the topic instead the teacher's talk is related to student's social affairs (Viiri & Saari, 2006). This talk pattern could be useful in creating fun or humour in order to make students feel alert during classroom activities (Virri & Saari, 2006).

Discourse patterns have unique characteristics that foster learning. The dialogic discourse pattern is democratic because it involves free dialogue between the teacher and his/her students during classroom activities (Aggrawal, 2002). In a biology lesson, the teacher using the dialogical discourse pattern in teaching opens up a discourse on a biology problem for

students to verbally and freely contribute ideas that could reveal their knowledge and understanding of the problem. There is no restriction to the direction of the discourse. During the lesson, the teacher accepts views and seeks the opinions of students in the teaching and learning process. The teacher also gives reinforcement like praises and encouragement to meaningful contributions from students (Viiri & Saari, 2006). Students are also encouraged to ask questions during the process of teaching (Maftoon & Rezaie, 2013).

The democratic discourse pattern contrasts sharply with the authoritative discourse pattern because the authoritative discourse pattern affords little or no interaction between the teacher and the students during lesson activities, this discourse pattern is similar to lecture method of teaching because the two strategies share common characteristics of being teacher-dominated. In addition, students are inhibited from sharing ideas and opinions among themselves and with the teacher, instead they are required to comply with orders from the teacher without questioning (Ugwuadu, 2011). The main pre-occupation of the teacher in using the authoritative discourse pattern is verbal presentation of facts and principles to students while students remain passive (Padron & Waxman, 1999). The democratic and authoritative discourse patterns when used together may be of benefit in improving the persistent poor achievement of students in biology and in understanding of difficult topics (Cater & Numan, 2001; Viiri & Saari, 2006). This is due to the fact that the democratic discourse pattern provides students with an opportunity to interact with the teachers thereby asking where they are not clear while the authoritative discourse pattern gives teachers enough authority to explain difficult terms in biology which are not well understood by the pupils.

Broder (2016) claims that discourse is the most important means of sharing information and developing insight and as such, is the teacher's main pedagogical tool. Through discourse the teacher plays a key position in shaping students' role and their level of involvement in the

lesson. In dialogical discourse participants build on each other's input and collaboratively contribute towards creating an information network based on thinking and exploration. Through utterances that precede dialogical discourse such as open ended questions, the teacher acknowledges students' opinions and encourages their involvement in the learning process. In contrast discourse in the monological classroom is asymmetrical, meaning that the teacher's voice is dominant. He or she tends to ask closed-ended recap questions and students are required to pay close attention and to answer through rote learning. However, direct monological teaching is applied more often than dialogical teaching despite its recognition. It appears that teachers lack the information required to implement dialogical discourse in their classroom.

Authoritative discourse is often used to deliver a large amount of information to the students in a short period (Berry, 2008). According to Gehlen-Bauum and Weiberger (2014), lectures are designed to deliver new information to a large group of students. This method is known to be effective in dealing with a large class. However, Franklin, Sayre and Clark (2014) argued that students taught in lecture-based classes learn less than those taught with activity-based reformed methods. Lecture method is frequently a one way process unaccompanied by discussion, questioning or immediate practice that makes it a poor teaching method. Lecture method concentrates on information rather than learners (Al-Rawi, 2013). In the lecture method the teacher tells the students what to do instead of activating them to discover for themselves (Miles, 2015).

Demonstration teaching method is a useful method of teaching because it improves student's understanding and retention (McKee, Williamson & Ruebush, 2007). According to Al-Rawi (2013), the demonstration is effective in teaching skills of using tools and laboratory experiment in science. However, the time available to perform this demonstration is limited in a classroom setting due to long experiments in biology (Schmid & Teraro, 1990).

Section 2.2 has outlined the discourse patterns. The next section will focus on perceived difficult topics in senior secondary biology.

2.3 Topics perceived to be difficult in senior secondary biology

The biology content at senior secondary school level in Zambia is prescribed by the Curriculum Development Centre (CDC, 2013). A number of topics in biology at senior secondary school level have been identified as difficult to teach or learn by various researchers (Haambokoma *et al*, 2002; Musonda, 2013). According to research carried out in Scotland by Johnstone and Mahmoud (1980) where they sought to determine the topics of maximum perceived difficult in the biology syllabus of the Scottish Certificate of Education Examination Board (SCEED, 1974), questionnaires were distributed to 167 first year under graduates who had just come from high school with a pass in higher biology and 166 pupils who were about to sit for the higher biology examination. Questionnaires were also distributed to 50 teachers where they were asked to list the topics which they thought were giving pupils most trouble. Other sources of information on the difficult topics included a discussion with inspectors and university lecturers and a review of examiners' reports. There was a general agreement among all the sources of information for this study concerning the topics which were causing more trouble to pupils and teachers. Apart from genetics, the other areas of maximum difficult coming out from this study were: Water transport in organisms including osmosis, water potential and water balance, energy conversions in photosynthesis, respiration and mechanism of evolution. The weakness in the study is that Johnstone and Mahmoud (1980) did not go into the classroom to observe how these topics were taught. Instead they got views from pupils, university students, teachers of biology, inspectors of schools and university lecturers through questionnaires and interviews. Therefore, there was no first-hand information on classroom discourse by observation. .

In another study, Musonda (2013) conducted a research on topics perceived to be difficult in biology at 11 secondary schools in Kasama and Mungwi Districts of Northern Province of Zambia. Questionnaires were distributed to 19 teachers of biology and 11 heads of department for Natural Sciences. Questionnaires were also distributed to 451 pupils while 66 pupils were orally interviewed. In this study Musonda (2013) discovered that pupils indicated that genetics was among the topics perceived to be difficult in biology followed by nervous system, skeletal system, reproduction in plants, excretory system, mitosis and meiosis, enzymes, DNA synthesis and ecology. The weakness in this study is that Musonda (2013) did not observe the perceived difficult topics being taught in the classroom to get first-hand information on why these topics were perceived difficult by pupils and teachers. Instead he relied on getting information from teachers and pupils by means of questionnaires and interviews. Topics such as genetics, classification of living organisms, ecology and diversity of living organisms have been identified as difficult topics in biology by teachers and pupils (Johnston & Mahmoud, 1980; Musonda, 2013). However, apart from identifying these topics perceived to be difficult these authors did not look at classroom interactions of lessons on topics perceived to be difficult in biology.

The above mentioned topics were found to be difficult by teachers and pupils because teachers neglected the practical aspects when teaching these topics (Schmid and Teraro, 1990). In most cases pupils were passive as they received instructions from their teachers on these topics (Kambi, 2012).

In another study on the identification of perceived difficult topics, a total number of forty eight heads of departments participated in the baseline study in Zambia which was done by Haambokoma *et al* (2002). In this study, the following topics in biology were found to be areas where teachers needed more help in terms of methodology to be more effective: inheritance, ecology, coordination and response, use and abuse of drugs, diversity of

organisms, nutrient cycles, chemical control of plants, skeleton and locomotion as well as homeostasis. They also indicated that teachers needed help in practical work. In the case of practical work teachers needed help in the preparation of reagents such as Iodine Solution, Biuret Reagent and Benedict's Solution. This help was supposed to be provided through workshops by their peers who were more informed on the methods to use when delivering these topics to pupils.

In the same study, findings from the heads of departments in most cases corroborated with what was said by some teachers, who revealed that they experienced difficulties teaching some topics like: inheritance and genetics, diversity of organisms, functions of the brain and the nerves, chemical control of plants, the use and abuse of drugs, energy flow, food chains and food webs, homeostasis, nutrient and water cycles, support and locomotion. Haambokoma *et al* (2002) claim that genetics was difficult to learn because of calculations involved in it and too many similar terms. Not surprisingly, the topics which teachers found difficult to teach were in most cases the same ones pupils found difficult to learn (Haambokoma et al, 2002). This simply means that teaching and learning are interrelated.

Some of the topics listed above have also been identified as difficult topics for teachers by other studies. For example, Rugumayo (1978) found that teachers of biology needed help in ecology and genetics implying that they had difficulties teaching these topics. Haambokoma and Mwale (1998) found that in two technical high schools, teachers expressed having difficulties in teaching genetics, coordination, use and abuse of drugs, ecology and diversity of living organisms, homeostasis, support and movement. The weakness here is that all these studies used questionnaires and interviews to get their findings but they did not observe teachers teaching the perceived difficult topics. Therefore it was necessary to conduct this study to get first-hand information on classroom discourse.

Abimbola (1998) also discovered that physiology content areas are mostly abstract and microscopic and contain many fine processes that require proper explanations to enable pupils understand them, thus posed a challenge to pupils to comprehend.

From the studies above, it can be concluded that practical activities, genetics, meiosis and mitosis, classification and diversity of living organisms are the most frequently reported topics to be difficult in biology and therefore these topics were the focus of this study.

2.3.1 Practical activities in relation to mitosis, meiosis and classification of living organisms

Practical activities in biology provide opportunities for pupils to actually do science as opposed to learning about science (Nzewi, 2008). Nzewi further asserted that practical activities can be regarded as a strategy that could be adopted to make the task of a teacher more real to the pupils as opposed to abstract or theoretical presentation of facts, principles and concepts of subject matter. However, Nzewi (2008) recommends that practical activities should engage the pupils in hands-on, mind-on activities, using varieties of instructional materials and equipment to drive the lesson home.

If the objective of teaching science by using practical activities is to become a reality, it is necessary that equipment and situations which allow pupils to use their own hands and conduct investigations are identified. In this vein, there is need to encourage creativity in teachers to engage in fabrication and improvisation of equipment for hands-on activities (Nachiyunde, 2013).

Nwagbo (2008) recommended that the use of practical activities approach to the teaching of biological concepts should therefore be a rule rather than an option to biology teachers, if

pupils are to acquire the necessary knowledge, skills and competence needed to meet the scientific and technological demands of society.

A lot has been done to improve science teaching in secondary schools in Nigeria by trying to incorporate the practical activities in lessons. In spite of that, students continue to perform poorly in science subjects of which biology is one (Obiekwe, 2008). In Zambia the situation of promoting the use of practical activities in lessons is not very different from what is prevailing in Nigeria (Chocha, Namayanga & Ndhlovu, 2014). The National Science Centre of Zambia distributed mobile laboratories to be used in science lessons throughout the country. Chocha, Namayanga and Ndhlovu (2014) who did a countrywide survey in Zambia confirmed that teachers of biology were not able to use the given apparatus correctly and could not correctly record the observed results in tabular and graphical form. Teachers of biology were not able to correctly draw a given specimen and had difficulties in calculating magnification. Chocha, Namayanga and Ndhlovu (2014) further reported that teachers of biology faced challenges when collecting data, using thermometers and translating data in graphical form, interpreting collected data and making logical conclusions. This could be attributed to minimal incorporation of practical activities in their daily lessons, lack of knowledge on data collection and analysis, graphs and their interpretation.

Chocha, Namayanga and Ndhlovu (2014) further observed that teachers of biology could not represent all details highlighted from a specimen on paper. Furthermore, some teachers wrote wrong formulae, used abbreviations without indicating correct units; a clear indication of negative attitude and poor commitment to tasks given. It was further noticed that some teachers made drawings as seen in the textbooks an indication of not appreciating the importance of practical activities in science. In this study 400 trained teachers of biology with the average age ranging from 25 years to 35 years were randomly sampled from the 10 provinces of Zambia. Out of these trained teachers 340 were male while 60 were female, 300

were diploma holders while 100 were degree holders. Their teaching experiences ranged between 5 years to 10 years. The teachers were selected from schools which benefited from the mobile science laboratory project of the National Science Centre. The said schools did not have laboratories because they were just upgraded from being primary schools to secondary schools, others had dilapidated laboratories while the newly built schools had empty laboratories. These teachers were given work sheets on which they had specific tasks to accomplish in a stipulated period of time to assess their competences in handling scientific apparatus, conducting practical experiments, collecting, presenting and analysing data. The study revealed that 240 teachers from the sample had difficulties in answering questions on the worksheets. This simply indicates that the use of practical activities in lessons should go with the provision of laboratory apparatus and infrastructure. The teachers who were sampled in this study came from schools which had nothing to talk about in terms of laboratory apparatus as a result they exhibited incompetence in handling laboratory apparatus.

Weaknesses in practical work have been observed among pupils who write school certificate examination. For example Haambokoma (2007) found that pupils made different types of errors in the areas of observation and recording. Other areas of errors included drawing, labelling drawings, carrying out measurement of parts of specimen, calculating of magnification, comparing and contrasting specimens, carrying out tests for food nutrients in substances provided as well as in the interpretation of test results. In this study, data was obtained by means of a questionnaire from 31 respondents who marked school certificate biology practical tests. This study was going to be more beneficial if sample scripts were sampled and analysed. However, this was not possible to get from the Examination Council of Zambia.

Haambokoma (2007) indicated that with respect to drawings, the commonly observed errors by practical biology school certificate markers were: drawing small diagrams, drawing

diagrams candidates saw in the textbooks instead of the specimen provided, label lines not touching the parts being labelled. Other mistakes reported were the use of wrong formula to calculate magnification of the drawing, giving similarities not seen on the specimen provided and inability to state differences properly, failure to carry out food tests using correct procedures and failure to interpret observations correctly. ECZ (2009) reported that most drawings were of poor quality. Once more, the issue of failure to calculate magnification was reported to be prevalent among candidates in most schools. Candidates still had problems with the formula for calculating magnification. In the practical examination of 2008, the chief examiner said that the drawing skills were still very poor. Among the expectations in the questions were that the drawings should be realistic (i.e. close to the actual specimen), clean and neat. In most cases the drawings were dirty with a lot of rubbing, in some cases there was shading (ECZ, 2009). Interpretation of graphs has also been identified as a problem area. According to the chief examiner's report of the 2006 biology practical examination, generally most of the candidates failed to apply mathematical skills in trying to answer a question on graphs. The majority of candidates failed to draw the graph. Many candidates performed poorly on a question involving reading points on the graph and interpretation of data on homeostasis (ECZ, 2006).

Apart from failure to draw the graph, a large number of candidates also failed to explain what they were expected to use in the experiments on the leaf. The explanation given showed either some memorised work or total ignorance of what they were supposed to do (ECZ, 2009).

The errors indicated above suggest that pupils' understanding of practical work and mastery of experimental skills are rather low. Various factors have been advanced to explain this situation. One major factor which has been cited as contributing to this situation is that pupils do not carry out enough practical work during the time they are learning biology

(Chibesakunda, 1983; Kapolyo, 1990; Haambokoma *et al*, 2002). There are various reasons for this situation; one reason is that some schools do not have facilities or materials for practical work such as apparatus and chemicals (Haambokoma *et al*, 2002). Some schools may have some materials but usually these are not enough for every pupil to have the experience of carrying out a practical activity. Another reason is that in some schools, administration is of the view that buying chemicals and apparatus for use during science lessons is expensive and only releases money to buy materials required for examination purposes.

Furthermore, it is claimed that some teachers were also a contributing factor to lack of practicals when teaching biology (Haambokoma, 2007). For example they did not see the value of practical work to pupils' learning of biology. Therefore, even when it was possible to engage pupils in practical activities such as observing, drawing and measuring using locally available materials such as leaves, stems and flowers which did not cost anything, they never made efforts to do so. Instead they concentrated on the theory part without practical exercises when teaching. In some cases, teachers did not even know the experimental skills learners were expected to acquire by the end of the biology course. This is due to inadequate understanding of what they were expected to do arising perhaps from inadequate training in the teaching of biology or negligence on what they are expected to do (Centre for International Development and Training, 2005).

Another issue which contributed to candidates making similar errors in practical activities nearly every year was lack of or inadequate feedback on the performance of pupils in practical work to teachers of biology in schools. Lack of feedback from the examinations council of Zambia to teachers brings about a situation where teachers keep on teaching wrong things year in and year out (Haambokoma, 2007).

The overloaded biology syllabus also contributes to lack of practical work in the sense that it does not give adequate time for teachers to engage pupils in practical work such as conducting experiments which require enough time to give results (Haambokoma, 2007). Hence teachers use theoretical methods which enable them to cover the vast syllabus before pupils sit for the examination. Some pupils also contribute to their poor performance in the practical examination in that they lack seriousness to do what is expected of them during biology practical examinations (Mudenda, 2008).

Further analysis of the biology results show that in most cases, pupils' performance was worse in the practical test than in the theory examination papers (ECZ, 2009). In other words, the performance in the practical test is a major contributor to candidates' overall poor performance in biology. This means that pupils are rarely engaged in meaningful practical activities and therefore they find the biology practical examination new (Haambokoma, 2007; Mudenda, 2008).

2.3.2. Genetics as a difficult topic

As mentioned at the beginning of this chapter, studies have shown that genetics is a topic in biology which is difficult for pupils to understand (Johnstone & Mahmoud, 1980; Musonda, 2013). Haambokoma (2007) set out to investigate the nature and causes of learning difficulties in genetics at secondary school level. Areas identified as being difficult included genetic crosses, genetic terms, mutations and sex determination. One of the factors cited by Haambokoma (2007) as contributing to learning difficulties in Genetics is the inability of some teachers to explain certain aspects of genetics adequately to learners. Lack of proper explanation makes it difficult for students to comprehend the topic (Brophy & Good, 1986). One possible reason for teachers not being able to explain could be that they do not understand the topic well possibly because their background is poor in this topic. It is argued

that the extent of mastery of the topic has a major influence on the quality of explanation a teacher can give to students (Hashweh, 1987).

Another factor which was identified by Haambokoma (2007) was that some students were not taught this topic because some teachers were not comfortable teaching genetics. When a topic like genetics is not taught to pupils, it becomes difficult for them to learn it on their own without guidance (Brophyl & Good, 1986; Hiebert, 1999). Fast pace of lesson presentation by some teachers was also another factor cited by learners (Haambokoma, 2007). When a topic like genetics is presented too fast, students especially the slow ones experience difficulties following the lesson and hence lose interest to learn the topic (Reece & Walker, 1997). Furthermore, new information given to students too quickly is not retained because it cannot be processed by the short term memory of the brain (Petty, 1993).

Haambokoma (2007) also highlighted the fact that scheduling of genetics towards the end of the grade 12 syllabus contributed to students having difficulties in understanding this topic. The major reason for this is that the concentration of students during lessons at that time is low because of pending examinations. They concentrate much more on thinking about the coming examination than on what they are being taught. Concentration on the topic being taught is an important pre-requisite to learning what is being taught. ECZ (2009) revealed that a lot of candidates had performed poorly on a question on genetics. It appeared as if many candidates had not learned this topic. Many candidates did not give a correct genetic diagram indicating the stages of parents, gametes and offspring. They did not use the correct symbols such as 1^A, 1^B, and 1^O. They did not identify genotype and phenotype correctly. ECZ (2009) also revealed that the use of genetic diagrams had been asked almost in all past papers but teachers had not guided candidates well in this area. A good genetic diagram without labelling the parents, parental genotype, gametes and offspring could not score any marks.

This is a clear indication that teachers did not know the mistakes which their pupils were making during final examinations.

According to ECZ (2015) genetic diagrams have continued being a very big challenge for the school certificate candidates. Each year, ECZ guidelines are sent to schools to show questions where pupils find challenges but there is no improvement in answers given by candidates. This again shows that teachers dot not check through examiners' reports to see mistakes which are made by pupils during biology examinations. Nearly all candidates failed to explain what is meant by the term sex-linked characteristic. Wrong responses were too many and with no connection with sex linkage. The correct answer required candidates to explain that these are characteristics controlled by genes found on sex chromosomes specifically on the X chromosome.

Haambokoma (2007) further says that the unfriendly attitude of some teachers, towards students when teaching this topic also make it difficult for learners to understand. Another contributing factor cited by some respondents was that some students come to lessons on genetics with a negative attitude towards the topic. Hence no matter how a teacher tries to teach, such pupils do not make efforts to understand what is being taught. When learners have no interest in a topic, they tend to pursue it with less eagerness and persistence (Maqsud, 1992). Positive attitude towards a topic is an important pre-requisite to learning it (Reece &Walker, 1997).

However, Haambokoma's study (2007) did not involve lesson observations of genetics. This lack of observations could have compromised the research findings. All the respondents were either only interviewed or exposed to a questionnaire. Classroom observations could have increased the reliability of the research findings.

Awang-Kanak *et al* (2016) did a study which was aimed at identifying the difficulties experienced by science foundation students in understanding basic Mendelian genetics, the focus on their ability to solve monohybrid and dihybrid cases. In this study, 95 students were given a quiz on three types of genetics problems at the University of Malaysia Sabah. Prior to this quiz, students were given four hours of lecture, class tutorials and problem based learning assignment on genetic inheritance. It was revealed that the majority of students found genetic inheritance difficult. The weakness in this study is that there were no interviews for research participants. Their difficulties in learning genetic inheritance were only seen through written answers.

Genetics has also been identified as the most problematic topic in learning biology by secondary school and university students (Altunoglu & Seker, 2015; Bahar *et al*, 1999). In a related report, Knipples (2002) identified five problems in genetics education. The domain specific vocabulary and terminology, the mathematical part in executing Mendelian genetics tasks, the cytological process, the abstract nature of the subject and the complex nature of genetics.

This scenario of pupils experiencing difficulties in learning genetics has been aggravated by the lack of experiments in genetics. Usually all the experiments conducted by Mendel are just described since they are slow to yield results (Sandra & Lederman, 2007).

2.3.3. Mitosis and meiosis as difficult topics

Another area identified as challenging to learning biology were processes of mitosis and meiosis (Johnstone & Mahmoud, 1980). Mitosis usually leads to the duplication of chromosomes in the parent cells so that the daughter cells formed share the chromosomes. Mitosis occurs in the ordinary cells of the body (autosomal cells). Mitosis is a continuous process but for convenience it has been divided into five stages which are interphase,

prophase, metaphase, anaphase and telophase (Kateka, *et al*, 1996). Meiosis is the cell division that takes place in reproductive organs to produce reproductive cells (gametes). It leads to the reduction in the number of chromosomes, thus it is called reduction division. Meiosis occurs in two parts and these are the first meiotic division and second meiotic division (Kateka, *et al*, 1996).

Since meiosis has two parts it causes confusion to the pupils because what happens during the second stage of meiosis is the same as what occurs during mitosis. There is however, no interphase. The stages of second meiotic division are called prophase II, metaphase II, anaphase II and telophase II (Tekkaya, Ozkan & Sungur, 2001).

The difficulties in learning mitosis and meiosis can be attributed mainly to terminology and abstract level of concepts. The biological terminology used in mitosis and meiosis is very complicated and includes many terms such as chromosomes, genes, alleles, chromatids and DNA. Pupils mix these terms and generally memorise these concepts and forget them after some time (Tekkaya, Ozkan & Sungur, 2001). The phases of mitosis and meiosis are also confusing to pupils (Haambokoma, *et al* 2002).

This confusion is also supported by the chief marker who reported on the 2007 biology school certificate examination that most candidates seemed not to have learnt the process of meiosis and as a result failed to answer the question. Even those who attempted, failed to bring out the actual events during meiosis which could cause each ovum to be genetically different from the others (ECZ, 2008).

Cossa *et al* (2008) in a study of undergraduate understanding of cell division specifically explored students' understanding of mitosis and meiosis before and after laboratory instruction using a phenomenological analytical approach. A cell biology test was administered to 41 first year biology students at Eduardo Mondlane University in

Mozambique at pre and post-test stages and the students' activities during laboratory sessions were observed and recorded. The topic of cell division was taught by a senior lecturer over a period of 16 weeks and involved two one hour tutorials per week and one laboratory session of 2 hour duration per week. The overall findings of this study suggested that, the cell biology laboratory work improved students' level of understanding of mitosis and meiosis. Despite this improved level of understanding from the laboratory instruction, the students consistently demonstrated a poor knowledge of the basic concepts (such as chromosome structure, chromosome number, specific events in prophase I of meiosis and DNA replication). This study observed that practical difficulties students experienced in the use of the light microscopes impacted negatively on the envisaged aims of the laboratory work in cell division. This study demonstrated that even university students had difficulties understanding the specific events occurring during cell division and that practical difficulties contributed to lack of understanding among learners during laboratory work.

Difficulties in understanding mitosis and meiosis by learners have also been reported in India (Chattopadhyay, 2012). In this study a total of 289 students (158 boys and 131 girls of class 12 (16-18 years old) from three different undergraduate colleges in Northeast India were given written questionnaires having both fixed and free answer–type questions on cell division. The study revealed that a significant number of students did not understand the primary differences between the two cell division processes and seemed to be confused by closely related words like mitosis and meiosis. Students had difficulties appreciating the importance of the maintenance of chromosome numbers in mitosis and that students did not understand the significance of the formation of gametes with haploid number of chromosomes and the recombination events taking place during meiosis and their implications. The study also revealed that although some awareness of the significance of mitosis and meiosis was present among the students, they did not seem to have an idea of

how this was achieved. Students were also confused by the contradictory words like replicating, dividing, copying, splitting, multiplying and sharing. Although this study shades some light on challenges experienced by leaners, it did not look at how mitosis and meiosis were taught to the students but instead just tested the students on mitosis and meiosis without finding out what could have caused the lack of understanding among the students.

2.3.4. Diversity of living organisms as a difficult topic

It was clear from the answers candidates were giving during the 2008 biology paper 2 examination that candidates just learn classification without the aspect of biodiversity (ECZ, 2009). Under classification it is expected that learners should be able to identify various types of plants and animals and they should also be able to formulate a simple key for classification of plants and animals. They should also be able to use a simple classification key to identify different plants and animals (CDC, 2013). However, the examiner's report of 2016 revealed that candidates failed to use scientific names of locally known plants and animals in the practical examination (ECZ, 2016). In addition, the chief examiner reported that on classification of living organisms, most pupils showed lack of proper biological understanding of the concepts despite some questions being routine (ECZ, 2008).

For example most candidates had very little understanding of the term biodiversity (ECZ, 2008). According to the chief examiners report of the 2008 joint examination for School Certificate and General Certificate of Education ordinary level biology, most candidates did not answer the questions on biodiversity correctly and it was also evident from the pupils' responses that most teachers do not cover the whole syllabus (ECZ, 2008). Hence topics like biodiversity suffered a lot. Candidates demonstrated lack of understanding in the way they were answering questions. Other candidates left blank spaces on questions based on biodiversity (ECZ, 2008).

2.3.5. Classification of living organisms as a difficult topic

Other studies have also revealed misconceptions on classification of organisms among learners. For example in a study done by Naz and Nasreen (2013) on students' misconceptions about classification of animals at secondary school level and the effectiveness of inquiry method for conceptual change, it was revealed that students had misconceptions in very basic biological concepts and that biology was taught to pupils as if the pupils had no prior experiences. The preconceptions that students bring with them to biology education can exercise a powerful influence on what they learn and recognise as valid knowledge. There is sufficient evidence to indicate that many of these ideas made by students before prescribed teaching differ from the accepted scientific ideas. It may also be noted that these prior concepts or knowledge could drastically influence classroom teaching. This corroborates with the transaction model developed by Huitt (1995) which described input as those qualities or characteristics of teachers and students that they bring with them to the classroom experience. Naz and Nasreen (2013) found that students had fewer misconceptions about the animals for which they had first-hand experience. Students identified an earth worm as an invertebrate but failed to give a scientific reason for their response (Naz & Nasreen, 2013).

Challenges associated with the classification of plants have also been reported among teacher trainees. For example in a study which was done in Turkey on 78 first year and 84 fourth year prospective teachers between 2012 and 2013 majoring in Elementary School Classroom Teacher Education Programme, it was revealed that the prospective teachers in both groups had misconceptions and considerable confusion over the concepts of vascular plants and non-vascular plants, gymnosperms and angiosperm plants (Yangin, Sidekli & Gokbulut, 2013). Furthermore, it was noted that pre service teacher training did not have an influence on correcting misconceptions about classification of plants as a result teachers graduated with

misconceptions about classification of plants. In this study students were given questionnaires consisting of closed and open-ended questions on classification and it was revealed that almost all of the participants confused fungi with plants and related some gymnosperm plants with angiosperm plants. The findings of the study above is in line to some extent with those of Kellert (1995) who reported that elementary and secondary school students have problems in the classification and diversity of living organisms. Students often have difficulties learning classification of living organisms and one reason is due to misconceptions. In broad terms, misconceptions correspond to the concepts that have peculiar interpretations and meanings in students' articulations that are not scientifically accurate (Yangin, Sidekli & Gokbulut, 2014).

Section 2.3 has outlined perceived difficult topics in biology. While, the next section will concentrate on topics perceived to be easy

2.4 Topics perceived to be easy in senior secondary biology

In South Africa a sample of 125 first year pre-service life sciences and natural sciences teachers from a university responded to a questionnaire in regard to their experiences with the newly implemented life sciences curricula. The responses to the questions were analysed qualitatively and quantitatively. The results indicate that the easiest topics for them to learn were reproduction and digestion. These topics were found to be easy because they were more interesting, useful and informative (De Villiers, 2011). In another study which was done by Ozcan, *et al* (2014) the cell and ecosystems were found to be learnt more easily in secondary schools because the topics were found to be easy and understandable. These topics were found to be enjoyable, interesting, visually rich and related to daily life.

An easy topic is one that arouses a feeling of interest in the pupil (Wade, 2001). When a student is interested in a topic their attention is particularly engaged. Interest is therefore

specific and develops over time. It is relatively stable and is associated with personal significance, positive emotions, high value and increased knowledge. Therefore, more emphasis needs to be placed on what students are interested in and having this incorporated into a curriculum which serves the student. Teachers also need to consider the appropriateness of their selected pedagogy. To enhance student interest in science Christidou (2006) advised that there should be careful selection of topics to be included in a school curriculum. A science curriculum should emphasize those topics that are of interest to the students and encourage activities that are familiar and readily adopted by them.

2.4.1 Reproduction as an easy topic

Reproduction is important for the survival of all living things. Without a mechanism for reproduction, life would come to an end. There are two types of reproduction to learn in secondary schools, asexual and sexual reproduction. Many teachers are afraid of discussing human reproduction, but if the lesson is delivered well it is easy for students to understand the principles without difficulties (Kambi, 2012). However, teachers find plant reproduction very friendly to teach (Hershey, 1992). This is because of its connectivity with elements of students' daily lives such as fruits and crops which are visible. Plant reproduction also offers many possibilities for simple experiments and observations which can easily be implemented at school or in outdoor education programmes. The opening of flowers, fast growth of seedlings and active seed dispersal are just some of the phenomena that can be observed in the context of plant reproduction (Wilmer, 2011).

2.4.2 Human digestion as an easy topic

Digestion in mammals is divided into physical and chemical digestion. Physical digestion includes those physical processes that break large food particles into smaller ones. Mastication or chewing of food is a physical aspect of digestion. Chemical digestion is

achieved with the aid of chemical substances called digestion are thus complimentary to each other. Digestion is carried out in the mouth, stomach and small intestines of the alimentary canal. Once digestion is completed, the end products are absorbed mainly in the small intestine (Chaebwa *et al*, 1995). In a study which was done to identify student teachers' existing ways of thinking and ways of understanding digestion and the digestive system at Karadaniz Technical University in Turkey respondents provided correct answers to the questions but when probed further, they could not provide an explanation because they had learned via memorization without understanding the relationships or underlying concepts (Ursavas, 2012). Similar observations were reported by Bhattacharyya and Bodener (2005), who demonstrated that the graduate students in their study could produce correct responses to problems via memorization without understanding the chemical concepts behind their solutions. However, teaching about the digestive system can be easier for teachers when they use pre-planned lessons, units and additional teaching resources (Ursavas, 2012).

2.5. Patterns of science lesson presentation

There are various ways science lessons are presented and during this process, the behaviour or actions of teachers and leaners vary. For example, Ugwuadu (2011) claims that during the teaching and learning process, teachers and pupils use the democratic and authoritative discourse patterns in classroom interactions. In the democratic discourse pattern the teacher opens up a discourse for pupils to verbally and freely contribute ideas that could reveal their knowledge and understanding of the problem (Viiri & Saari, 2006). On the other hand, the authoritative discourse pattern affords little or no interaction between the teacher and pupils during classroom activities. In addition, in this discourse pattern pupils are not allowed to share ideas and opinions with the teacher. The main task of the teacher is verbal presentation of facts and principles to pupils while pupils remain passive (Ugwuadu, 2011).

Classroom discourse is the way a teacher talks and expresses himself/herself verbally to his/her students and students express themselves to their teacher during classroom activities. The verbal discourse is a two way communication between the teacher and students which may affect learning depending on the clarity of the message (Ugwuadu, 2011). However, in his study on effects of discourse patterns on students' achievement and interest in biology, concentrated on defining the types of discourse patterns used in the teaching and learning process but did not look at how these discourse patterns are used in lessons involving topics perceived to be difficult in biology.

The transaction model developed by Huitt (2005) described classroom processes as teacher and student behaviours in the classroom as well as some other variables such as classroom climate. This is in agreement with Nwagbo (2001) who identified a number of factors as contributing to the non-acquisition of skills by secondary school pupils which invariably leads to poor performance and one of the factors is the teacher variable that is the teacher's method of teaching. Furthermore, Nzewi (2008) asserts that many science teachers prefer the traditional expository method of teaching, which is a teaching technique in which one person, the teacher presents a spoken discourse on a particular subject. They shy away from activity-oriented teaching methods which are student centred such as inquiry method, discovery method and investigative laboratory approach. Nwagbo (2006) observed that such teacher-centred approach which places the teacher as the sole possessor of knowledge and the students as passive recipients of knowledge may not enhance achievement or promote positive attitude to biology. This is because pupils also come to school with alternative ideas on certain concepts of biology and therefore they should not be treated as empty vessels to be filled with knowledge since learning is an active process (Chiappetta & Koballa, 2006). That is why before giving the lesson the teacher needs to know the pupils' previous knowledge.

This is to know the background of the class and thus to prepare ground for developing the present lesson.

Through proper questioning, the teacher should test the previous knowledge of the pupils and then introduce the lesson linking it with their previous knowledge (Das, 2013). These alternative conceptions are resistant to change by conventional teaching strategies (Chiappetta & Koballa, 2006). These misconceptions may also cause misunderstandings in certain science topics (Behar & Polat, 2007). This may especially be the case if the teaching strategies used by teachers are not adequate to allow for conceptual change by allowing pupils air out ideas they have on the new lesson.

Despite the fact that pupils come to school with some prior knowledge which needs to be heard, biology teachers in secondary schools usually prefer to employ mainly traditional teaching approaches and techniques hence biology lessons are mainly presented in a teacher-centred manner. Lesson presentation is the stage of actual giving of the lesson, the time for the teacher to show his ability in selecting, organising and presenting the content matter and helping in demonstrations, doing individual or group work. The pupils should be kept busy with one or the other type of activity (Das, 2013). However, teachers transfer the knowledge that they have and what is written in the textbook without conducting student centred teaching activities. This has negative effects on student's attitudes towards biology and their motivation to learn (Cimer, 2004) because students are not given time to express themselves.

The transaction model developed by Huitt (2005) describes input as those qualities or characteristics of teachers and students that they bring with them to the classroom experience. This prior knowledge by learners is also supported by Behar and Polat (2007) who point to misconceptions about science phenomena possessed by students as contributing to the difficulty of certain science topics.

A related argument put forward by Behar and Polat (2007) concerns the many terms and symbols used in the teaching of various science concepts. Many such terms are new to the students and so cannot be linked to their cognitive structures, which according to Behar and Polat (2007) may also cause information overload in the working memory. In addition, some terms are known by students, but in a different context and with a different meaning to that used in science.

Obiekwe (2008) reported that science teaching in Nigeria lays extreme emphasis on content and the use of "chalk and talk" method neglecting the practical activity method which enhances teaching and learning. This negligence and shy-away altitude from activity oriented-method of teaching has led to abstraction which makes the students less active and more prone to rote memorisation. Behar and Polat (2007) alluded to this when they identified the passive roles of students in the classroom and their perception of the teacher as the only source of knowledge, as contributing to the perceived difficulty of science topics.

Many times, teachers use the excuse of the overloaded science curricula to explain their reliance on strictly didactic methods of teaching. Though these claims may have some merit, these teaching strategies may in effect, portray the subject as difficult to many students. Zoller (2000) asserts that teacher-centred or traditional lessons can be non-productive and in some cases, detrimental to student learning. In addition, Lanier and Little (1986) claim that traditional lessons are less likely to promote conceptual understanding or facilitate conceptual change and thus are less likely to promote the development of technical skills. Therefore, teacher's competencies and knowledge in both biology as a discipline and its teaching are crucial for enhancing students learning. If teachers show weaknesses in their knowledge of the subject, this might create pupils' distrust of their teacher's abilities and knowledge. Students may then not listen to teachers in the lessons and might develop negative attitudes towards both biology and its teachers (Cimer, 2004).

A number of studies conducted in Africa have revealed that in most cases, science lessons are dominated by teachers. For example, Beccles (2012) investigated science teaching, classroom discussion and contexts in junior high schools in Ghana. Twenty three science teachers (19 males and four females) in 20 schools were selected and each teacher taught a science lesson that was observed in camera. The average age of the teachers was 29 years. In addition, 10 Head Teachers in the Junior High Schools (7 females and three males with an average of 49 years took part in the study. Twelve of the science teachers and 34 students were later interviewed and the study revealed that science teachers spent most of their lesson time on science instruction, whole classwork and teacher presentation sessions but very little time was spent on independent work, practical activities and discussion. Beccles (2012) further discovered that science teachers stressed recall of factual knowledge rather than eliciting high order cognitive processes and conceptual, procedural and Meta-cognitive dimensions. Beccles (2012) concentrated on the factors that influence the selection of lesson content by science teachers in Ghana but the current study focussed on the choice of discourse patterns to be used in the delivery of lesson content and the effects of the discourse patterns on pupils' understanding in Zambia.

Recent data on classroom practices suggest that biology lessons are generally carried out through lectures and can be identified as teacher-centred lessons. In most biology lessons teachers just talk and transfer theoretical or abstract knowledge and do not provide examples from daily life. This results in students losing their motivation to learn biology and developing negative attitudes towards it (Cimer, 2004). Styles of biology teaching and teaching methods and techniques may also be factors that affect students learning in biology (Cimer, 2004).

According to Hughes (2005) in lessons where pupils spend the majority of the time writing down notes, either from the board, a book or dictated by the teacher, they may be writing

down what the teacher thinks they have learned but they are not necessarily learning a great deal through the process of writing. This implies that teachers should not just give notes to pupils but should be able to explain concepts before asking pupils to copy anything from the board. This is very common in Zambian secondary schools, in most cases, teachers even ask pupils to write notes on the board on their behalf. This tendency leaves the pupils who copy notes to be behind as they have to find time to copy the notes in their own spare time (Kambi, 2012).

During the democratic discourse, it is necessary for the teacher to wait for a few seconds for pupils to answer a question. This increases the motivation of the pupil responding but negatively influences the interest of another pupil who would like to respond and slow the pace of the lesson for the rest of the class (Good & Brophyl, 1997). During pupil to pupil discourse, some pupils can monopolize small groups just as they dominate whole-class discussions (King, 1993; Mulryan, 1995). Blumenfeld (1992) reported that students found small-group work more motivating and enjoyable but noted that active learning declined during group work. When small group tasks are poorly designed, students often spend more time carrying out superficial procedures than thinking about the meaning of the task (Good, Mulryan & Mc Caslin, 1992; Mc Caslin & Good, 1992). Unless teachers monitor students carefully as they work in groups, teachers may unintentionally create situations in which some students within groups have much more power and influence than others. Pupils often have misconceptions about academic content and these may be reinforced during small group work (Good & Brophy, 1997). Despite that, small groups can provide useful learning experiences for students, problems that develop in some group situations may prevent or minimise constructive learning (Good, Mulryan & Mc Caslin, 1992). However, Paulus *et al* (1993) have argued that individuals produce fewer ideas in interactive brainstorming groups than when brainstorming alone. Nevertheless, a helpful activity when closing a lesson is to

engage students in a quick discussion on what exactly they learned and what it means to them (Lewis, 2018).

Section 2.5 has discussed patterns of science lesson presentations. The next section will look at teachers' choice of discourse patterns used for teaching biology topics perceived to be difficult.

2.6. Teachers' choice of discourse patterns used for teaching biology topics perceived to be difficult

The choice of discourse patterns used for teaching topics perceived to be difficult in biology hinges on the availability of facilities such as teaching and learning materials in the school and many other reasons like knowledge of the teacher and his or her flexibility (MIE, 2004). Other considerations during choosing a method of teaching are number of students to be taught, age, time and prior knowledge of the learner (MIE, 2004). It should come as no surprise that prior research (Schmidt & Kennedy, 1990) has suggested that teachers' beliefs about subject matter influence what they choose to teach and how they teach it. Choice is the outcome of a process which involves assessment and judgement; that is the evaluation of different options and making a decision about which option to choose. In order for this process to take place and a choice to be made, there is need to have two or more alternatives from which to choose. In addition, these alternatives should have some positive value (Hastie & Dawes, 2001).

About the general approach to the teaching of science and choice of methods, it can be said that there is no set approach which the science teacher must follow (Das, 2013). Some students may be taught more effectively by following a particular method and others by following another method. The use of a variety of methods during teaching helps to avoid monotony and the nature of the content also determines the method or procedure to be

followed. The teachers themselves vary in their liking for different methods. Moreover, different topics and objectives may demand the use of different methods (Das, 2013). The method to be adopted by a teacher depends on factors such as teachers' talent, interest and experience. Ability to arouse interest and gain co-operation of pupils also determines the discourse pattern to be adopted by the teacher. Other factors affecting choice of discourse patterns include intelligence levels of pupils and laboratory resources. Therefore, it remains for the science teacher to choose one or more different methods of teaching science, which the teacher thinks will be best suited and most effective for a particular situation. Teachers differ in their ability and so do the pupils they teach. Methods of teaching also vary in efficiency according to situations (Das, 2013).

The choice of teaching method and the design of the teaching within that method will depend very much on the context of teaching. However, a key criterion should be the suitability of the method or design model for developing the knowledge and skills that learners will need in this digital age. Other critical factors will be the demands of the subject domain, characteristics of the learners likely to be taught, the resources available, especially in terms of supporting learners, and probably most important of all, the teacher's own views and beliefs about what constitutes good teaching (Dirksen, 2016).

Pedagogical methods and strategies range from discussions, to collaborative learning practices, to multi-media, to experiential learning and beyond. The choice may be different for each course and context. Getting a solid grasp on the possibilities will help teachers to have a complete toolkit from which they can choose the most appropriate tool for each learning experience. By answering the questions about the learners and the goals of the subject and by learning new pedagogical practices, teachers are well on their way through

the shift from information hub to master architect leading students to build their own solid structures (Dirksen, 2016).

The development of scientific skills largely depends on methods of teaching used. Every science teacher is expected to have a clear understanding of the basis for his/her profession. A command of facts of science as well as the ability to encourage and inspire his/her students is very important (Dorcas, 2004). Studies have shown that no single method is best for all topics and for all teachers and learners. The crucial factor is that teaching should focus more on the needs of the learners. The teacher is required to consider the subject matter, the objectives, facilities and other factors in relation to the learners needs. Some of those most important needs are the learners' aspirations, which become a reality through knowledge and skills previously acquired in school. Examinations, which are presumed to measure achievement in knowledge and skills, continue to be poorly performed by many secondary school students in Kenya (Dorcas, 2004). Among the factors blamed for the poor performance are poor teaching methods. In a study done by Dorcas (2004) which drew its inspiration from the need to identify the teaching methods used in teaching biology, there was an attempt to bring to light the factors that influence teachers' choice of the teaching techniques and problems that hamper use of effective teaching methods and to make recommendations for their improvement. The study was done in Kenya and employed descriptive survey design. A sample of 160 biology teachers was drawn from public secondary schools. A questionnaire and an observation check-list were used to collect data. The analysis of data was done through the use of descriptive statistics such as percentages and frequencies. Contingency coefficient test was used to determine the extent of relationship among different variables related to the teacher. The study findings revealed that there was still heavy use of expository teaching methods in biology yet their contribution to teaching and learning has been established to be minimal or negative by several researchers. Several factors were studied

among them curriculum, administrative, pupil and teacher factors in relation to choice of teaching techniques. The findings indicated that younger teachers used more effective methods than older ones. Experience appeared not to add much value to use of more effective methods. Male teachers seemed to use higher order inquiry oriented methods compared to females. The weakness in this study was that learners' needs appeared to have been ignored by teachers as they attempted to choose teaching methods.

Section 2.6 has looked at teachers' choice of discourse patterns used for teaching biology topics perceived to be difficult. The next section will discuss challenges of teaching perceived difficult topics in biology.

2.7 Challenges of teaching perceived difficult topics in biology

Chifwa (2015) outlined a lot of challenges teachers faced when teaching genetics such as the following; learner's lack of background knowledge, lack of teaching and learning aids, negative attitude of learners towards genetics, the bulkiness of this topic and the teaching of genetics in the third term of grade 12 just before final examinations. The implications of these findings are that the learners found it difficult to construct their own knowledge about genetics. Due to these challenges outlined above teachers were forced to use teacher-centred methods instead of learner centred methods when teaching genetics in secondary schools in Kitwe District of Zambia.

However, based on the findings of Chifwa (2015) biology teachers experience more challenges unique to their discipline including: time and budgetary constraints to run laboratory practicals. In addition there are challenges that come from having extremely large class sizes (Kambi, 2012). For this reason there is need for affordable, timely professional development among teachers of biology. It is particularly difficult for teachers of biology to keep up with advances in their field such as advances in molecular and cellular biology,

genetics and biotechnology. This is because most teachers are not interested in school based CPD (Musonda, 2013).

Chifwa's (2015) research can be questioned in that despite carrying out a qualitative study the choice of grade 12 respondents was inappropriate as they were randomly sampled and most of them were not knowledgeable enough to respond to the questionnaire which was distributed on the teaching of genetics in selected secondary schools in Kitwe District of Zambia. These grade 12 respondents were supposed to be purposively sampled with the assistance of teachers of biology so as to select pupils who were knowledgeable enough on genetics. This could have enhanced the trustworthiness of the research findings.

The primary purpose of teaching at any level of education is to bring a fundamental change in the learner (Tebabal & Kahssay, 2011). To facilitate the process of knowledge transmission, teachers should apply appropriate teaching methods that best suit specific objectives and outcomes. Regular poor academic performance by the majority of students is fundamentally linked to application of ineffective teaching methods by teachers intending to impact knowledge to learners (Adunola, 2011). Substantial research on the effectiveness of teaching methods indicates that the quality of teaching is often reflected by the achievements of learners. According to Ayeni (2011) teaching is a process that involves bringing about desirable changes in learners so as to achieve specific outcomes. In order for the method used for teaching to be effective, Adunola (2011) maintains that teachers need to be conversant with numerous teaching strategies that take recognition of the magnitude of complexity of the concepts to be covered. Adunola (2011) asserts that teaching methods work effectively mainly if they suit learners' needs since every learner interprets and responds to questions in a unique way. Thus alignment of teaching methods with students' needs and preferred learning influence students' academic attainments.

Under teacher-centred teaching methods students simply obtain information from the teacher without building their engagement level with the subject being taught (Boud & Feletti, 1999). The approach is least practical, more theoretical and based on memorizing (Teo &Wong, 2000). It does not apply activity based learning to encourage students to solve real-life problems based on applied knowledge. The teacher may attempt to maximise the delivery of information while minimizing time and effort, as a result, both interest and understanding of students may get lost. To address such short falls Zakaria, Chin and Daud (2010) argue that teaching should not merely focus on dispensing rules, definitions and procedures for students to memorise, but should also actively engage students as key participants.

Most teachers in secondary schools apply the student-centred approach to promote interest, analytical research, critical thinking and enjoyment among students (Hesson & Shad, 2007). The student-centred approach is regarded to be more effective since it does not centralize the flow of knowledge from the teacher to the student (Lindquist, 1995). The approach also motivates goal-orientated behaviour among students, hence the method is very effective in improving student achievement (Slavin, 1996).

Ganyaupfu (2013) observed that in light of the fact that learning is a process that involves investigating, formulating, reasoning and using appropriate strategies to solve problems, teachers should realise that it becomes more effective if the students are tasked to perform rather than just asked to remember some information. A typical learning environment with a presentation from the teacher neither promotes learners' participation nor builds the required level of reasoning among students. Students build a better understanding of the main concepts more effectively when they are engaged to solve problems during class activities (Ganyaupfu, 2013).

A student-centred learning environment seems to produce higher- level learning outcomes more efficiently than a traditional teacher-centred environment (Tynjala, 1998). Therefore, bias in selection of teaching methods by teachers in areas in which they possess exclusive monopoly knowledge should be avoided to improve students' academic performance (Adunola, 2011). Instead, teachers should create an atmosphere conducive to learning in order to enhance the development of students' learning experiences. In addition, teachers should also increase their knowledge of various instructional strategies in order to keep students engaged and motivated throughout the learning process.

In classroom teaching and learning, a large proportion of time is spent on talking by the teacher and listening by the learners (Zhang, 2013). Being one basic medium of classroom interaction, talking should play a crucial part in the process of learner development. Being the medium of classroom teaching and learning, language plays a significant role in affecting the kinds of opportunities for knowing and coming to know as well as encouraging collaborative group work (Wells, 1999). When talking in groups or whole class, pupils can learn a great deal from each other and present the significance of what they have done and come to understand in front of the teacher. Likewise, Nyastrand (1997) points out that certain kinds of classroom talk creates more opportunity and flexibility for students to contextualise and assimilate new information. It is through talk that learners actively engage and teachers constructively intervene (Alexander, 2000).

Apart from avoiding school based CPD activities teachers also face time constraints that limit their ability to structure inquiry-based lessons that incorporate enough time for students to truly move at their own pace through the inquiry and problem solving processes. These are in addition to the layer of challenges that face all teachers like lack of respect, student apathy, inadequate pay and the pitfalls of standardised testing (Hughes, 2005).

Science teachers in general face challenges ranging from preparing students for public examinations while giving students a positive outlook of science to change in mind set when moving to a learner focused teaching method. Creating a rubric that can be used to effectively assess students in a timely manner is also another challenge facing science teachers. Another challenge is tailoring class plans, activities and scientific language for students of different ages and skills (Das, 2013).

Moreover, lack of institutional commitment to science, expense, storage and choice of science materials is another challenge. In addition coming up with activities that will spark imagination and fit the curriculum is also another challenge. Most science teachers are single-subject specialists and it is difficult to find teachers with the knowledge of and enthusiasm for the teaching of a scheme of work covering a wide spectrum of scientific content. Any teacher teaching unwillingly outside his discipline will lack confidence and enthusiasm and the quality of teaching will suffer (Hughes, 2005).

Chocha, Namayanga and Ndhlovu (2014) conducted an assessment of teacher competences in O-Level biology practical work in Zambia. Their results showed that 240 teachers who participated in this study lacked some basic scientific skills such as correct handling of apparatus, observation, collecting and interpreting data. Their performance in the given tasks indicated that most of the teachers had difficulties in answering the worksheets. This raised serious concerns on the quality of knowledge, skills and values these teachers were imparting in the learners, a situation that demands an intervention to improve teacher competences in practical work.

Schmid and Teraro (1990) reported that biology is so difficult to teach and learn because it consists of a myriad of unfamiliar concepts involving complex relations. They identified rote

learning as the school's favoured approach to teaching unfamiliar material. However, rote learning fails in the face of complex interactions involved in biology.

One of the limitations to biological investigations in the laboratory is that either many life processes are far too lengthy, such as the effect of parents, dominant and recessive genes on subsequent generations of offspring, or far too complex such as the effects of nutrition on blood sugar levels in the school laboratory (Schmid & Teraro, 1990). Therefore it is not easy for teachers to illustrate some biological facts using experiments.

In Zambia, there is a serious shortage of qualified science teachers and the teachers are poorly paid forcing them to engage in other part-time jobs thus neglecting their pupils (MoE, 1996). This situation was reported as early as the nineteen sixties by Richardson *et al.* (1968) who attributed the causes of learning difficulties on the suffering of the science programme in our schools due to the shortage of adequately prepared teachers hampered by a lack of adequate physical resources and an unimaginative educational programme. The salaries of our teachers have suffered to the extent that many have been unable to continue in their work and have chosen other occupations. Many have taken a second position, or part-time work, thereby diluting their time and energy. Usually teachers do not prepare much for the pupils due to fatigue. This fatigue results in teachers having unfriendly attitudes towards pupils when teaching and pupils are not even allowed to seek clarification on issues they do not understand (Haambokoma, 2007).

The shortage of university graduate teachers in Zambia has been experienced mostly in mathematics and science subjects at high school level (MoE, 1996). This situation has forced the Ministry of General Education and some private schools to employ graduates without teaching methodology to teach science in schools provided they have a science background. Because of lack of training in teaching, their lesson presentation is not effective in most cases

and this has also contributed to underachievement of pupils in science subjects in schools where they have been deployed (Haambokoma & Chabalengula, 2003).

Haambokoma (2007) established that most of the heads of science department have never attended any kind of workshop or course pertaining to managing a department. This suggests that they lack management skills as a result they do not monitor learning of pupils in the subjects they have been mandated to supervise. Haambokoma (2007) goes on to say that the majority of heads of science department have expressed willingness to be trained in the monitoring of teaching and learning and in the management of practical examinations. It would appear from their submissions that these areas have been giving heads of science departments problems to handle.

Schmid and Teraro (1990) put the blame on the highly conceptual nature of biology which seems to be difficult for most pupils. They believed that the techniques used in the classroom have not sufficiently eased the learning process and they feel that little has been done regarding the learning processes that underlie biology instruction.

Reece and Walker (1997) argued that when lessons are presented in a very fast manner, pupils fail to follow the lesson therefore learning cannot take place. Usually many teachers of biology would like to present lessons very fast so that they can cover the wide biology syllabus.

High-ability pupils are usually rewarded with the highest grades, marks and publicity while the efforts of less-able pupils are seldom acknowledged, and their attainments do not inspire added effort. Hence, low-ability pupils and those who are disadvantaged-pupils who must work hardest have the least incentive to do so (Monk & Osborne, 2000).

Very few textbooks of biology have presented alternative forms of practical work on genetics for the pupils. This view is also held by Haambokoma (2007) who recommended that text book writers should ensure that biology textbooks meant for high schools should cover genetics adequately in a way students can understand and that teachers should give adequate explanations to students using visual aids, practical activities and relating genetics to real life situations.

Many biology textbooks discuss classical experiments and accepted results on genetics but they do not suggest in any detail experiments or observations which might be performed by pupils and many experiments on genetics are incapable of leading to simple results (Schmid & Teraro, 1990).

Section 2.7 has outlined challenges teachers experience when teaching science. The next section will focus on practices which enhances the learning of biology.

2.8 Practices which enhance the learning of biology

A number of suggestions have been advanced to improve the teaching of biology and science in general. For example, Hughes (2005) advises that schools should enquire whether all teachers have adequate understanding of how children learn. It is good advice to understand how children learn because this is the key to effective classroom practice (Hughes, 2005) and as such should provide the focus for our attention and research.

There are two requirements for effective learning. The pupil must be able to learn, that is possess the necessary processing capability and prior knowledge, and the pupil has to be willing to learn, that is possess the necessary motivation to engage in a task and to persevere (Adey, 2001). This simply means that learning can only be effective if learners are able and willing to learn. Teachers' attitude is very important in facilitating learning as reported by

Safuli and Mtunda (1986) who said that most educational thinkers agree that besides knowledge about the learner, teachers' attitudes play an important role in the teaching and learning process. This promotes confidence, trust and respect for one another and eventually promotes pupils' learning.

An important prerequisite in science learning is motivation (Das, 2007). Without interest and incentive, learning does not become meaningful. Motivation may therefore be said to be the heart of the learning process. The teacher should introduce a topic of science in an interesting way and make the content presented meaningful so that the learners find their work interesting and do all the activities willingly. It is the responsibility of the science teacher to evolve new patterns in his or her teaching to motivate the pupils to learn with zeal and eagerness. Das (2007) advised that during lesson introduction the teacher needs to find out the pupils' previous knowledge. Through proper questioning, the teacher should test the previous knowledge of the pupils and then introduce the lesson linking it with their previous knowledge

In the teaching and learning process, the teacher should structure classroom activities in such a way that students are allowed freedom to participate in biology classes using a variety of activities, reinforcement and feedback (Onuachu & Nwankonobi, 2009). It is important for teachers to work towards a classroom where responsibilities are shared with students. This does not imply that the teacher has to give up the role of general class manager to take on some sort of equal participant role, but it does mean that the teacher should encourage learners to manage their own learning, engage in co-operative tasks and learn how to learn (Onuachu & Nwankonobi, 2009). This clearly indicates that classroom interaction is a process in which teachers and pupils have a reciprocal effect upon each other through what they say and do in the classroom.

According to Beccles (2012) science teachers need to organise lesson time effectively on various classroom activities and actively involve students in lessons. This can help to elicit student thinking and nurture student understanding.

Consequently different types of tests should be given to pupils to help them revise difficult topics as shown by Das (2007) who believed that assessment is key in encouraging pupils to revise topics perceived to be difficult.

Examinations remain a critical factor in influencing the learning of biology. Teachers tend to focus on those aspects which gain examination grades rather than on important outcomes such as practical skills, in depth understanding of the discipline and socially relevant attitudes and values. The role of teachers in determining examination policy and in contributing to question banks is also an important issue, especially if examinations are to be intellectually stimulating and challenging instead of being channelled into modes of presentation which are mechanically and intellectually similar from year to year and from test to test (Meyer, 1988).

Moreover, ECZ (2007) recommended that candidates should be encouraged to draw neat and clear diagrams which are well labelled. At least the diagrams should occupy three quarters of the space provided and must also be realistic. In most cases pupil's poor performance in biology is as a result of their lack of practical skills.

Pupils in Turkey defined effectiveness in learning as retention of knowledge for a long time and they expressed that teaching biology through visual materials and tools helped them retain biological knowledge for a long time and to remember or recall the information much more easily (Cimer, 2004). This simply means that teachers of biology must try by all means to include charts and pictures in their lessons in order to capture the attention of pupils.

There is need to present lessons in a way that stimulates the interest and excitement of students, and promotes deep and accurate understanding. Multimedia has the potential to bring abstract concepts and invisible objects and processes to life, and to do so in a flexible and reliable way which increases retention and learning (Moore & Miller, 1996). The interactive, user-friendly format and excellent graphics should improve student's satisfaction and attention and their learning outcomes. In combining written and spoken word with dynamic pictures, models and animations, the resource should suit a range of students and learning styles, including the visually oriented (Beakes, 2003).

Practical work is one of the hallmarks of science and many educators argue that a science education without practical work fails to reflect the true nature of scientific activity. This has led to a widespread acceptance in many countries of a strong emphasis on pupils doing practical work. There is now a need to examine carefully the purpose of different kinds of practical activities in order to select appropriate strategies for achieving different aims. Theory and practice are interrelated. Practical work needs essentially to be about thinking; that is about trying to understand the relations between evidence and theory and to stimulate and challenge pupils (Monk & Osborne, 2000).

The natural environment of any region is another aspect that can work for or against the spread of effective biological education. Therefore, the curriculum should be based on an analysis of the local environment which should focus on the study of local flora and fauna because this will have immediate relevance. Great care must be taken, therefore not to import unsuitable resources and curricula, without at least undertaking extensive adaptations to match local circumstances (Meyer, 1988). This coincides with Ozcan (2003) who revealed that field trips have effective instructional role to provide students with meaningful understanding and consequently higher achievement in biology. Through fieldtrips, the events and the objects that cannot be brought into class are possible to be observed.

In biology, the interactions between predators and prey form one of the most important features of an ecosystem, and there are now many computer programs which enable pupils to experiment with a simulated predator-prey system. Pupils can study complex interactions using one prey and one predator species. Given the limitations of time for studying such a system, and lack of access to species in their natural habitat, pupils have no other way of investigating these interactions, either in the laboratory or through field work (Monk & Osborne, 2000).

For cooperative learning to be successful, Johnson (1998) indicated that there are five requirements, namely: 1. Positive interdependence where the success of one person depends on the others. Students must both (i) learn the material and (ii) ensure all group members learn it. No free loaders are allowed; everyone must contribute; 2. Face to face interaction, where students facilitate each other's success; 3. Individual accountability and personal responsibility to achieve group's goals and students learn together but perform alone. The group holds each person responsible for contributing their fair share to the group's success. Each person's contribution should be assessed. Feedback should be given to individuals and the group; 4. Interpersonal and small group skills where students must get to know and trust each other, communicate accurately, accept and support one another and resolve conflicts constructively. Students need to be taught group skills and to be motivated to use them; 5. Group processing where the effectiveness of group work is influenced by whether groups reflect on how well they function and also time needs to be allocated for group processing.

Since teachers are confronted with big classes, cooperative learning has the potential to improve learning. One teacher is confronted with many learners and this could be of value (Johnson, 1998). The preceding arguments on the use of visual aids suggest that a lesson presentation that is consistent with active learning is characterised by activities in which pupils fully engage their higher order–thinking mental capacities like analysing, synthesizing,

comparing, evaluating the concepts, principles and procedures, predicting and justifying with each other (Das, 2007). The teachers should make use of incentives such as: providing scope to display pupils work, giving responsibility and leadership in scientific activities, keeping the pupils informed of their progress in science, providing opportunity for pupils' demonstration, arranging for pupils' co-operative enterprise in science, organising field trips or visits and also science clubs and science fairs, creating a sense of healthy competition among the pupils. The learners should be actively involved in the learning experience (Das, 2007). This logical suggestion simply implies that if pupils are not involved in the learning process, then science teaching will be difficult.

Haambokoma (2007) and Hashweh (1987) also discovered that the extent of mastery of a topic by the teacher has a major influence on the quality of explanation a teacher can give to students. The art of formulating questions is a major task of the teacher. However, it should not be assumed that principles of biology can be taught best by merely stating them and supplying the necessary facts to prove them. Some biology teachers who teach biology in terms of everyday problems are able to develop an understanding of the principles of biology more effectively as one of the outcomes of solving biological problems is organising the course around daily problems (Dreyer, 1994).

Beccles (2012) advised that teachers need to use questions to elicit student thinking, regularly invite questions from students and encourage responses from students. He further advised that teacher questions need to stress remember, understand, apply, analyse, evaluate and create cognitive processes as well as factual, conceptual, procedural information and meta-cognitive knowledge dimensions. He observed that the quality of student's answers and thinking is a reflection of teacher questions, therefore, the cognitive processes and knowledge dimensions need to be appropriately stressed in the classroom.

In many instances, asking questions is an assessment technique which is effective. However, it should not be confused with activities that promote new learning. It can provide an effective start to a lesson by recapping and consolidating prior learning and can provide the teacher with instant feedback about what has been remembered from the previous session. However, even when used for this purpose, we must be aware of the limitations of the strategy as only one pupil is able to answer each question. The danger being that his or her response is mistakenly assumed to be a representative answer (Hughes, 2005). Many teachers will undoubtedly point to the fact that skilfully designed questions of a more open-ended nature are more than just an assessment tool and when executed well, can challenge thinking and contribute to learning in their own right. The contribution that effective questioning makes to the learning process is beyond dispute (Hughes, 2005). Therefore, there is need for teachers to practice how to ask questions which could provoke the thinking of pupils. Petty (1993) also emphasised the need for pupils to ask questions because this is a very important part of learning and contributes positively to the learning process.

At the heart of good teaching lies good planning and good management. Individual lessons need to be well planned and structured. Individual lessons must also relate to previous lessons, previous knowledge and previous understanding and must connect to future lessons and future learning. This is why individual lessons need to be planned and sequenced into a scheme of work (Wellington, 2004). In this regard, the Zambian teacher training curriculum is geared towards producing an effective and competent teacher to meet the expectations of society (MESTEVEE, 2014). Cooper (1982) advised that for a teacher to be effective, the teacher must have a command of theoretical knowledge about learning and human behaviour. The teacher should know how humans develop and learn and also understand that children have differences. This would assist the teacher plan lessons appropriately and vary the teaching strategies. Qualities such as well trained teachers, highly qualified teachers and

having teachers who perform their duties responsibly have a bearing on the effectiveness of teaching and creation of a good learning culture.

A teacher should also have command knowledge of the subject matter to be taught. With this, he/she can teach confidently and effectively. The teacher should also have control of technical skills of teaching that facilitate learning. The teacher, in this case, is perceived as a person who needs to be conversant with various skills so that when he comes in contact with the children who have varied social backgrounds and learning abilities, the teacher should find it easy to switch from one teaching strategy to another (Safuli & Mtunda, 1986).

CPD for teachers of biology should be enhanced as training and professional developments underpin what a teacher can accomplish in a school MoE (1996). The essential competences required in every teacher are mastery of the material that is to be taught, and skill in communicating that material to pupils. These deceptively simple formulations cover a great array of knowledge, understanding and skills that must become integral to every teacher. The initial preparation provided at training colleges and universities does no more than lay the foundation for a life time of teaching. There is need for regular on-going development in a process that is never complete. This is because a teacher's professional life revolves around two areas of never ending growth and progression.

Bennett (2001) observed that learning through discovery helps to retain knowledge much longer than we could make it through our traditional way of teaching. The learner should be made aware that it is not only his or her teacher that has all the information needed to know but that there are other sources. Self-reliance is also required in learning and this increases pupil's interest and their desire to continue with the study of science subjects. It has also been discovered that teaching challenges can only be minimised when teachers facilitate for pupils

to experience, observe, hypothesise, predict, manipulate objects, pose questions, research for answers, imagine and invent in order for new constructions to be developed (Fosnot,1988)

ECZ (2007) reported that there is need to encourage all schools in Zambia to have laboratories which are well equipped and that students should be encouraged to carry out experiments so that they do not face difficulties during the final grade 12 biology examinations. Teachers should use open-ended questions and allow waiting time for responses, use appropriate levels of challenges. Teachers should cultivate work environments in which they are able to watch pupils at work and listen to them explaining learning strategies that could be used in the presentation. Create opportunities to use problem solving, games, puzzles, and small group work (Johnson, 1998).

The instructions should be organised to involve students to actively construct their own knowledge with understanding and that instructions should stress relationships among concepts, skills and problem solving. The learning activities that students employ determine to a large extent the quality of the learning outcomes they achieve. Therefore, teachers should be directed at encouraging students to use high quality learning activities (Vermunt, 1996). The teacher does not take centre stage in the classroom but should be a facilitator and listener. The teacher should design activities that focus on allowing pupil support, refine or repute their theories about a particular phenomenon or event (Kristensen, 2000).

ECZ (2002) advised that teachers should introduce pupils to examination words such as explain, state, list, illustrate and many more as outlined at the end of the biology syllabus. Usually pupils do not know how to use these words which examiners use when asking questions. Interest in the teaching profession may not be enough for one to be effective. There are different skills of teaching which, when used correctly, would promote good teaching. In this regard, it may be necessary to point out that variation in the use of those

skills help to facilitate learning. That is why it would be necessary to emphasize that any teacher training program should try to include a training component that focuses on the acquisition of teaching skills (Safuli & Mtunda 1986).

Modern biology education also emphasizes outcomes such as community values and improvements in the quality of life. If such outcomes have to be achieved, teaching methodologies must be creative, responsive and innovative (CDC, 2000). Teachers should use a variety of teaching aids as advised by Wellington (2004) that instructions should be given using a variety of visual or aural support materials including: drawings, diagrams and pictures as support for the spoken words. For some practical activities preferred pictures with words of different stages in an experiment can be given and pupils asked to sequence them correctly and perhaps label them. Obviously, the sequence will need to be checked before starting. However, Matsubara (2010) discovered that there was lack of teaching materials in Zambian schools. Therefore he advised that lessons should involve verbal scientific interaction which does not require materials. He further observed that this verbal interaction consisted of teacher initiation, pupil response and teacher evaluation. ECZ (2007) advised that calculation of magnification should be emphasised once more as it is a serious setback for most candidates. The formula is:

$$\textit{Magnification} = \frac{\textit{Size of image}}{\textit{Size of object}}$$

Magnification is also a serious setback in practical examinations and pupils should be advised that magnification has no units because it is a ratio. Therefore, they should not include units when calculating magnification.

In addition, it is believed that for teachers to effectively encourage good learning by students, they should possess such qualities as good manners, modesty, responsibility, friendliness, and appropriate speech (Mtunda & Safuli, 1986). By its nature biology touches on beliefs and

more especially on religion and morality. An effective program, therefore, must take cognizance of cultural differences in the development of curricular. Language, of course, is an obvious attribute of culture and problems associated with mother tongue in contrast with a foreign language, must be considered (Meyer, 1988). Qualities such as well trained teachers, highly qualified teachers and having teachers who perform their duties responsibly have a bearing on the effectiveness of teaching and creation of a good learning culture (Das, 2007).

Large scale curricula projects in science and mathematics as well as numerous research studies, encourage independent discovery, self-directed study or heuristic methods. The teacher or the experimenter using these approaches directs the learner's attention to some data or problems and encourages him to search more or less independently for solutions, rules, or effective strategies. The teacher may provide various forms and degrees of guidance, but not the answers, the learner is expected to find, derive, infer or discover them. This popularity may suggest that discovery methods have been shown to be generally superior to other methods (Monk & Osborne, 2000).

2.9. Summary of literature review

In this chapter, the researcher presented a review of literature related to this study. The major issues identified from the reviewed literature are that teachers find certain topics in biology difficult to teach like: topics involving practical work, genetics, mitosis and meiosis, classification and diversity of living organisms. Teachers also find certain topics easy to teach like reproduction and digestion. Also during practical examinations, pupils fail to draw proper biological diagrams and find it difficult to calculate magnification. Literature has also shown how biology teachers present perceived difficult topics to senior secondary school pupils in biology and has revealed that biology teachers, when teaching topics perceived to be difficult show the following weaknesses: Lack of seriousness by teachers, lack of practical work, lack of explanation from teachers. Literature review has also shown that the most

frequent reasons given for teachers to present perceived difficult topics in biology the way they do it include: inadequate teaching and learning materials, difficulties in the use of the language of instruction, complexity of the content areas, abstractness and sophistication of certain biology topics. Physiology content areas are mostly abstract and microscopic and they contain many fine processes that require proper explanations to enable pupils understand them.

Ways of improving the teaching of biology coming out from the literature include: Strengthening of continuous professional development in schools, which will help broaden the teachers' teaching skills. Use of appropriately qualified personnel to teach, promote practical work and encourage cooperative learning, teaching in line with what the pupils already know, considering varying learning styles among learners and the use of teaching aids.

The reviewed literature is limited on account of being based mainly on studies conducted outside Zambia and those which have been conducted in Zambia have been done outside Luapula province which is the focus of this study. The review of the literature presented in this chapter sheds some light on topics perceived to be difficult and how biology teachers present them. However, it has shown that there are a number of knowledge gaps with respect to discourse patterns used in teaching perceived biology topics in Luapula Province. Thus, it is important to carry out the present study in Zambia and in particular Luapula Province not only to corroborate findings with studies conducted abroad and in other provinces of Zambia, but most importantly to address these knowledge gaps.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter covers the research paradigm, research design, research sites, study population, study sample, sampling procedure, research instruments, pilot study, data collection procedure, trustworthiness of the study, data analysis and ethical issues.

3.2 Research Paradigm

A research paradigm can be defined as an overarching philosophical or ideological stance, a system of beliefs about the nature of the world and ultimately, when applied in the research setting, the assumptive base from which we go about producing knowledge (Rubin & Rubin, 2005).

Ontology is the nature of reality (Hudson & Ozanne, 1998) and the epistemology can be defined as the researcher and the reality (Trochin, 2000; Carson *et al*, 2001) or how this reality is captured or known. There are two dominant ontological and epistemological ideologies namely; positivism and interpretivism. The positivist ontology believes that the world is external (Kolakowski, 1972; Carson *et al*, 1988; Hearly & Perry, 2000) and that there is a single objective reality to any research phenomenon or situation regardless of the researchers' perspective or belief (Hudson & Ozanne, 1988). Positivist researchers remain detached from the participants of the research by creating a distance, which is important in remaining emotionally neutral to make clear distinctions between reason and feeling (Carson *et al*, 2001). Statistical and mathematical techniques are central to positivist research, which adheres to specifically structured research techniques to uncover the single and objective reality (Kolakowski, 1972; Carson *et al*, 2001).

The position of interpretivism in relation to ontology and epistemology is that interpretivists believe that reality is multiple and relative (Hudson & Ozanne, 1988). The knowledge acquired in this discipline is socially constructed rather than objectively determined and perceived (Hirschman, 1985; Carson *et al*, 2001). Interpretivists avoid rigid structural frameworks such as in positivists' research and adopt more personal and flexible research structures (Al Zeera, 2001; Carson *et al*, 2001) which are receptive to capturing meanings in human interaction (Black, 2006) and make sense of what is perceived as reality (Carson *et al*, 2001; Dobson, 2002). They believe that the researcher and his informants are interdependent and mutually interactive (Hudson & Ozanne, 1988). The researcher remains open to new knowledge throughout the study and lets it develop with the help of informants. An interpretivist researcher will maintain that knowledge is socially constructed and reality is ultimately subjective. The methodology utilised by an interpretivist researcher is referred to as qualitative. On the other hand, a positivist paradigm will maintain that reality is fixed and that objective knowledge can be produced through quantitative means.

This study is located in the interpretivism paradigm which is underpinned by observation and interpretation (Kraus, 2005). It attempts to understand that knowledge is established through the meanings attached to the phenomena studied (Krauss, 2005). Interpretivists assume that knowledge and meaning are acts of interpretation hence there is no objective knowledge which is independent of thinking, reasoning humans (Gephart, 1999). An interpretivism paradigm is appropriate for this study on discourse patterns of lessons on perceived difficult topics in biology because biology is taught in schools which are in social settings. In relation to this paradigm, discourse patterns of lessons on perceived difficult topics in biology have been constructed from subjective experiences of teachers and learners within the classroom setups.

3.3 Ontological assumptions

Interpretivist ontology asserts that there are multiple realities constructed by human beings who experience a phenomenon of interest (Lythcolt & Duschl, 1990). Reality is very fluid and elusive and only exists through teachers' and pupils' claims. It is a constructed account of discourse patterns of lessons on topics perceived to bedifficult topics in biology.

3.4 Epistemological assumptions

Interpretivist epistemology asserts that knowledge is constructed subjectively by teachers and pupils. It involves discursive analysis, working with the interactive construction of knowledge (Kraus, 2005). Discourse patterns during lessons on perceived difficult topics in biology are subjective and are dependent on teachers and pupils minds, values and perceptions.

3.5 Research design

A qualitative research approach was used in this study to acquire understanding of how teachers present topics perceived to be difficult. In this study, the researcher used group interviews, one to one interviews and lesson observations as methods of collecting data from senior secondary school pupils and biology teachers to answer the research questions.

Meanings attached to qualitative research vary (Hatch, 2002). For example, Strauss and Corbin (1990) define qualitative research as any kind of research that produces findings that are not arrived at by means of statistical procedures or other means of quantification. Anderson (1987) defines qualitative approach as a research paradigm which emphasises inductive, interpretive methods applied to the everyday world which is seen as subjective and socially created. In the researcher's view, qualitative research is an approach which involves analysis of limited data in form of words from interviews and observations.

Although there are different meanings of qualitative research, there are qualities that distinguish qualitative research from other research approaches such as quantitative research (Hatch, 2002). Some of these attributes are that: it generates words, rather than numbers, as data for analysis (Green & Thorogood, 2004); it involves non probability sampling procedures such as purposive sampling (Borg & Gall, 1989); it is more concerned with understanding social phenomena from the perspectives of the participants (White, 2005); it involves intensive data collection of several variables, over an extended period of time in a natural setting. In qualitative work, the intention is to explore human behaviours within the context of their natural occurrence (Bogdan & Biklen, 1992; Creswell, 2003).

Other features of qualitative approach include the following: Data is gathered directly by the researchers themselves (Hatch, 2002); Qualitative work starts with the assumption that social settings are unique, dynamic, and complex; Qualitative methods provide means whereby social contexts can be systematically examined as a whole, without breaking them down into isolated, incomplete, and disconnected variables; Qualitative data contains objects, pictures or detailed descriptions that cannot be reduced to numbers without distorting the essence of the social meanings they represent (Hatch, 2002); Qualitative reports are usually complex, detailed narratives that include the voices of the participants being studied. They build the case for the researcher's interpretations by including enough detail and actual data to take the reader inside the social situation under examination (Bogdan & Biklen, 1992). Other elements of research such as research questions and methods can be altered as studies unfold (Jacob, 1988; Creswell, 2003). Samples are small and not necessarily representative of the broader population (Green & Thorogood, 2004). This is because data collection ends as saturation in collecting data is reached.

Qualitative research covers different types of research methods which do not use numerical sophistication for the analysis of data (Ghosh, 2013). Qualitative research is mainly based on

observations and utilises the inductive method of enquiry. However, it does not imply that qualitative research involves no manipulation of numerical figures but that such manipulation does not often require specialised knowledge of mathematics and statistics (Ghosh, 2013).

In terms of validity, qualitative research is not a highly reliable type of research because it is not very precise as far as the generalisations and conclusions are concerned (Ghosh, 2013). This means that its findings cannot be generalized to other settings. However, despite the shortcomings cited, qualitative approach was used in this study because of its flexibility in design (Creswell, 2003). In this regard, the researcher was free to make adjustments to the design as the study unfolded. Furthermore, the fieldwork aspect of qualitative approach was conducted in the natural settings which were schools. In addition, the interactive nature of the qualitative approach was appropriate when gathering data from biology teachers and senior secondary school pupils by talking to them. Since the researcher wanted to start data analysis as soon as data was collected from the first school, qualitative approach was seen to be more appropriate for this purpose. This is because qualitative approach allows commencement of data analysis as soon as some data is collected instead of waiting until all the data is collected (Creswell, 2003).

In this study, a qualitative approach which focused on a collective case study was used. The researcher had chosen multiple case studies which formed one collective case study because the researcher wanted to collect extensive data on classroom interactions during lessons on perceived difficult topics in biology.

3.6 Research sites

The study was conducted in Luapula Province of Zambia at four secondary schools whose pseudo names are Mango Secondary School, Orange Secondary School, Lemon Secondary School and Guava Secondary School. Mango Secondary School is a very big school with

enrolment of over 1600 pupils. The school has 5 laboratories and is situated in the rural community of Luapula province. There are 83 teachers at this school and 19 teachers of science. Five teachers are specialised in the teaching of biology. Orange Secondary school is in a rural community with about 1500 pupils and 72 teachers. The Natural Sciences Department has 17 teachers of science of which five are specialised in teaching biology. Lemon Secondary School is small with only three grade 12 classes. It has slightly above 400 pupils. The school was recently upgraded from a primary school to a secondary school and has no laboratory. The school is situated in a rural community of Luapula province. There are only four science teachers in the school of which two offer biology. The school has a total number of 20 teachers. Guava Secondary School is very big because it runs from grade one to grade 12. There are 95 teachers and most of them are seconded from the primary sector. There are ten science teachers teaching at the secondary sector out of which three are specialised in teaching biology. Pseudo names were used in order to promote confidentiality. The reasons for collecting data from four different schools were to get different perspectives and also to deepen the researcher's understanding of the issues which were being investigated. It is claimed that collecting data from different schools increases the trustworthiness of the findings (White, 2005). This is because different situations are examined and data is sourced from different people.

3.7 Study population

The study population included all grade 10, 11 and 12 pupils taking senior secondary biology and all teachers of biology. These pupils and teachers were in a better position to respond freely to questions which were posed to them. This is because grade 10 and 11 pupils were observed while learning classification of living organisms. Grade 12 pupils were mainly observed while learning mitosis and meiosis. In a qualitative study it is important to select knowledgeable participants on the issue to be investigated (Creswell, 2003).

3.8 Study Sample

At each school only three grade 10, three grade 11 and four grade 12 pupils making a total of ten pupils were selected to participate in the focus group discussions. This means that a total of 40 pupils participated in the study. A total of 11 teachers were selected from the four schools, three from each of the first three schools and two from the fourth school. This was done on the basis of availability and willingness to participate in the study. In the fourth school there were only two teachers of biology in the science department, as a result only the two teachers were interviewed. There is no clearly recommended adequate sample size in a qualitative research (Mason, 2002), as this varies and depends on the purpose of the study. For this study, a total of 40 pupils from the 4 schools were appropriate. This is because the sample size is usually small in a qualitative study (Merriam, 1998). The number of times a certain response is given is not always important in a qualitative study (Mason, 2002), meaning that more data does not necessary lead to more information (Grouch & McKenzie, 2006). It is said that in a large sample size data becomes repetitive as a result the majority of qualitative studies should generally follow the concept of saturation (Mason, 2010). Data collection should stop when the collection of new data does not shed any further light on the issue under investigation.

3.9 Sampling procedure

Luapula was purposively selected for this study because it was considered to be more convenient for the researcher to visit the participating schools easily and several times during the data collection phase, since the researcher is based in Luapula province at Lubwe secondary school. Four schools were purposively sampled, two out of the four were old established schools and had poor school certificate pass percentages for 2015 grade 12 examinations. For example Mango had 47.5% and Orange 46.6% (PEO, 2016). The other two

Lemon and Guava were newly upgraded from primary schools to secondary schools and had no school certificate results for 2015.

Senior secondary school pupils were selected using purposive sampling at each of the four participating schools. The teachers who were observed in the four schools were asked to help the researcher in the selection of pupils who participated in the study because they knew pupils very well compared to the researcher. In this study, the purposive sampling method was used to select schools which would assist the researcher to address the research problem which was being investigated.

The topics perceived to be difficult to both pupils and teachers are many. However, only three topics namely; classification of living organisms, mitosis and meiosis were selected because pupils fail to provide meaningful answers when these topics appear in the final biology grade 12 examinations (ECZ, 2008). The 33 lessons observed were also purposively sampled based on the schemes of work.

Purposive sampling is a type of sampling which is based entirely on the judgement of the researcher, in that a sample is composed of elements that contain the most characteristic, representative or typical attributes of the population. On the basis of the researcher's knowledge of the population, a judgement is made about which subjects should be selected to provide the best information to address the purpose of the research. Purposive sampling is normally used in qualitative research (White, 2006).

Purposive sampling helps a researcher to target a group of people believed to be reliable for the study. The power of purposive sampling lies in selecting cases with rich information for in-depth analysis related to the focal issue being studied (Kasonde-Ngandu, 2013).

The great danger in purposive sampling is that it relies more heavily on the subjective considerations of the researcher than on scientific criteria. Although it has some value, especially if used by an expert who knows the population under study, this sampling technique often leads to uncontrollable results (Bless & Smith, 1995).

In purposive sampling, the selection of the sample is completely left to the judgement of the investigator who is likely to introduce his or her biases in sampling and it is also not possible to find out mistakes and inaccuracies till the end when it may be too late to rectify (Sidhu, 2013). Therefore, in order to ensure that the pupils selected provided the required data to answer the research questions, these pupils came from the classes which were observed during the study.

3.10 Research instruments

The research instruments used for data collection included semi- structured interview guides for pupils and teachers. Observation schedules based on Flander's classroom interaction analysis were also used (see Appendix A, B and C). Semi- structured interview schedules start with a defined questioning plan, but will shift in order to follow the natural flow of conversation. Interviewers may also deviate from the plan to pursue interesting tangents (O'Leary, 2012). The advantage of semi-structured interview guides is not only being able to come out with intended data but also having interesting and unexpected data that emerges. The disadvantages are that it can be time consuming due to open-ended questions used and analysis of data may be problematic due to many responses (Creswell, 2003; White, 2005).

The contents of the interview guides were derived from the research questions, the lessons observed and the theoretical framework. Interview guides comprising open-ended questions were used to collect data from pupils and teachers. Semi-structured Interview guides are flexible because they comprise both open and closed ended questions. Therefore, a lot of

information was gathered from them. Open-ended questions were the most appropriate to use because they generated detailed data as they allowed the respondents to express themselves freely without restrictions (Kumar, 1996; Kasonde-Ngandu, 2013). Open-ended questions also allow more opportunity for creativity or self-expression by the respondent (White, 2005).

Research instruments were subjected to scrutiny to ensure that they were simple to understand and this helped reduce misinterpretations (Creswell, 2003). There was need to ensure that each item included had a specific purpose and contributed to the study and achieved, this was done by peer review so as to improve the quality and validity of the instruments.

3.11 Pilot study

Data collection was preceded by a pilot study at Lubwe Secondary School in Samfya District of Luapula Province. This school and the pupils had similar characteristics to the schools where the main study was undertaken. The pilot study was used as a small scale version or trial run in preparation for a major study (Baker, 1994). It can also be used to determine if the procedures for data collection will work out or not. The purpose of this pilot study was to examine the open-ended questions in the interview schedules for bias, sequence, clarity, face validity and to assess their suitability for use in the study (Fink & Kosekoff, 1985; Marshal & Rossman 1995; Denzin & Lincoln, 2000). Ten grade 12 pupils and three teachers of biology participated in the pilot study. Three lessons were observed, which were based on classification of living organisms, mitosis and mitosis. The interview schedules were modified after the pilot study to include more open-ended questions. Although the pilot study has disadvantages such as costs and time consumption, it greatly increases the likelihood of success (Baker, 1994). This is because it serves its purpose of informing the main study effectively.

3.12 Data collection Procedure

Data collection involved three phases or stages namely: Accessing research sites, lesson observation and focus group discussions.

3.12.1 Accessing research sites

The researcher got a letter of permission from the University of Zambia which introduced him as a Ph.D. candidate in the Department of Mathematics and Science Education. He also got ethical clearance from the Directorate of Research and Graduate Studies of the University of Zambia. The researcher then got permission from the Permanent Secretary in the Ministry of General Education to conduct research in Luapula province. While in Luapula Province the researcher got another letter from the Provincial Education Officer to allow him conduct research in the selected secondary schools in the region. After getting permission from the Provincial Education Officer, the researcher then proceeded to the District Education Board Secretaries, for the two Districts which were involved in the study, for permission to gain access into participating secondary schools.

At each school, the researcher had first to meet the Head teacher before embarking on data collection. The researcher introduced himself to the school administrator and provided verbal and written information about the study including the letter of permission from the Provincial Education Officer. The introductory letters for school administrators contained the following information; Purpose of the study, relevance of the study, why their school was selected for study, the activities the researcher had to carry out at the school, the target pupils, how the findings of the study were to be reported and what the school would benefit from the study. This information was provided to Head Teachers for them to understand the purpose of the study and to solicit their co-operation.

After getting permission from the school administrators, the researcher met the Head of Department and briefed him or her about the study, its relevance, purpose and procedures involved so as to make the data collection manageable. The researcher worked with the Head of Department and biology teachers who were observed to identify the 10 pupils from the classes observed, to participate in the focus group discussions. The following criteria were used to select pupils to participate in the study; (a) the pupils had to be in grade 10, 11 or 12 of the classes observed (b) the pupils were supposed to be willing to share information with the researcher and other participants (c) the pupils were supposed to be willing to spare some of their time to participate in the focus group discussion session. A similar criterion has been used by other researchers to select participants (Haambokoma, 2015).

3.12.2 Lesson observations

Lesson observation was the major technique used for data collection. Observation is the process of acquiring knowledge through sense organs such as eyes and ears (Ghosh, 2013). Observation is also defined as a systematic method of data collection that relies on a researcher's ability to gather data through his or her senses (O'Leary, 2012). A total of 33 lessons were observed out of which 11 were video recorded and transcribed. From the 11 lessons transcribed, four were on mitosis, three on meiosis and four on classification of living organisms. In this study, lessons were observed before interviewing the participants. An observation schedule was used to help the researcher gather information on classroom discourse patterns during lessons on topics perceived to be difficult by both pupils and teachers. In non-participant observation, researchers do not become or aim to become an integral part of the system or community they are observing. The observer was physically present but attempted to be unobtrusive. Non–participant observation tends to occur over a fixed-time period and is often highly structured. Examples here include watching interactions

through a one–way mirror and sitting in the corner of a room observing a meeting or a lesson in progress (O'Leary, 2012).

In semi-structured observations, the observer used observation schedules or checklists to organise observations, but also attempted to record the unplanned or the unexpected. One disadvantage of observations is that it is hard to act natural when you know you are being watched, worse still, when you know you are being studied. Therefore, building trust and making sure participants are comfortable is essential (White, 2005). Moreover, it is important that researchers offer full disclosure of the nature of their study, the role the observations will play in their research and what they might expect to find through the observation process (O'Leary, 2012). Full disclosure is often an ethics requirement (Hatch, 2002).

Limitations of observations include establishing the validity of observation. The problem of subjectivity is also involved; a person tends to see what he or she knows while other things will escape their attention. Also the observer tends to see only things he or she wants to see (Sidhu, 2013). Moreover, the people being observed become conscious and begin to behave in unnatural manner. The situation does not become real and natural (White, 2005). However, to avoid overlooking important facts, the researcher constructed a list of items to be noted during each observation (Sidhu, 2013). Furthermore, the observer was able to record immediately and accurately the results of his observations. Postponement of recording an event for a few minutes may increase the likelihood of inaccuracy (Ghosh, 2013).

The researcher observed and listened to classroom interactions during lessons on classification of living organisms, mitosis and meiosis. The researcher wrote notes in a note book on what was happening in the classroom as the lesson progressed. The lesson observations focused on the following; lesson introduction, lesson progression and teaching strategies, questioning skills, teaching and learning aids, note taking, class exercises and

homework, lesson evaluation and conclusion. Lesson plans of the observed lessons were collected after observation. This was done in order to check for the following; teacher preparedness for the lesson, the rationale for the lesson and lesson objectives. This also helped to check if what was taught had been planned.

Data recording was done using three methods namely, digital voice recorder, video recorder and taking down notes during the focus group discussion and lesson observation sessions. Recording interviews and lessons is convenient and inexpensive. The digital voice recorder provides a means of verifying responses later. It also preserves the emotional and vocal character of replies and helps the investigator to avoid the omissions, distortions, modifications and errors that sometimes are made in written accounts of an interview (White, 2005). Furthermore, the interviews recorded may be replayed as often as necessary for complete and objective analysis at a later time (Sidhu, 2013).

Apart from the digital voice recorder and video camera, the researcher took down the notes of lesson proceedings in case the devices failed to record, for one reason or another, a record of proceedings would still be available. The researcher also used the digital voice recorder and video camera to ensure that all sound and picture communication during interviews were captured. The use of a recorder when carrying out interviews is also supported by White (2005) who admits that a digital recorder is part of the indispensable equipment for researchers using qualitative methods. However, permission to use a recorder during interviews had to be obtained from the interviewee.

3.12.3 Conducting Focus Group Discussions

The use of Head of Departments and biology teachers who were observed, to participate in the selection of participating pupils had both advantages and disadvantages. The advantage was that the Head of Department and biology teachers knew the pupils very well as compared

to the researcher, therefore they were in a position to select pupils who were capable of expressing themselves clearly (Kumar, 1996). The disadvantage was that the Head of Department and biology teachers could have been biased in selecting the pupils using the purposive sampling method. This strategy is however recommended by other researchers (White, 2005). The focus group discussion with the pupils and the one to one interviews with the teachers were done after the lesson observations.

A consent form was given out to all the pupils, who were selected for the study, before the focus group discussion. This form contained the following information regarding the study: purpose, procedures, benefits, discomforts, confidentiality and the right to refuse to participate or right to withdraw from the study if need be (Appendix F). After giving each pupil a consent form, the researcher had to go through it with the pupils explaining each point. Pupils were assured by the researcher that when they accept to participate in the study their identities would be protected by not revealing their names in the report. The pupils who accepted to take part in the study were requested to participate in focus group discussions where data was solicited by the researcher from them through asking oral questions (Creswell, 2003).

There are a lot of challenges associated with focus group discussions such as getting the participants in one place at the same time, some pupils may refrain from expressing certain points before a group. Moreover, one person (and not necessarily the best informed one) may dominate the discussion so that the viewpoints of other participants are not explored thoroughly (Sidhu, 2013).

Despite the challenges highlighted above, focus group discussions assisted pupils to help one another recall, verify or rectify items of information (Sidhu, 2013). Therefore, this improved the data collected for this study. The researcher ensured that chance was given to all the

pupils in the group to participate, by pointing at pupils to contribute during the focus group discussions. Data collection took place between September 2016 and February 2017.

3.13 Data Analysis

The researcher listened to the recording several times during transcription to ensure that the transcribed data corresponded with spoken words as much as possible. Data analysis took place concurrently with data collection. This meant that as soon as data was collected from one school, the researcher started data analysis and this continued as more data was collected from the other three schools until all data was analysed. This was in line with the views held by Silverman (2005) and Creswell (2003).

Qualitative data analysis involved reducing, organising, finding interconnections, developing themes and building theories (O'Leary, 2012). Sidhu (2013) describes data analysis as the studying of the tabulated material in order to determine inherent facts or meanings. It involved breaking down existing complex factors into simpler parts and putting the parts together in new arrangements for purposes of interpretation. A plan of analysis was prepared in advance before the actual collection of material. Larger divisions of material were broken down into smaller units and rearranged in new combinations to discover new factors and relationships.

Data analysis involved two steps. The first step was for the researcher to familiarise himself with the lessons observed and interview text. This was accomplished through listening to and watching the videos of the lessons observed and interviews which were held with the pupils then transcribing them. The Second step involved the researcher reading the responses given by pupils during the focus group discussions several times so as to further enhance his understanding of what the respondents were saying.

Data from lesson observations was analysed using discourse analysis (Louis *et al*, 2000). This was done by documenting the questions from the teachers and the answers from the pupils. In discourse analysis, as in qualitative data analysis, generally the researcher used coding at an early stage of analysis, assigning codes to the textual material being studied (Parker, 1992; Potter & Wetherall, 1987). This enabled the researcher to discover patterns and broad areas in the discourse (Miles & Huberman, 1984).

In discourse analysis, rather than taking the classroom talk as evidence of children's thought process, the researcher explored it as contextualised dialogue with the teacher. The discourse itself was the educational reality and the issue became that of examining how the teacher and the pupils constructed a shared account, a common interpretative framework for curriculum knowledge and for what happened in the classroom (Edwards, 1991).

The data collected from interviews was analysed using the thematic analysis approach (Creswell, 2003). This form of analysis categorised related responses into themes. In using this form of analysis, major concepts or themes were identified (White, 2005). This involved examining the responses participants gave and coding them. Themes were then developed and similar responses were grouped according to themes (Kasonde-Ngandu, 2013).

After reading through the responses, the researcher started by putting away some data which was not relevant in answering the research questions. Miles and Huberman (1994) describe this practice as data reduction. After data reduction, the researcher went through the data again and carefully began coding the data by assigning codes or tags to parts of the transcribed data (Miles & Huberman, 1994). In this study, words were used as codes while paragraphs and sentences were mainly coding units (Denscombe, 2007).

Data segments were classified according to research questions. After generating piles of data segments, the researcher came up with initial category names for each pile of data segments.

The researcher continued refining the codes and categories throughout the analysis of data from respondents at the four schools. Through this process, category headings were generated from the data and these were used in reporting the findings.

3.14 Trustworthiness of the study

Specific strategies can be used throughout the research process to increase the trustworthiness of qualitative projects (White, 2005). The trustworthiness of qualitative research is generally often questioned by positivists, perhaps because their concepts of validity and reliability cannot be addressed in the same way in naturalistic work (Shenton, 2004). Nevertheless, many naturalistic researchers have however, preferred to use different terminology to distance themselves from the positivist paradigm. One such author is Guba (1981) who proposed four criteria which should be taken into consideration by qualitative researchers in pursuit of a trustworthy study. This study therefore followed four constructs developed by Guba (1981) for ensuring rigour namely; credibility, transferability, dependability and confirmability.

3.14. 1 Credibility

One of Guba's four trustworthy criteria that were used in this study, to ensure quality of data collected, was credibility (Lincoln & Guba, 2005). Credibility is the adoption of well recognised research methods. This was achieved by ensuring that the collection, analysis and interpretation of data was in line with the qualitative characteristics that had been prescribed. Positivists have ways in which they seek to ensure that one key criterion of internal validity in their quantitative studies, which is equivalent to credibility in qualitative studies, test what actually is intended (Merriam, 1998). In this study, to ensure that the findings were congruent with reality, the following measures were taken; First and foremost, the line of questioning

pursued in the data collection sessions and methods of data analysis were derived from those that have been utilised successfully in comparable studies.

Secondly, the development of an early familiarity with the culture of participating schools was achieved through analysis of examination results and preliminary visits to the schools before observations and interviews took place. This prolonged engagement between the researcher and the participants, in order to establish a relationship of trust, was recommended by Lincoln and Guba (1985). Thirdly triangulation was achieved by involving the use of different methods, especially lesson observation, focus groups for pupils and individual interviews for teachers. This was in line with Guba (1981) as well as Brewer and Hunter (1989) who assert that the use of different methods compensates for their individual limitations and exploits their respective benefits.

In order to ensure honesty in informants when contributing data, participants were free to refuse to participate in the study or withdraw from the study at any point. This freedom of withdrawal from the study by participants was to ensure that data was collected from those who were genuinely willing to take part in the study. The researcher also welcomed peer scrutiny of the study by University of Zambia postgraduate students and lecturers during seminar presentations. This enabled the researcher to refine the data collection methods thereby strengthening the research findings

3.14.2 Transferability

Another of Guba's trustworthy criteria that was used to ensure quality of data collected was transferability (Lincoln & Guba, 20005).Transferability is the provision of background data to establish context of the study and description of the phenomenon in question to allow comparison to be made (Lincoln & Guba, 2005). This was done by ensuring that a review of literature was done through the outlined objectives of the study. The literature in this study,

was used to contextualize the study so as to have similarities and create new information as a result. This has the capacity to be transferred and it results in a chain transfer from one study to others. The findings of a qualitative study are specific to a small number of particular environments and individuals, therefore it is impossible to demonstrate that the findings and conclusions are applicable to other situations and populations (Silverman, 2005). Therefore, in order to achieve transferability, a detailed description of the background data was provided in order to establish the context of the study and allow comparisons to be made.

3.14.3 Dependability

Another of Guba's four trustworthy criteria that was used in this study was dependability to ensure quality of data (Lincoln & Guba, 2005).Dependability is the employment of overlapping methods to allow the study to be repeated by ensuring research instruments are subjected to a pre-test. This is because when research instruments are subjected to a pre-test, it is possible for another researcher to collect the same data because of the standardised research instruments (Lincoln & Guba, 2005).

In qualitative studies, observations are tied to the situation of the study and are static and frozen in the ethnographic present (Shenton, 2004). This is at variance with the positivist view of addressing the issue of reliability where they employ techniques such that if the work was repeated in the same context, with the same methods and participants, similar results would be obtained (Fidel, 1993). Therefore, in order to address dependability in this study, the research procedures were reported in detail and overlapping procedures such as focus group discussions and individual interviews were used so as to enable future researchers to repeat the work and gain similar results.

3.14.4 Confirmability

The last of Guba's four trustworthy criteria that was used to ensure quality of data was confirmability (Lincoln & Guba, 2005). The concept of confirmability is the qualitative researcher's comparable concern to objectivity (Shenton, 2004). Therefore, the issue of confirmability in this qualitative study was achieved by ensuring that the findings reported were experiences and ideas of the participants rather than the preferences of the researcher. Triangulation by using lesson observation, focus groups and individual interviews was used to reduce the effects of researcher bias. The researcher had also accepted shortcomings and limitations of the methods of data collection used in this study. In conclusion, all the four trustworthy criteria embraced both research reliability and validity from a qualitative perspective.

3.15 Ethical issues

Creswell (2003) advises that consideration of ethical issues at every stage of research is important so as to make the identities of the respondents confidential, by not revealing their names in the study. Therefore, before conducting this study in the selected schools the researcher had to get an introductory letter from the University of Zambia introducing him as a Ph.D. candidate from the Department of Mathematics and Science Education and a letter of ethical clearance from the Directorate of Research and Graduate Studies. The researcher also got permission from the Permanent Secretary at the Ministry of General Education and thereafter the researcher had to seek permission from the Provincial Education Officer for Luapula Province and District Education Board Secretaries for Mansa and Samfya District to visit selected secondary schools in the Province. The researcher also had to seek permission from the Head teachers of the schools, before embarking on collecting data. At each school, the researcher revealed his identity and the purpose of his visit to Head Teachers, participating pupils and teachers.

The participants were informed that the information they had provided was to be used for research purposes only and their actual names and that of their schools were not going to be revealed in the report as recommended by Creswell (2003). Therefore fictitious names for participants and schools were used.

Consent forms were given to all the participants before recording the interviews and filming the lessons. The researcher also asked for permission from participants and explained why he needed to record the interviews and film the lessons.

CHAPTER FOUR

FINDINGS

4.1 Introduction

The findings in this chapter are presented in the form of a collective case study under which the researcher focuses on an issue and then selects several bounded cases to illustrate that issue or concern. This involved the teaching of mitosis, meiosis and classification of living organisms at four different secondary schools in Luapula Province of Zambia. Findings of the study are presented according to the research questions. The first part of this chapter gives the findings on the classroom discourse patterns used during lessons involving topics perceived to be difficult in biology. The second part presents findings on the reasons for choice of discourse patterns biology teachers use when teaching. The third part looks at the effects of discourse patterns used by teachers on pupil's understanding of perceived difficult topics in biology. The last part covers what could be done to improve the teaching of perceived difficult topics in biology.

4.2. Question 1: What are the discourse patterns during lessons involving topics perceived to be difficult in biology?

To answer this question, 33 lessons were observed out of which 11 lessons were video recorded and transcribed. The first 22 lessons which were not video recorded were used by the researcher to familiarise himself with the teachers before video recording the last 11 lessons. Four lessons were on mitosis, three on meiosis and four on classification of living organisms at four different secondary schools in Luapula Province of Zambia. The following were the findings:

(a) Mitosis

The following were the findings with respect to four lessons on mitosis.

Lesson one

This first lesson on mitosis was observed at Orange Secondary School. The teacher who the researcher observed teaching mitosis, had been teaching biology for ten years since completing her secondary teacher's diploma in science teaching. Although the teacher was asked to teach biology she was trained to teach grades eight and nine integrated science. She assigned to teach biology due to the shortage of teachers with degree qualifications in biology in Luapula Province.

Biology is allocated five periods, two doubles and one single. This translates into 3hrs 30 minutes per week. The researcher conducted classroom observations on a grade 12 biology class with a view to understanding how pupils interacted with their biology teacher, with each other and with the biology content during lessons. This class had 44 pupils in total (14 girls and 30 boys). The lesson observed was of 80 minutes duration.

The introductory part of the lesson took ten minutes. Below is an excerpt of the introduction to the lesson on Mitosis.

Teacher A: What is cell division?

Pupil 1: Cell Division is a process by which new cells are formed from already existing cells

Teacher A: Can you mention the two types of cell division?

Pupil 1: Mitosis

Pupil 2: Meiosis

Teacher A: What is Mitosis?

Pupil 1: Cell division which occurs in the body cells

Teacher A: Others what do you have to say?

Pupil 3: Two identical cells are produced from a zygote mother

Teacher A: Others

Pupil 4: Mitosis is a type of cell division where 2 diploid and genetically identical cells are produced from one mother cell.

The teacher was supposed to clearly guide the pupils to describe mitosis as a type of cell division which takes place in all cells, except sex cells. The teacher should have asked pupils to explain that cells, other than sex cells, are called somatic cells. The teacher also forgot to emphasise that mitosis results in two cells that are identical to the original cell.

The main part of the lesson took 60 minutes and proceeded as shown by the following excerpts.

Teacher A: Mention 4 stages of mitosis

Pupil 5: Prophase

Pupil 6: Metaphase

Pupil 7: Anaphase

Pupil 8: Telophase

After each response the teacher restated the answer in order to appreciate the pupils' response. This was the only way the teacher appreciated pupil's responses.

Thereafter, the teacher divided the class into four groups to discuss the four stages of Mitosis. The teacher encouraged the pupils to use the text books they had on their desks. After ten minutes, the teacher asked the group leaders to present their findings. This time was not enough for pupils to complete their work in groups. During group work, the teacher was moving from one group to another facilitating the group discussions by resolving issues pupils did not understand. Pupils were seen interacting with each other in the groups. At the beginning of group discussions the teacher distributed worksheets showing different stages of mitosis for pupils to look at before describing the stages of mitosis in their groups. This worksheet show different stages of the process of mitosis (Figure 4.1)

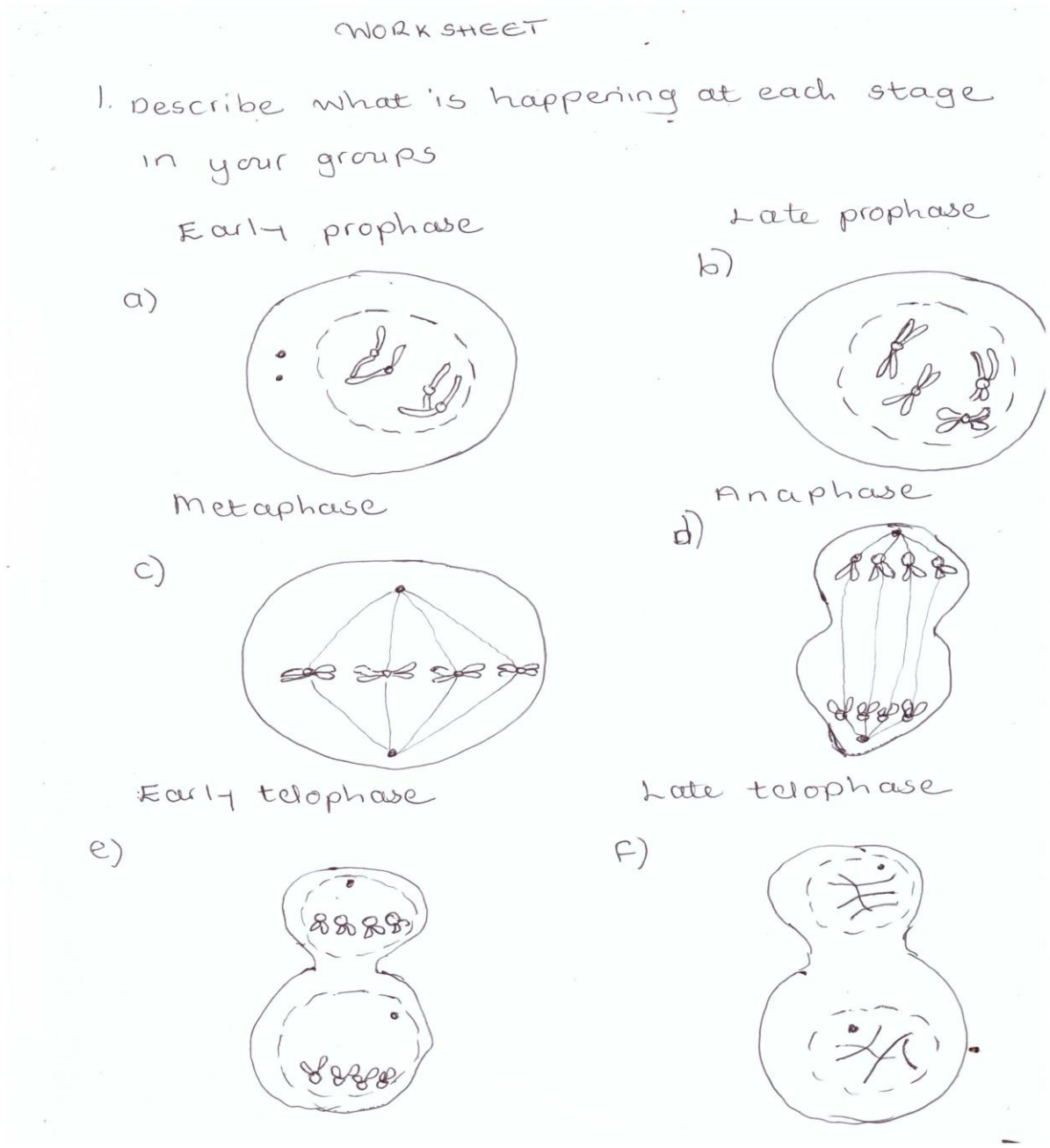


Figure 4.1: Worksheet showing stages of mitosis (Source: Orange secondary school lesson observation)

In this worksheet the teacher asked group one to describe what was happening at 1 (a) and 1(b) of prophase, group two was told to describe what was happening at o1 (c) of metaphase, group three was given 1 (d) of anaphase and group four was told to describe what was happening at 1 (e) and 1(f) of telophase.

Report from group one on prophase: Pupils were expected to state what happens to the cell during prophase. The group representative stated the following statements from their discussion.

The cell divides itself to perform its functions

Chromosomes shorten and thicken to become visible

Connected at the centromere, each chromosomes is now seen to contain 2 strands

Nuclear membrane and nucleus disappear marking the end of prophase

After this presentation the teacher extended the pupils presentation and guided the pupils in this group by saying that they were expected to report that during early prophase, the chromosomes become visible in the nucleus as the threads of the chromatin network become shorter and thicker. During late prophase, the chromatids become visible. They are held together by a centromere. The centrioles move to opposite ends of the cell and spindle fibres begin to form between them. The good thing about this is that the pupils knew that chromosomes became visible by shortening and thickening, but they did not know where this was happening within the cell. The teacher reminded them that the process of shortening and thickening of the chromosomes was happening in the nucleus.

Report from group two on metaphase: In this group pupils were expected to explain what happens during metaphase. The group representative reported the following from their group discussion:

The chromosomes line up along the equator

The spindle fibres attach themselves to the centromere of the chromosomes

This group explained exactly what happens during metaphase because they were able to explain that chromosomes line up in the centre of the cell on an imaginary line called the equator and that chromosomes attach to the spindle fibres.

Report from group three on anaphase: Pupils were expected to describe what happens to the cell during anaphase. The group representative made one statement in his presentation as follows:

Sister chromatids are separated from each other and pulled from each other.

This group was supposed to report that during anaphase the spindle fibres contract and pull the chromatids towards the opposite ends of the cell called poles. Pupils in this group did not know what was pulling the chromatids away from each other. This was pointed out by the teacher when she said that the contraction of spindle fibres assisted in the separation of the chromatids from each other.

Report from group four on telophase: Pupils were expected to explain what happens to the cell during telophase. The statements below were reported from the group discussion by the group representative.

Chromatids reach the poles of the cells and align to form chromatin again.
Nuclear membrane reappears
Spindle fibres disappear.

Pupils in this group were supposed to explain that during early telophase the chromatids reach the poles and a new nuclear membrane starts to form around them. Spindle fibres break down. The pupils were also supposed to show that during late telophase the chromatids are now called chromosomes and they unwind becoming long threads and finally each new nucleus contains chromosomes identical to the parent chromosomes.

The teacher restated and even extended group representatives' responses and explanations. This was done to appreciate the pupils efforts and motivate them. The teacher did not ask other pupils to react to their group representatives' presentations. According to her it was time wasting. She put it this way:

'I did not allow pupils to react to their group representative's presentations because I thought it was just wasting time'.

The teacher described the stages of mitosis to help make statements pupils made during group work presentations clearer as follows;

Prophase stage

Centrioles move to opposite poles

Spindle fibres appear from centrioles.

Nuclear membrane and nucleolus disappear.

Chromosomes coil and shorten becoming visible.

Metaphase stage

Chromosomes line up along the equator

Spindle fibres attach themselves to centromere of chromosomes

Anaphase stage

Sister Chromatids are separated from each other and pulled to opposite poles, centromeres first.

Telophase stage

Chromatids reach the poles of the cell uncoil and lengthen to form chromatin again.

Spindle fibres disappear.

Nucleolus and nuclear membrane reappear.

The teacher should have guided the pupils to explain that the preparation for cell division occurs in a stage called interphase and that at the end of interphase the cell nucleus and cytoplasm are ready to divide. However, the teacher ruled out the fact that mitosis starts with interphase and went on to emphasise that mitosis starts with prophase. This statement was not correct.

In order to conclude the lesson the teacher explained that mitosis is very important to living organisms. The excerpt below shows how the teacher concluded the lesson within ten minutes.

Teacher A: Why is mitosis important to living organisms?

Pupil 1: It is needed for growth

Teacher A: Another way in which mitosis is important to living organisms

Pupil 2: Replacement of cells

Teacher A: Another way

Pupil 3: Asexual reproduction

Pupil 4: To maintain stability

Pupil 5: Regeneration

Teacher A: What is regeneration?

Pupil 6: Continuity of the same characteristics of the cell.

Pupil 7: Regeneration is another type of asexual reproduction.

Pupil 1: Does mitosis occur in plants or Animals?

Teacher A: It occurs in both plants and Animals.

Pupils only understood the importance of mitosis and this was seen from the number of participants who wanted to contribute when the teacher asked the class to state the importance of mitosis. The teacher concluded the lesson by restating the importance of mitosis to living organisms.

Only eight pupils were answering questions from the teacher except when he asked on the importance of mitosis, the rest were just quiet and the teacher did not bother to even point at them to give answers. The teacher was only pointing at pupils who had raised their hands to contribute to the lesson by answering questions. The discourse patterns which emerged from this lesson were three, namely the teacher-led, pupil to pupil and the teacher explanation. This lesson combined all the three discourse patterns which were dominated by the teacher-

led and this raised pupils' morale towards the end of the lesson as almost every pupil wanted to contribute to the importance of mitosis during the question and answer session of the concluding remarks. This lesson started with the teacher asking a series of questions. The teacher's questions in this lesson required pupils to give one word or short sentence answers, which is not good for encouraging substantive student discourse in the classroom. Later on during the lesson the teacher divided the class into groups where they discussed the stages of mitosis. After group presentations, the teacher again explained further the stages of mitosis.

Lesson two

This second lesson on mitosis was observed at Lemon Secondary School. The grade 12 class observed had 46 pupils (20 boys and 26 girls). The teacher observed during this lesson had been teaching biology for 13 years and was initially trained to teach grades eight and nine integrated science. The teacher brought a number of plants to use as teaching aids. The duration of the lesson was 80 minutes. Lesson introduction lasted 15 minutes. The teacher introduced the lesson as follows:

Teacher B: What are some examples of vegetative reproduction?

Pupil 1: Reproduction of sweet potatoes

Teacher B: How do sweet potatoes reproduce?

Pupil 2: Sweet potatoes reproduce by runners

Teacher B: How do humans grow?

Pupil 3: By changing the voice

Pupil 4: By cell division

The teacher here asked a lot of questions which were not related to each other as a result pupils could not connect what the teacher was trying to talk about. The teacher should have exhausted questions on vegetative reproduction and then introduce the concept of cell

division through mitosis. The main part of the lesson took over 60 minutes and proceeded as shown by the following excerpts.

Teacher B: What do we call the process by which cells divide?

Pupil 5: Cell specialisation

Pupil 6: Cell division

Pupil 7: Plasmolysis

Pupil 8: Meiosis

Pupil 9: Mitosis

The pupils did not seem to understand the process of cell division as a result they gave a lot of irrelevant responses which led to the teacher to start asking questions on each of the responses pupils gave. The teacher asked the pupils to analyse the responses given using follow up questions as follows:

Teacher B: What is cell specialisation?

Pupil 1: This is when cells form specialised cells

Teacher B: What is plasmolysis?

Pupil 2: Bursting of the cell after taking in water

Teacher B: What is meiosis?

Pupil 3: It is cell division

This made the teacher to waste a lot of time asking questions on items which were not part of the lesson.

Thereafter, the teacher brought out a flower and asked pupils questions on the flower as follows:

Teacher B: What is a flower?

Pupil 4: It is the reproductive organ of the plant

Teacher B: What is contained in a flower?

Pupil 4: The male and female gametes

Teacher B: What reproductive cells are found in the flower?

Pupil 1: Ovary

Pupil 2: Stamen

Pupil 3: Sepals

Pupil 4: Pollen grains

Pupil 5: Ovules

Here the teacher was trying to bring out the concept of meiosis and yet what was required was to bring out the concept of mitosis. The teacher described the production of pollen grains and ovules as meiosis. He explained that meiosis occurs in the reproductive organs.

One pupil having seen that the teacher had moved out of line in terms of the topic at hand which was mitosis, asked the teacher to locate the part of the body where mitosis occurs.

Pupil 6: In which part of the body does mitosis take place?

Teacher B: Mitosis takes place in all parts of the body mainly in growing points except reproductive organs.

Teacher B: What is Mitosis?

Pupil 1: This is the type of cell division where parts of the body are formed.

Pupil 2: The process by which the body increase in size and number of cells

Pupil 3: Cell division which occurs in autosomes and form diploid chromosomes

Pupils had different views about mitosis therefore the teacher was supposed to guide them to explain clearly the meaning of mitosis. The teacher did not clarify the concept of mitosis, he never accepted or rejected the responses from the pupils. Some pupils might have been confused because of this.

Without the help of any teaching aid or diagrams on the stages of mitosis, the teacher started asking pupils questions on mitosis as follows:

Teacher B: What stages are involved in mitosis?

Pupil 4: Interphase

Pupil 5: Anaphase

Pupil 7: Telophase

Pupil 8: Metaphase

The teacher was choosing pupils to respond to questions from those that had raised their hands, leaving those that had not raised their hands. The teacher described the process of interphase by saying that the cell had its normal structure. This was not clear to the pupils and one pupil asked the teacher to explain clearly what he meant by interphase.

Pupil: What is interphase?

Teacher B: This is a stage where the genetical materials are enclosed in the nuclear membrane.

Still this explanation from the teacher was not adequate because pupils did not understand what happens during interphase. They expressed dissatisfaction on the teacher's responses. The teacher continued with the following questions despite the dissatisfaction from the pupils:

Teacher B: What happens during prophase?

Pupil 2: During this stage nuclear membrane disappears

Pupil 3: Centrosomes will form the fibres

Pupil 4: Centrosomes move to the poles

The teacher did not comment on any of the responses coming from the pupils concerning the process of prophase. Since the teacher had wasted a lot of time explaining issues which were not related to the topic of the day which was mitosis, he started rushing and ended up drawing diagrams with wrong labels which led to one of the pupils to ask him to clarify on the labels.

Pupil 1: But sir the arrows are pointing at the same point but you have given them different names.

Teacher B: One arrow is pointing at the centrosome and the other one is pointing at the centromere.

The teacher corrected the mistake on the drawing and continued asking questions on the stages of mitosis as follows:

Teacher B: What happens during metaphase?

Pupil 2: Spindle fibres attach themselves to the centromere

Pupil 3: Chromatids are placed at the equator

Teacher B: What happens during Anaphase?

Pupil 4: Chromatids are separated

Pupil 5: Spindle fibres are shortened

Pupil 6: Sister cells are put to the opposite direction by the spindle fibres

Teacher B: What happens during Telophase?

Pupil 7: Nuclear membrane appears

Pupil 8: Spindle fibres disappear

Pupil 9: The nucleus of each daughter cell carries the same genetic information

Pupil 1: The cell is ready to divide to form two identical cells

Pupil 2: How long will the process take place?

Teacher B: About 20 minutes

Pupil 1: What makes the nuclear membrane to disappear?

Pupil 2: In readiness for the cell to divide

Teacher B: Enzymes dissolve nuclear envelope

Pupil 2: Which enzyme dissolves nuclear envelope?

Teacher B: There is a limit where we should end. This topic you can study it for four years at a university. So let us just know that they are enzymes.

The teacher could not explain to pupils how the nuclear membrane disappears. When he was asked to state the name of the enzyme which dissolves the nuclear membrane, he became annoyed and threatened the pupil who had asked him the question on the enzyme responsible for making the nuclear membrane to disappear.

This lesson was dominated by question and answer. The teacher asked simple questions which merely required recall of facts. The teacher did not conclude the lesson as there was

very little time remaining to end the period. During the lesson only nine pupils were participating in the lesson by answering and asking questions, the rest of the pupils remained quiet as the lesson progressed. The teacher did not even bother to involve the other pupils who were not involved in the lesson. However, the lesson was dominated by the teacher-led discourse pattern.

Lesson three

The third lesson on mitosis was observed at Mango Secondary School. The teacher did not have any teaching aids apart from the black board. There were 48 pupils in this class (18 boys and 30 girls). Below is an excerpt of the lesson introduction which took about 5 minutes.

Teacher C: How do babies grow?

Pupil 1: Only God knows

This question which was asked by the teacher could not receive a proper response from pupils because the teacher was not clear about what he wanted hence one pupil just said only God knows how babies grow. The rest of the pupils were still thinking on how to respond to the teacher.

The teacher drew a chromosome on the board and asked pupils to state the parts of the chromosomes.

Pupil 2: Chromatid

Pupil 3: Centromere

The teacher accepted the responses from the pupils and went on to ask the following questions:

Teacher C: How many chromosomes do you have in your cells?

Pupil 4: 23

Pupil 5: 46

Pupil 6: 48

Pupils were not sure of the number of chromosomes found in their body cells and could not realise that both haploid and diploid cells can divide by mitosis to produce two daughter cells with the same chromosome component as the parent cell.

The teacher stated that 48 was the number of chromosomes for a chimpanzee.

Teacher C: How many pairs are in 46 chromosomes?

Pupil 7: 23

Teacher C: What name is given to these pairs?

Pupil 8: Homologous pairs

Teacher C: Mention the two types of cell division?

Pupil 9: Mitosis and meiosis

Teacher C: Where does mitosis occur?

Pupil: body cells

Teacher C: Where does meiosis occur?

Pupil 1: Reproductive organs

Teacher C: What type of cell division occurs during penis enlargement?

Pupil 2: Mitosis

Pupils 3: Meiosis

Teacher: How many chromosomes will be found in the daughter cells when body cells divide?

Pupil 2: 23

Pupil 3: 46

The teacher stated that during mitosis the diploid number is maintained. The teacher did not react to the responses from pupils and kept asking questions to very few pupils, denying others chance to participate during the lesson.

Pupil 4: Why is it that when body cells divide, 46 chromosomes are produced in the daughter cells?

Teacher C: We shall come to that later

Teacher C: What is mitosis?

Pupil 5: This is the type of cell division which occurs in body cells where the diploid number is maintained.

Teacher C: Do you know any stage of mitosis?

Pupil 6: Metaphase and Anaphase

There was no other attempt from pupils apart from one pupil who mentioned metaphase and anaphase. The teacher stated that there are five stages of mitosis. The first stage is called interphase and it is the resting stage. The teacher stated that during interphase there is protein synthesis. Chromosomes appear as very thin chromatids and long. The teacher further said that prophase is the longest stage. The chromatids shorten and thicken and they become very visible and the chromatids duplicate. The chromosomes appear. The nucleus disappears. Centrosomes appear and migrate to the poles. Centromeres produce elasticated fibres. The teacher asked one pupil to draw the second stage of mitosis on the board. While the pupil was drawing a diagram of a cell undergoing prophase on the board, the teacher described metaphase as the stage when chromosomes will be placed along the equator.

During this lesson there was no group work for the pupils. The teacher spent most of the lesson time giving the pupils notes on the board. He would now and again stop to ask the pupils a question and then continued writing the notes on the chalk board.

The teacher concluded the lesson by giving homework to pupils to state the importance of mitosis to living organisms. During the question and answer session most of the pupils were passive except a few individuals who were putting up their hands. The lesson was largely characterised by pupils copying notes from the black board. Two discourse patterns emerged from this lesson namely: teacher-led and teacher-explanation discourse patterns.

Lesson four

The fourth lesson on mitosis was conducted at Guava Secondary School. The grade 12 class observed had 50 pupils (23 boys and 27 girls). The duration of the lesson was 80 minutes. The teacher introduced the lesson by asking questions on sexual reproduction. This introduction lasted less than 10 minutes. Below is an excerpt of the lesson introduction.

Teacher D: What happens during sexual reproduction?

Pupil 1: Fusion of sperm and ovum.

Teacher D: What happens during the fusion of sperm and ovum?

Pupil 2: Formation of zygote

Teacher D: What happens during formation of zygote?

Pupil 3: Cell division occurs

Teacher D: What is cell division?

Pupil 4: It is the process by which daughter cells form from parent cells

Pupil 6: It is the division of cells from parent to daughter cells.

The teacher concluded the introduction by saying that cell division is the division of cells and explained that there were two types of cell division.

Teacher D: What are these two types of cell division?

Pupil 1: Mitosis

Pupil 2: Meiosis

The teacher asked pupils to define mitosis as follows:

Teacher D: What is mitosis?

Pupil 3: Mitosis is the type of division of a chromosome and it passes exact features to the daughter cells and it is sometimes called duplicative division

Pupil 4: Mitosis occurs during the growth of an organism or during sexual reproduction

Pupil 5: It is cell division which result in the formation of two daughter cells which are diploid and genetically identical.

The teacher analysed the three responses from pupils by saying we do not know where the chromosomes are coming from in the first definition and said that parent cells should be included in the first definition.

The teacher analysed the second definition and said it should be placed under the importance of mitosis and not a definition. The teacher also said that the third definition lacked the source where the daughter cells were coming from. The teacher then explained that mitosis is the process in which two daughter cells, which are genetically identical, are produced from a parent cell.

Pupil 4: Why are we using the word 'diploid'?

Teacher D: The word diploid stands for complete number of chromosomes.

Pupils did not appreciate the difference between haploid and diploid cells because most of them wanted to ask about the meaning of the two terms.

The teacher explained that mitosis is also referred to as duplicative division.

Pupil 5: How does mitosis occur?

Teacher D: Mitosis occurs when body cells divide.

Teacher D: How many stages are involved in mitosis?

Pupil 6: 4

Pupil 7: 5

Pupil 8: 6

Pupils did not know the number of stages involved in mitosis and this made the teacher to explain that mitosis involves 5 stages. He used the IPMAT mnemonic to assist the pupils remember the stages of mitosis as interphase, prophase, metaphase, anaphase and interphase. The teacher did not refer questions from pupils back to the class instead he went on to respond to them. The teacher then continued to ask questions as follows:

Teacher D: What happens during interphase?

Pupil 1: The cell prepares itself for cell division

Pupil 2: The cell attains maturity

The teacher added that production of energy is also done here in form of Adenosine Triphosphate (ATP) whose purpose is to provide energy to the cell.

Teacher D: What happens during prophase?

Pupil 3: Chromosomes become visible, coil and shorten.

Pupil 4: Chromosomes are paired

Pupil 5: Nucleolus and nuclear envelope disappears

Pupil 6: Centromeres are formed and attach chromosomes

The teacher also added that centrioles are being formed and moved to the opposite poles to form spindle fibres. The teacher was asking questions to very few pupils while other pupils remained passive. The lesson was not concluded due to lack of time. The discourse patterns which emerged from the lesson were the teacher led, pupil to teacher and teacher explanation.

(b) Meiosis

Lesson one

The first lesson on meiosis was observed at Orange Secondary School. The grade 12 class observed had 43 pupils (21 boys and 22 girls). The teacher had been teaching biology for six years. She was diploma holder who was trained to teach grades 8 and 9. The duration of the lesson was 80 minutes. The teacher spent 11 minutes to introduce the lesson. Below is an excerpt for the lesson introduction.

Teacher E: How many types of cell division do we have?

Pupil 1: They are two

Teacher E: What are they?

Pupil 2: Mitosis and Meiosis

Teacher E: What is Mitosis?

Pupil 3: The type of cell division where the number of chromosomes of the parents is equal to the number of chromosomes in the daughter cells.

Pupil 4: Process by which new daughter cells are produced from the mother cells with the diploid number of chromosomes.

Teacher E: Another one to try

Pupil 5: It is a type of cell division where two genetically identical daughter cells are produced.

Teacher E: In which type of body cells does mitosis occur?

Pupil 5: Somatic cells

Teacher E: What are somatic cells?

Pupil 4: Somatic cells are all these other cells apart from the gametes

Teacher E: What type of cell division occurs in the gametes?

Pupil 5: Meiosis

Teacher E: Today we are going to look at meiosis. What is meiosis?

Pupil 6: It is the type of cell division where gametes are produced and they maintain a number of haploid chromosomes.

Teacher E: Others

Pupil 5: It is a type of cell division which takes place in the reproductive organs to produce reproductive cells or gametes.

Pupil 7: It is a type of cell division where by one parent produces 4 daughter cells which are not genetically identical.

Teacher E: What is meant by the term haploid?

Pupil 7: Daughter cells having half the number of chromosomes.

Teacher E: Which symbol do we use for haploid?

Pupil 8: n

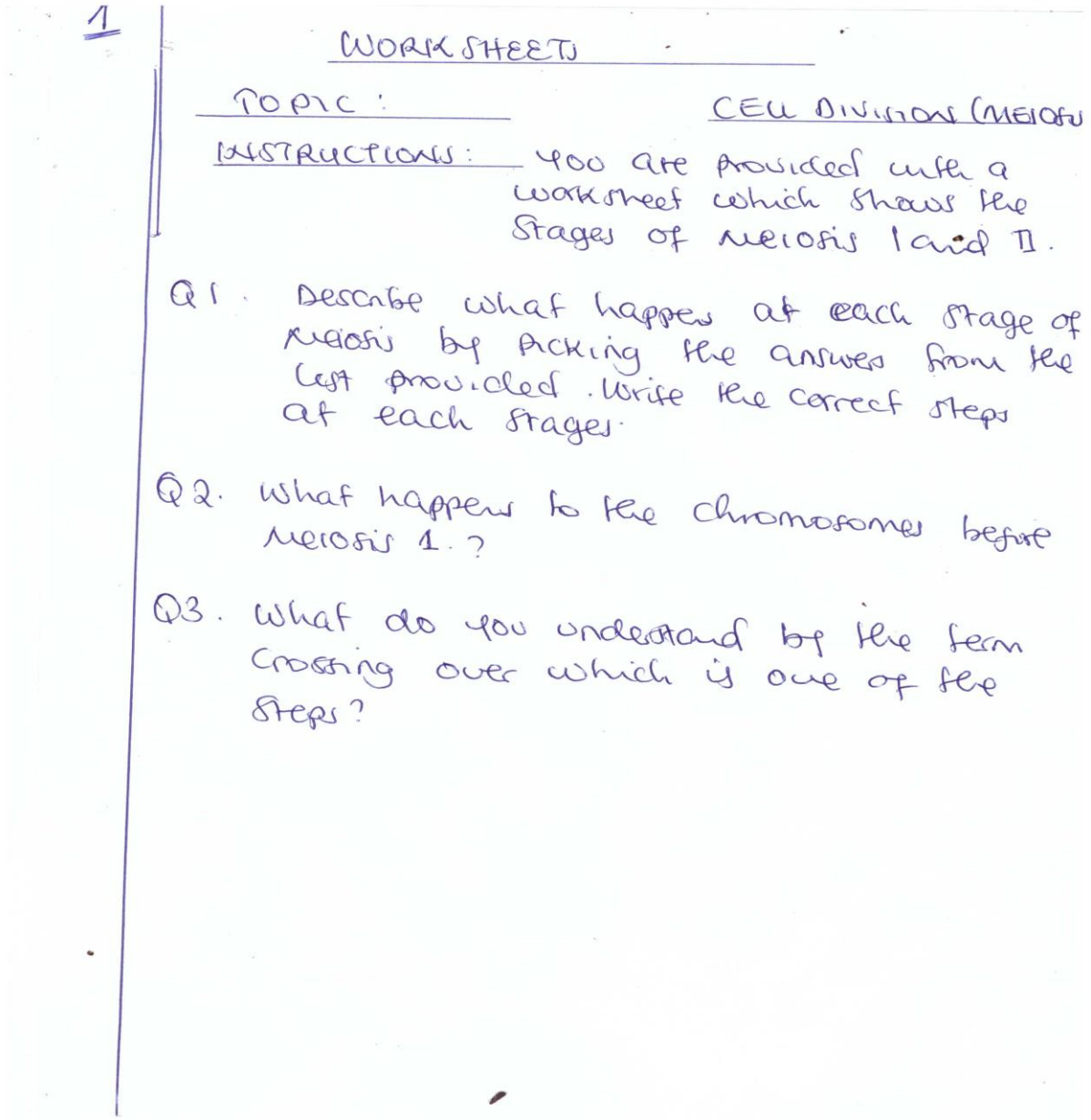
The teacher explained that each human being has 23 pairs of chromosomes.

Teacher E: What are the stages of meiosis?

Pupil 4: The first stage is prophase I followed by metaphase I then anaphase I and telophase 1.

The teacher emphasised that meiosis involves two divisions which are the first and second meiotic division.

The teacher divided the class into four groups to do an activity of describing the two types of meiotic divisions. The teacher distributed pictures of diagrams involving the two meiotic divisions. Each group was expected to examine the two meiotic divisions. The worksheet which was given to the pupils in groups is shown in Figures 4.2, 4.3, 4.4 and 4.5.



1

WORKSHEET

TOPIC: CELL DIVISION (MEIOSIS)

INSTRUCTIONS: You are provided with a worksheet which shows the stages of meiosis I and II.

Q1. Describe what happens at each stage of meiosis by picking the answers from the list provided. Write the correct steps at each stages.

Q2. What happens to the chromosomes before meiosis 1.?

Q3. What do you understand by the term crossing over which is one of the steps?

Figure 4.2: Instructions and questions for the group work (Source: Orange secondary school lesson observation

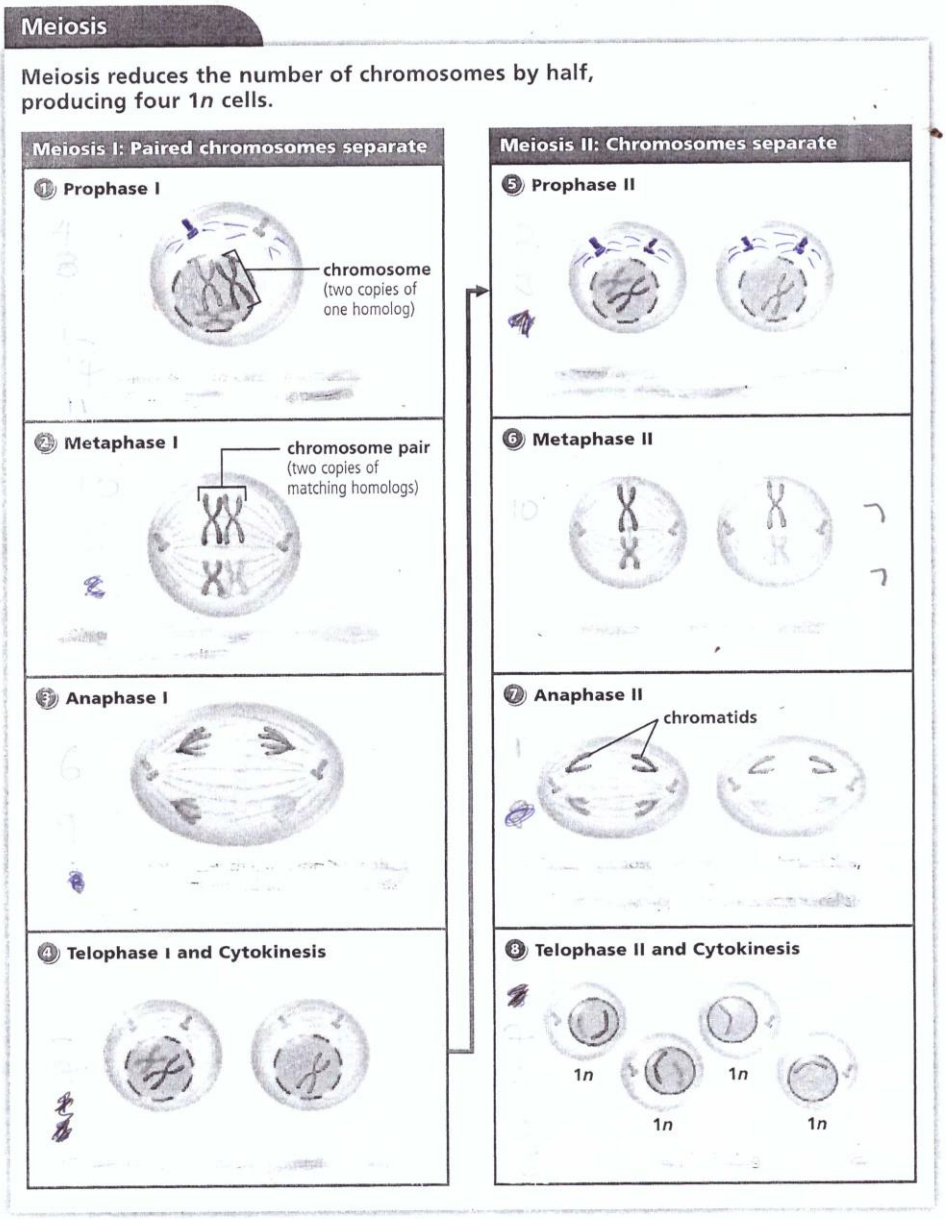
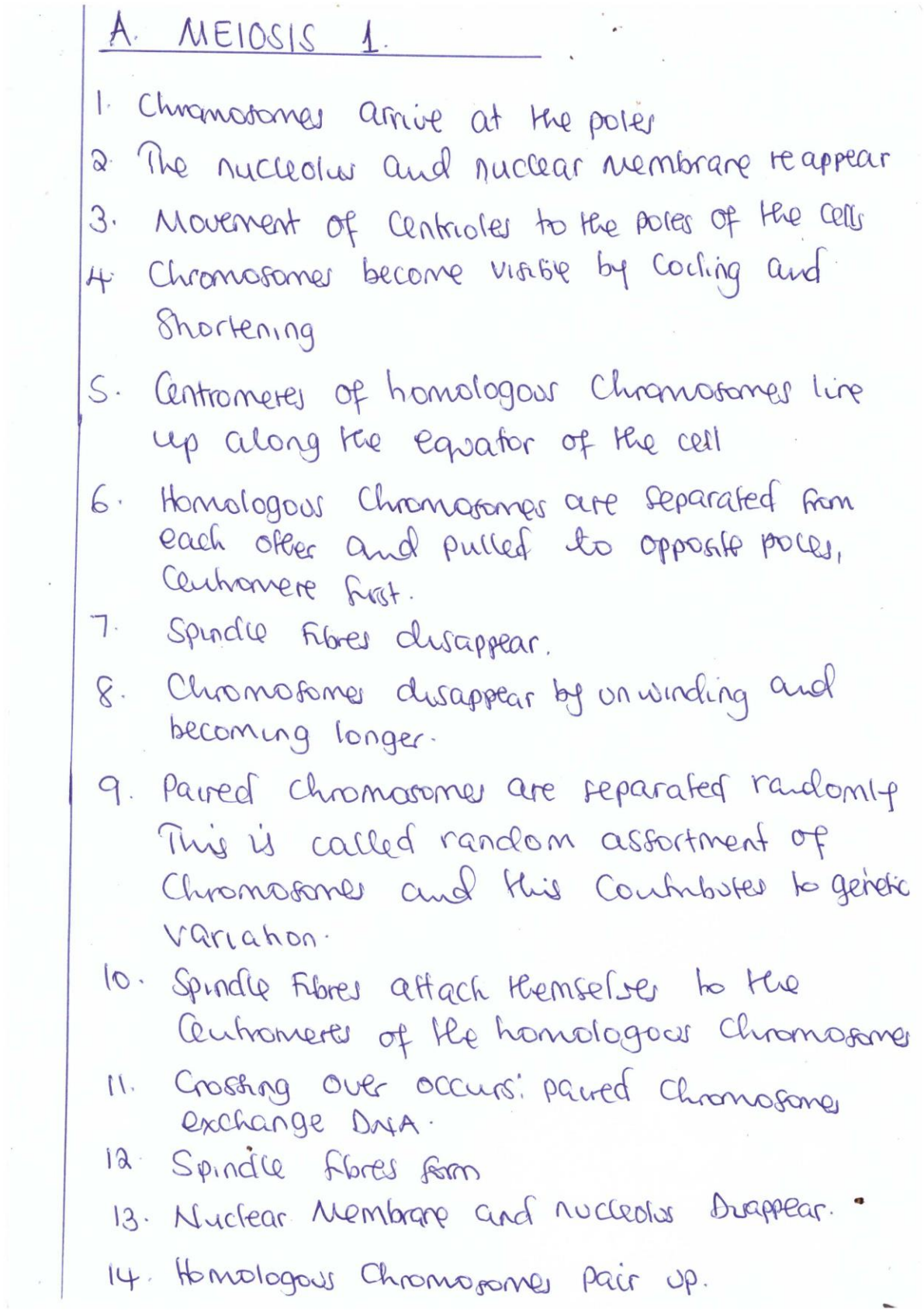


Figure 4.3: Diagrams showing stages of meiosis I and meiosis II (Source: Orange secondary school lesson observation)



A. MEIOSIS 1.

1. Chromosomes arrive at the poles
2. The nucleolus and nuclear membrane reappear
3. Movement of Centrioles to the poles of the cells
4. Chromosomes become visible by coiling and shortening
5. Centromeres of homologous Chromosomes line up along the equator of the cell
6. Homologous Chromosomes are separated from each other and pulled to opposite poles, Centromere first.
7. Spindle fibres disappear.
8. Chromosomes disappear by unwinding and becoming longer.
9. Paired chromosomes are separated randomly This is called random assortment of Chromosomes and this Contributes to genetic variation.
10. Spindle fibres attach themselves to the Centromeres of the homologous Chromosomes
11. Crossing over occurs: paired Chromosomes exchange DNA.
12. Spindle fibres form
13. Nuclear Membrane and nucleolus Disappear.
14. Homologous Chromosomes pair up.

Figure 4.4: Descriptions of meiosis I (Source: Orange secondary school lesson observation)

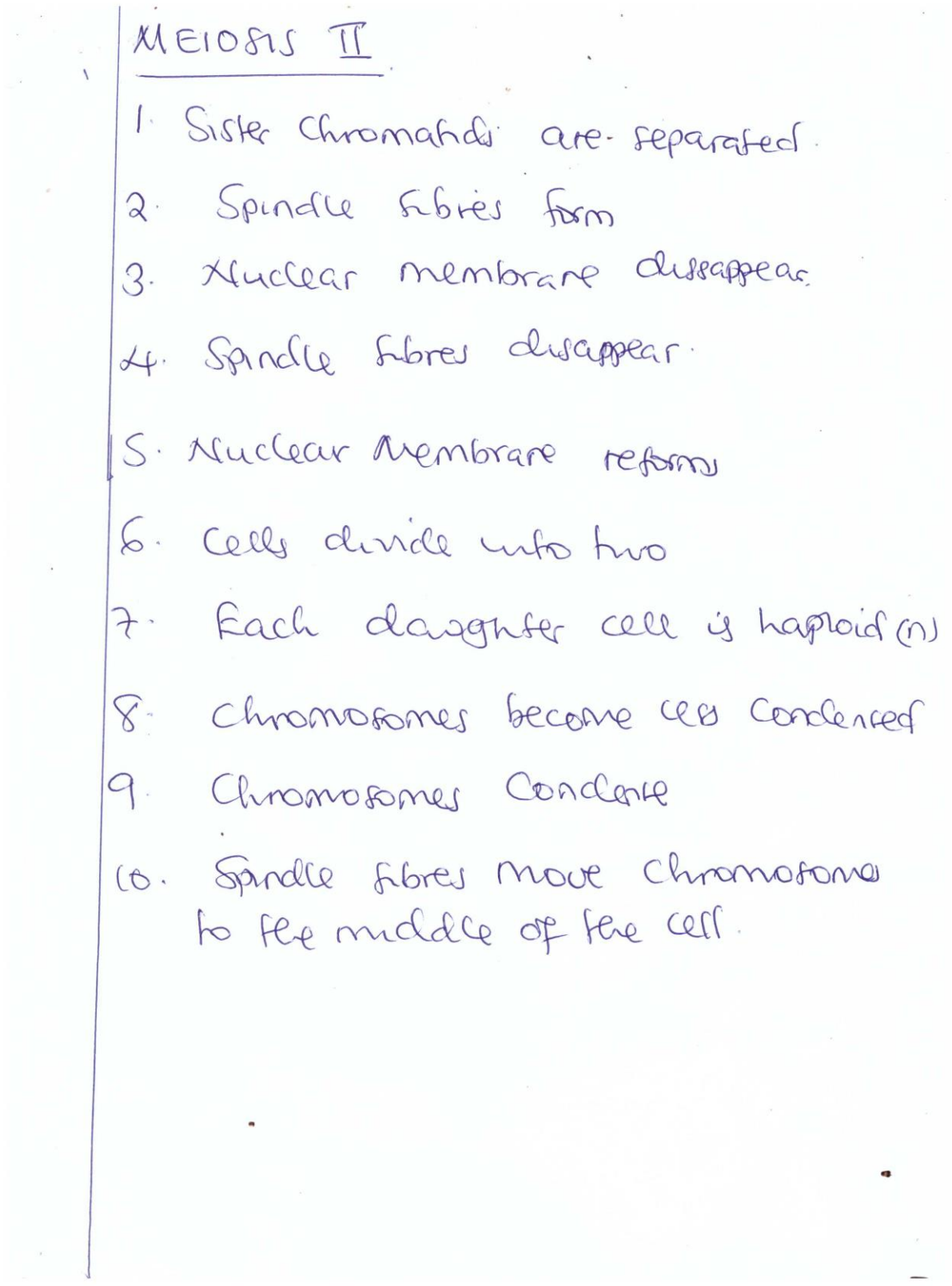


Figure 4.5: Descriptions of meiosis II (Source: Orange secondary school lesson observation)

After 15 minutes group leaders were asked to report their findings.

Group one

This group reported on prophase I. They said that:

Chromosomes become visible by coiling and shortening.

There is movement of centrioles to the poles of the cells.

Nuclear membrane and nucleolus disappear.

Spindle fibres form.

Homologous chromosomes pair up.

Group one reported correctly about the events occurring under prophase one and the teacher promised to give them an incentive.

Group two

This group reported on metaphase I. They said that:

Spindle fibres attach themselves to the centromeres of the homologous chromosomes.

Centromeres of homologous chromosomes line up along the equator of the cell.

Chromosomes arrive at the poles.

Spindle fibres form.

Homologous chromosomes pair up.

Group two only reported the first two events correctly but ended up mixing ideas by including events which occur under prophase such as the formation of spindle fibres and the pairing of homologous chromosomes. They also included an event which occurs under anaphase such as the arrival of chromosomes at the poles.

Group three

This group reported on anaphase I. They said that:

> *Homologous chromosomes are separated from each other and pulled to opposite poles centromere first.*
>
> *There is movement of centrioles to the poles of the cells.*
>
> *Chromosomes arrive at the poles.*

Group three reported two events wrongly namely; the movement of centrioles to the poles of the cells and the arrival of chromosomes at the poles. The only statement which group three reported correctly was that homologous chromosomes are separated from each other and pulled to the opposite poles centromere first. The other event they should have included which happens under anaphase I was that paired chromosomes are separated randomly. This is called random assortment of chromosomes and this contributes to genetic variation.

Group four

This group reported on telophase I. They said that:

> *The nucleus and nuclear membrane reappear and also that spindle fibres disappear.*

However, they did not include the fact that chromosomes arrive at the poles and that chromosomes disappear by unwinding and becoming longer.

Meiosis II

Group one

Group one reported the following on prophase II:

> *Spindle fibres form and that the nuclear membrane disappears.*

However, the pupils in this group forgot to include the fact that chromosomes condense.

Group two

Group two reported the following about metaphase II:

> *Spindle fibres move chromosomes to the middle of the cell and this is the only event which occurs during metaphase II.*

This statement was adequate from group two.

Group three

Group three reported the following about anaphase II;

> *Sister chromatids are separated and that chromosomes become less condensed.*

However, under anaphase there is only one event which takes place and that is the separation of sister chromatids.

Group four

Group four reported the following on telophase II

> *Spindle fibres disappear and that the nuclear membrane reforms. They also said that cells divide into two.*

However, they forgot to include the fact that chromosomes become less condensed.

Before the lesson ended, the teacher gave the pupils an assignment on the importance of meiosis. The discourse patterns which emerged from the lesson were the teacher-led and pupil to pupil discourse pattern.

Lesson two

The second lesson on meiosis was observed at Lemon Secondary School. The class observed was a grade 12 one with 48 pupils (23 boys and 25 girls). The teacher observed had been teaching biology for eight years. He was diploma holder trained to teach grades 8 and 9. The

duration of the lesson was 80 minutes. Below is an excerpt of the lesson introduction which took about nine minutes.

Teacher F: What are the two types of cell division?

Pupil 1: Mitosis

Pupil 2: Meiosis

Teacher F: What is meiosis?

Pupil 3: It is a type of cell division which takes place in the reproductive organs to produce gametes.

Teacher F: What is a gamete?

Pupil 4: These are sex cells.

Teacher F: In females where do we expect meiosis to take place?

Pupil 5: Ovaries.

Teacher F: In males where do we expect meiosis to take place?

Pupil 6: Testes.

Teacher F: What about plants where do we expect meiosis to take place?

Pupil 7: Anthers.

Pupil 8: Ovaries.

Teacher F: How many chromosomes are produced during meiosis?

Pupil 9: Half of 46.

The teacher explained that meiosis leads to reduction of number of chromosomes contained in the number of cells. Hence meiosis is also referred to as reduction division. The number of chromosomes in a parent cell is called the diploid number. In daughter cells it is called haploid number.

Below is an excerpt of the main lesson which took about 60 minutes.

Teacher: What is the difference between diploid and haploid?

Pupil 1: Diploid is the number of chromosomes found in parent cells whereas haploid is the number of chromosomes found in daughter cells after meiosis.

Teacher F: Identify any cell which contains haploid number of chromosomes?

Pupil 2: Ovaries.

Pupil 3: Ovum.

Pupil 4: Sperms.

The teacher explained that meiosis occurs in two parts, that is first meiotic division and second meiotic division.

Teacher F: How many stages are involved in meiosis?

Pupil 5: 4

Pupil 6: 5

Teacher F: Name the stages of meiosis?

Pupil 6: Interphase, prophase, metaphase, anaphase, telophase.

Teacher F: How can you remember the stages of meiosis easily?

Pupil 7: By using the letters IPMAT.

The teacher divided the class into five groups to discuss the stages of meiosis. He distributed charts having different stages of meiosis. After ten minutes, pupils started reporting their findings from the groups.

Group one

Group one reported on interphase I as follows:

> *During interphase I this is the period when the cell grows and attains its normal size. Nuclear proteins are synthesised and chromatids replicate. After replication the chromatids remain attached at the centromeres.*

Group two

Group two reported on prophase I as follows:

> *During prophase I the chromosomes in the early prophase appear as very fine single strands. The Chromosomes then start to form matching pairs known as homologous pairs. Each homologous pair consists of one chromosome from the haploid set derived from one parent and the other haploid set derived from the other parent. These two chromosomes are similar in length, position of centromere and arrangement of the chromosomes. This pairing result in the formation of chromosomes pair called bivalents. The chromosomes in each bivalent then shorten*

and thicken. The chromosomes duplicate themselves such that each bivalent appears to have four chromatids.

Group two should have included the fact that it is during prophase I that the chromosomes exchange portions of their genetic materials. Group two should have concluded by saying that to mark the end of prophase I, the bivalents move further away from each other. The nucleoli and nuclear membrane disappear and the spindle fibres appear forming the spindle in the process.

Group three

Group three reported on metaphase I as follows:

The nuclear membrane disappears and the bivalents which are the chromosomes will attach to the spindles of the centromeres. The centromeres of the two chromosomes of homologous pair lie on either side of the equator.

Group three should have said that the bivalents are attached to the spindles by their centromeres and not that the bivalents are attached to the spindles of the centromeres.

Group four

Group four reported on anaphase I as follows:

Under anaphase I the homologous chromosomes are separated, each is dragged to the opposite pole of the cell. The centromeres of each chromosome do not divide as in mitosis. Each chromosome consists of two easily seen chromatids.

Group four reported correctly the events of Anaphase I

Group five

Group five reported on telophase I as follows:

Under telophase I, the chromosomes arrive at the poles of the cells. The nuclear membrane surrounds the chromosomes. The nucleus reappear and the chromosomes become less distinct causing the formation of two daughter cells. The cells will enter into a short interphase after which the second meiotic division takes place.

The group should have said that the nucleoli reappear and not that the nucleus will reappear. The teacher concluded the lesson by asking pupils to go and write reports on meiosis II at home and prepare to report their findings. The teacher failed to teach meiosis II due to lack of time and ended up asking the pupils to research on meiosis II. The discourse patterns which emerged from the lesson included the teacher led, teacher explanation and pupil to pupil discourse patterns.

Lesson three

The third lesson on meiosis was observed at Mango secondary School. There were 52 grade 12 pupils in class (22 boys and 30 girls). The teacher had been teaching biology for 12 years. He was a diploma holder who was trained to teach grades 8 and 9. The duration of the lesson was 80 minutes. Below is an excerpt of the lesson introduction which took less than ten minutes.

Teacher G: What is Genetics?

Pupil 1: The study of inherited characteristics.

Teacher G: Mention two types of cell division?

Pupil 2: Mitosis and Meiosis.

Teacher G: What is mitosis?

Pupil 3: Mitosis where two daughter cells are produced from a diploid mother cell.

Teacher G: What is meiosis?

Pupil 4: This is the type of cell division where a diploid mother cell produced 4 haploid daughter cells which are genetically different.

Pupil 5: What is found in chromosomes?

Teacher G: Genes.

The teacher explained that 22 chromosomes are diploid and one chromosome is haploid.

Pupil 6: What is the meaning of 22

Teacher G: 22 chromosomes are diploid and one chromosome is a sex chromosome.

Pupil 7: What are reproductive organs?

Teacher G: Sex cells

Teacher G: What sex cells are found in men?

Pupil 8: Sperms

Teacher G: What sex cells are found in women?

Pupil 8: ovum.

The teacher divided the pupils into five 5 groups to discuss the stages of meiosis I and the pupils were given 10 minutes to discuss what happens in the 5 stages of the first meiotic division.

Group one

Group one reported on interphase as follows:

> *During interphase all necessary requirements are available in order for the cell to undergo meiosis. The cell grows so that it attains the normal size.*

Group two

Group two reported on prophase I as follows:

> *During prophase I there is movement of centrioles of the poles of the cell and appearance of spindle fibres from the centrioles. There is disappearance of nucleus membrane and nucleolus. Chromosomes become visible by coiling and shortening. Homologous chromosomes pair up. Crossing over takes place between non-sister chromatids of homologous chromosomes.*

Group three

Group three reported on metaphase I as follows:

> *Under metaphase I centromeres of homologous chromosomes line up along the equator of the cell. Spindle fibres from the centrioles attach themselves to the centromeres of the homologous chromosomes.*

Group four

Group four reported on anaphase I as follows:

The homologous chromosomes are separated and each is dragged to the opposite poles of the cell. The centromeres of each chromosome do not divide as in mitosis. Each chromosome consists of two easily seen chromatids.

Group five

Group five reported on telophase I as follows:

During telophase I the chromatids arrive at the poles and each of them becomes a complete chromosome. The spindle fibres disappear. Chromosomes disappear by unwinding and becoming longer. The nucleolus and nuclear membrane reappears.

During group work fast learners were seen assisting slow learners. However, some pupils did not take group work seriously. Some pupils did more work than others. In addition, there was a lot of noise in the groups as a result very little work was done. Moreover, the time which was allocated to the tasks in groups was not enough. The discourse patterns which emerged from the lesson were teacher-led and pupil to pupil discourse patterns.

(c) Classification of living organisms

Lesson one

The first lesson on classification of living organisms was observed at Orange Secondary School. The class observed had 58 grade 11 pupils (25 boys and 28 girls). The teacher had been teaching biology for five years. He was the only graduate from the University of Zambia who was observed. However, the teacher was specialised in the teaching of agriculture science. The duration of the lesson was 80 minutes. Below is an excerpt of the lesson introduction which took about ten minutes.

Teacher H: What is classification?

Pupil 1: Classification is an orderly grouping of organisms according to common features

Teacher H: To which phylum does an earthworm belong?

Pupil 2: Oligochaeta

Teacher H: No

Pupil 3: Nematoda

Teacher H: No

Pupil 4: Annelida

Teacher H: Yes

The correct response was Annelida. However, pupils found it confusing to state the correct phylum due to different classes and phyla. The teacher rejected Oligochaeta because this is the class and not phylum to which earth worms belong. The teacher also rejected Nematoda because this is another phylum where round worms belong.

The teacher explained that there are various ways of classifying organisms. The teacher said that the common system used by biologists is called natural classification. This is where organisms with similar features are grouped together. The teacher emphasised that when classifying we start with a very general grouping.

Teacher H: Do we have cell walls as human beings?

Pupil 2: No

Teacher H: What of Plants do they have cell walls?

Pupil 3: Yes

The teacher further explained that animals with back bones are grouped together in one group and those without backbones are grouped in one group. The teacher said that organisms are arranged from the largest group in descending order to the lowest group. The largest group or unit is the kingdom.

The teacher classified maize as follows:

Kingdom: Plantae

Division: Angiospemophyta

Class : Monocotyledonae

Order: Poales

Family: Poaceae

Genus: *Zea*

Species: *mays*

After classifying a maize plant the teacher said that the smallest unit of classification is species. The teacher reminded pupils that it is difficult to remember the order or family to which an organism belongs. Classification is made easy by developing a dichotomous key.

The teacher gave an example as follows:

Using a dichotomous key below classify the following organisms

(a) Frog (b) Eagle (c) Bat

Stage 1: Warm blooded –4

Cold blooded---2

Stage 2: Has fins but no limbs—Fish

Has 4 Limbs ----3

Stage 3: Has no scales on body- Amphibian

Has Scales –Reptile

Stag4: Has feathers----Bird

Has hairs----Mammal

(a) We start with a frog –it is an amphibian
(b) An eagle is a bird
(c) A bat is a mammal

The teacher did not give reasons why he rejected some answers from pupils and did not even explain why certain answers from pupils were correct. The discourse patterns which emerged from this lesson included teacher-led and teacher-explanation discourse patterns.

Lesson two

This lesson on classification of living organisms was observed at Lemon Secondary School. The class had 45 grade 10 pupils (21 boys and 24 girls). The teacher had been teaching biology for 12 years. He was a diploma holder trained to teach grades 8 and 9. The lesson took 40 minutes to be concluded. Below is an excerpt of the lesson introduction which took about 5 minutes.

Teacher I: Give me some names of living organisms

Pupil 1: Plants

Pupil 2: Animals

The teacher said that the grouping of living organisms in groups is known as classification. The teacher further went on to define some terms as follows

Taxonomy as a way of grouping organisms by looking at similarities and differences.

Kingdom is the largest group in which a living organism can be placed

Phyla are made up of several related families of living organisms.

Class is made up of closely related organisms.

Genus is made up of species.

Species is a group of organisms having similar features and capable of interbreeding to produce fertile off spring.

The teacher went on to classify the organisms from a chart as shown in Table 4.1.

Table 4.1: Classification of Human beings, lions, maize and a wolf

Taxon	Human being	Lion	Maize	Wolf
Kingdom	Animalia	Animalia	Plantae	Animalia
Phylum	Chordata	Chordata	Angiospermophyta	Chordata
Class	Mammalia	Mammalia	Monocotyledonae	Mammalia
Order	Primates	Carnivora	Commelinales	Carnivora
Family	Hominidae	Felidae	Poacea	Canidae
Genus	*Homo*	*Panthera*	*Zea*	*Canis*
Species	*Sapiens*	*Leo*	*Mays*	*Lupus*

The teacher further said that all living organisms are classified into 5 Kingdoms

Teacher I: Give me an example of a Kingdom

Pupil 2: Animal Kingdom

The teacher then described five kingdoms from a chart (Table 4.2):

Table 4.2: Kingdoms, characteristics and examples

Kingdom	Characteristics	Example
Prokaryote/Monera	No double membrane organelles No nucleus Unicellular	Bacteria
Protoctista/Protista	Have well defined nucleus Double membraned organelles Unicellular	Protozoa Algae Protists Plasmodium Trypanosoma
Fungi/Mycota	Multi cellular Well defined nucleus Double membraned organelles Cell wall of chitin	Yeasts Moulds Mushrooms Toad stools
Plantae/Metaphyta	Multicellular Well defined nucleus Double membrane organelles Cell wall Have well developed roots Vascular system Leaves	Mosses Ferns Conifers Flowering Plants Monocotyledonous Dicotyledonous
Animalia/Metazoa	Multicellular Have well defined nucleus Have double membrane organelle No cell wall	Invertebrates Vertebrates

The teacher explained that Kingdom Monera is the same as Kingdom Protoctista which was not correct. He even wrongly gave an example of Kingdom Monera as algae. He ruled out the fact that Kingdom Monera contains Bacteria. The teacher confused himself here because Kingdom Monera is the same as Prokaryote. The teacher explained that Virus has not been assigned to any of the five Kingdoms. The discourse patterns from this lesson were the teacher-led dominated by the teacher-explanation discourse pattern.

Lesson three

This lesson was observed at Mango Secondary School. The lesson took 40 minutes to be concluded. There were 51 grade ten pupils in class (20 boys and 31 girls). The teacher had been teaching biology for nine years. He was trained to teach grades 8 and 9. Below is an excerpt of the lesson introduction which took about five minutes.

Teacher J: What is classification?

Pupil 1: Putting things in groups.

Teacher J: What are organisms?

Pupil 2: These are things which have life.

The teacher explained that classification of living organisms simply meant putting living organisms in groups according to features.

The fact is that there are five kingdoms. But in this lesson the teacher emphasised that there are just two groups of organisms as shown in Figure 4.6

This created confusion among the pupils because they knew that there were five kingdoms namely Monera, Protista, Fungi, Plantae and Animalia.

The teacher acted like this because the syllabus states that learners should be able to identify various types of plants and animals and not these other kingdoms. The teacher did not explain why he left out the other three kingdoms from his lesson to the pupils.

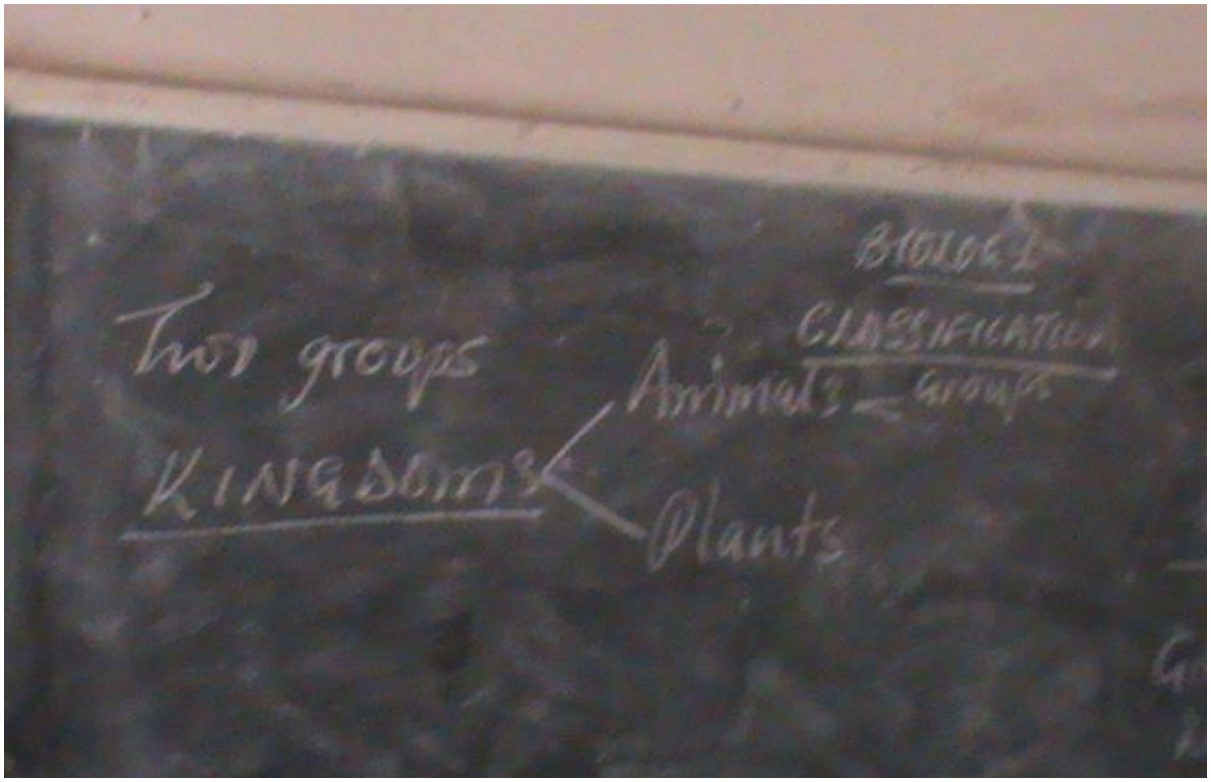


Figure 4.6: Two types of kingdoms explained by a teacher in one of the schools (Source: Mango Secondary School lesson observation)

The teacher then divided the class into four groups and asked them to complete the classification of organisms from Table 4.3.

Table 4.3: Classification of human beings, maize, lions and beans

Taxon	Group1 Human beings	Group 2 Maize	Group 3 Lions	Group 4 Beans
Kingdom				
Division				
Class				
Order				
Family				
Genus				
Species				

After ten minutes groups reported back their findings like this

Group one (Human beings)

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Primates

Family: Hominid

Genus: *Homo*

Species: *Sapiens*

Group two (Maize)

Kingdom: Plantae

Phylum: Angiospermophyta

Class: Monocotyledonae

Order: Poales

Family: Poaceae

Genus: *Zea*

Species: *Mays*

Group three (Lion)

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Carnivora

Family: Felidae

Genus: *Panthera*

Species: *Leo*

Group four (Beans)

Kingdom: Plantae

Phylum: Angiospermophyta

Class: Dicotyledonae

Order: Fabales

Family: Fabaceae

Genus: *Phaseolus*

Species: *Vulgalis*

The teacher did not have time to conclude the lesson. The time was not enough for him, as a result the lesson ended when pupils were still in groups.

Lesson four

This lesson was observed at Guava Secondary School. The class had 46 grade ten pupils (21 boys and 25 girls). The teacher had been teaching biology for seven years. He was trained to teach grades 8 and 9. The lesson took about 40 minutes to be concluded. The teacher brought out a lot of things to be sorted out such as plants, playing cards, stones, medicine droppers and asked pupils to sort them out. One pupil separated the plants from the rest of the things. Another pupil separated them according to their characteristics, stones alone, medicine droppers alone, playing cards alone and plants alone.

She then introduced the topic classification of living organisms. This introduction took 10 minutes.

Teacher K: What is classification?

Pupil 1: Classification is the arranging of organisms in groups according to their characteristics.

Pupil 2: Classification is the placing of organisms in groups based on features they have in common.

The teacher then said that this classification involves taxonomy, nomenclature and identification keys.

Teacher K: What is taxonomy?

Pupil 3: It is a branch of biology which places organisms in groups.

Pupil 4: It is a branch of biology which places organisms in a series of groups.

Teacher K: What are these groups?

Pupil 4: Kingdom

Pupil 5: Species

Pupil 6: Phylum

Pupil 7: Fungi

Pupil 8: Classes

Pupil 9: Order

Pupil 10: Genus

Pupil 11: Family

Teacher K: What is the correct order of these groups?

Pupil 2: Kingdom, Phylum, Class, Order, Family, Genus, Species.

The teacher asked the pupils to state the mnemonic which can be used to remember the arrangement of kingdom to species. Pupils failed to come up with the mnemonic and then the teacher suggested kings play chess on fine gold stools meaning kings for kingdom, play for phylum, chess for class, on for order, fine for family, gold for genus and stools for species.

Teacher K: What is nomenclature?

Pupils: Silence

Teacher K: The naming of organisms with scientific names is nomenclature

Teacher K: What is binomial system of nomenclature?

Pupils: Silence

Teacher K: This is the system used in naming organisms with scientific names

The teacher explained that the scientific name has two parts, the first part is the generic name and the second part is the species name. The teacher explained further that when you are typing a scientific name, you are supposed to write it in italics and that the generic name should start with a capital letter.

Teacher K: How should a scientific name appear in handwritten form?

Pupil 3: In capital letters

Pupil 4: In different ink

Pupil 5: Should be underlined

The teacher advised that when underlining the scientific name you should not draw a continuous line but underline the generic name separately from the species name.

Teacher K: What are identification keys?

Pupils: Silence

Teacher K: Identification keys are series of statements about characteristics of organisms which if followed will make you identify organisms.

Teacher K: How many kingdoms are there?

Pupil 6: 5 Kingdoms

Teacher K: What are the names of the kingdoms?

Pupil 7: Animalia

Pupil 8: Plantae

Pupil 9: Fungi

Pupil 10: Protista

Pupil 11: Monera

Teacher K: What kind of organisms are found in kingdom fungi?

Pupil 12: Mushrooms

Pupil 4: yeast

Teacher K: What kind of organisms are found in kingdom Protista?

Pupil 5: Amoeba

Pupil 6: Toads

Pupil 7: Protozoa

Teacher K: What kind of organisms are found in kingdom Monera?

Pupil 8: Bacteria

The teacher then displayed a chart showing the five kingdoms and examples of organisms found there.

Teacher K: Which kingdom are viruses found in?

Pupil 9: Monera

Teacher K: Others what do you have to say?

Pupils: silence

The teacher answered by saying that viruses are not classified into any of the five kingdoms. The teacher then classified human beings with the help of pupils like this

Kingdom- Animalia

Phylum- Chordata

Class- Mammalia

Order- Primates

Family: Hominids

Genus- *Homo*

Species- *Sapiens*

The teacher then gave pupils an exercise to classify a wolf in the same manner they classified human beings in the example. The teacher started moving around the desks while marking pupils work. The teacher did not give pupils homework and the lesson ended without a conclusion as the teacher was still marking pupils' exercise books when the bell rang indicating the end of the period for the lesson. The discourse patterns which emerged from the lesson included the teacher-led dominated by the teacher-explanation discourse pattern.

4.2.1 Summary of discourse patterns used in the lessons

Table 4.4 illustrates the discourse patterns used in the observed lessons in Luapula Province.

Table 4.4: Discourse patterns used in the lessons

Lessons	Introduction	Main lesson	Conclusion
Lesson 1 on Mitosis	Teacher-led	Teacher-led Pupil to pupil	Teacher-led Teacher-explanation
Lesson 2 on Mitosis	Teacher-led	Teacher-led Teacher-explanation	No conclusion
Lesson 3 on Mitosis	Teacher-led	Teacher-led Teacher-explanation	Teacher-explanation
Lesson 4 on Mitosis	Teacher-led	Teacher-led Teacher-explanation	No conclusion
Lesson 1 on Meiosis	Teacher-led	Pupil to pupil	No conclusion
Lesson 2 on Meiosis	Teacher-led Teacher-explanation	Pupil to pupil	Teacher-explanation
Lesson 3 on Meiosis	Teacher-led	Pupil to pupil	No conclusion
Lesson 1 on Classification of living organisms	Teacher-led Teacher-explanation	Teacher-led Teacher-explanation	No conclusion
Lesson 2 on Classification of living organism	Teacher-led Teacher-explanation	Teacher-explanation	No conclusion
Lesson 3 on classification of living organism	Teacher-led Teacher-explanation	Pupil to pupil	No conclusion
Lesson 4 on Classification of living organisms	Teacher-led	Teacher-led Teacher-explanation	No conclusion

The lessons were dominated by the teacher-led discourse pattern followed by the teacher-explanation discourse pattern and the least used discourse pattern was the pupil to pupil discourse pattern. Introductions and conclusions were teacher led and very brief. Teachers were in most cases using low level questions during the delivery of their lessons, which

impacted negatively on the pupils. Most of the lessons were not concluded due to lack of time. Some teachers ended up giving pupils homework as a way of concluding the lessons.

Most of the pupils were not engaged in the discussions during the pupil to pupil discourse pattern. In most cases, only group leaders were actively involved since they were seen searching from textbooks and writing a few things to be presented to the class after the discussions. Other pupils were simply observing or doing other things which were not even related to the work which was given to them by the teachers.

4.3 Question 2: How do teachers of biology arrive at the choice of discourse patterns they use for teaching topics perceived to be difficult?

Respondents (teachers) cited various reasons which influenced them to choose discourse patterns they used during lessons on topics perceived to be difficult in biology. These are presented below:

4.3.1 Non availability of teaching and learning materials

One of the reasons which teachers of biology gave for the choice of discourse patterns they used was non-availability of teaching and learning materials for teaching perceived difficult topics. One participant had this to say;

> *I had difficulties in accessing teaching aids such as videos, which I should have used to show the pupils on mitosis **(Mango Secondary School)**.*

Another teacher had this to say:

> *I had nothing to use in form of teaching aids to make the lesson interesting as a result I only drew stages of mitosis on the chalk board (**Lemon Secondary School)**.*

4.3.2 Desire to cover more content

Another issue which made them choose a particular discourse pattern was the desire to cover a lot of subject matter within a short period of time. Respondents were of the view that a

large amount of scientific content could be presented to pupils through a discourse pattern which involved them giving out information to pupils who were expected to merely listen. The statements below illustrate this point:

> *I used the lecture method to save on my time. I covered a lot of content in 80 minutes which was not going to be possible if I had used group work* ***(Mango Secondary School)***.

Another teacher had this to say:

> *I did not use the question and answer method for a long time because pupils were taking time to answer questions so I opted to start explaining most of the time to try and cover a lot of items* ***(Lemon Secondary School).***

7 respondents cited the unfamiliar content as the reason why they used a discourse pattern which involved providing information to pupils rather than one where learners participate in the learning process. This was pointed out by one teacher who said:

> *The lecture method was appropriate for this topic because the content was very new to the pupils. I was going to waste pupils' time if I had used group work because pupils were not going to find answers easily* ***(Orange Secondary School)***.

4.3.3 Desire to engage pupils in the lesson

Reluctant learners also made teachers decide to use the pupil to pupil discourse pattern because they rarely spoke though they were listening. Therefore, in order to involve them in the lesson, teachers tried to use stronger pupils to help weaker ones. This came out from one teacher who said that;

> *I think I involved every pupil in the lesson by making them discuss in small groups to make each and every learner to participate and those who are slow learners to be helped by fellow pupils* ***(Mango Secondary School)***.

In this case, the teacher should have even stopped dominating participants from consuming much time by talking too much.

When a lot of pupils were not involved in the lesson some teachers tried to use classroom discussions to involve them in the lesson. This was advanced by one teacher who said that;

> *Not all the pupils were involved in the lesson as a result I came up with class discussion instead of group discussion* ***(Lemon Secondary School)***.

In this case, the teacher directed the discussion by pointing at each and every pupil in the class to participate.

The choice of discourse pattern also depended on whether the pupils were engaged in the lesson or not. This was mentioned by one teacher who said that;

> *Pupils follow properly if they are actively involved in the lesson* ***(Guava Secondary School).***

Another teacher had this to say:

> *I used the question and answer method so that I could involve a lot of pupils in the lesson, by asking questions to each and every pupil in the class (****Mango Secondary School)***.

The teacher should acknowledge the pupils by involving them in the discussion and this is usually done when the teacher draws a good number of pupils into a discussion and prevents brighter pupils from monopolising the discussion.

4.3.4 Desire for pupils to relate lessons to real -life situations

8 teachers decided on the discourse pattern to be used with a view to make pupils appreciate the link between lessons and real life situations. One teacher had this to say;

> *I wanted them to appreciate how the knowledge obtained from classification can be useful in their lives* ***(Orange Secondary School).***

Another teacher had this to say:

> *I brought a lot of specimens to the class so that pupils appreciate that the classification of living organisms can be understood by using local and available organisms in their own environments (****Lemon Secondary School).***

Pupils appreciated the lesson because it was linked to their real life situation. This was normally achieved when the teacher gave real life examples during the lesson.

4.3.5 Familiarity

4 teachers said that they chose to use a discourse pattern they were familiar with and comfortable with. In most cases teachers used discourse patterns they were very conversant with. One teacher was asked why he used the pupil to pupil discourse pattern during the lesson on mitosis, he said that:

> *I had very good understanding of how to manage pupils in groups and how to make group work successful* ***(Guava Secondary School).***

Another teacher had this to say:

> *I used the lecture method more often because it is easy to use and I have been using this method ever since I started teaching (****Mango Secondary School****).*

Teachers used discourse patterns they were familiar with so that they could resolve conflicts and misunderstandings easily.

4.3.7 Need to provide concrete examples

5 teachers decided to use charts to explain mitosis because they believed that their pupils were not good at reading and that it was difficult to make sense out of words on the stages of mitosis. One teacher had this to say;

> *I experienced challenges because pupils do not know how to read, meiosis is very difficult for pupils to understand that is why I brought out the pictures for the pupils to see* ***(Orange Secondary School)***.

Certain pupils tend to make words from pictures, therefore it is important that stages of mitosis are first shown to pupils in form of diagrams before describing them using words. A good number of teachers brought out a lot of real specimens during classification of living organisms in order to make the lessons realistic. This was also mentioned by one teacher who said that;

> *I wanted to make the lesson more realistic, if pupils saw the organisms they were going to appreciate the lesson very much (****Guava Secondary School)***.

When pupils were shown real specimens during lessons on classification of living organisms which they could see with their eyes and verify, they enjoyed the lessons very much.

4.3.8 Laziness

Some pupils thought that their teachers decided to choose certain ways of teaching due to laziness. One pupil had this to say;

> *Whenever the teacher gives us group work then he has nothing to teach us, he even goes out of the classroom to talk to his friends, we just remain without any guidance on how to go about the work as a result we just start making noise* ***(Lemon Secondary School)***.

This is particularly true because some teachers did not even have lesson plans and they just introduced the lessons and went on to divide their classes into groups which they did not even monitor.

4.3.9 Summary on the choice of discourse patterns used by teachers

Respondents cited various issues which influenced teachers to choose discourse patterns used in the teaching of topics perceived to be difficult in biology. Teachers were not sticking to the same discourse patterns during lesson time, this was done in order to avoid monotony. The choice of discourse patterns, by teachers of biology, normally depends on the teacher's experience, interest, ability and the intelligence level of the class he/she is teaching. Since the approach to the teaching of science and methods to be used depend on various circumstances, the teacher of science should study these factors and choose a particular way of teaching which his/her experience convinces him/her to be best suited for the particular situation.

However, the most prominent reasons included non-availability of teaching and learning materials, desire to cover more content and engagement of pupils in lessons, need to relate lessons to real life situations, skill in managing groups, pupil participation and their

intelligence levels, need to provide concrete examples and ability to arouse interest among pupils and talent, interest, experience and laziness among teachers.

In section 4.3, I presented findings on how teachers arrived at the choice of discourse patterns they used when teaching topics perceived to be difficult in biology. In section 4.4, I will present findings on the negative effects and positive effects of the discourse patterns teachers used when they taught topics perceived to be difficult in biology.

4.4. Question 3: What effects do the discourse patterns teachers use have on pupils' understanding of perceived difficult topics in biology?

From responses given by participants in this study, discourse patterns which teachers used when teaching topics perceived to be difficult in biology had negative as well as positive effects on pupils' understanding of these topics. These are presented below:

4.4.1 Negative effects on pupil's understanding during lessons on perceived difficult topics in biology

One of the negative effects the discourse patterns had, which was advanced by some of the participants was lack of understanding. They reported various causes of this misunderstanding. One cause given was the lack of understanding of the group tasks given as the following statement by one learner illustrates:

> *We worked on our group work activity for two minutes only and abandoned the work because we did not understand what to do and we started doing other things like charting. Others were busy reading other books in our group which were not even related to what we were given by the teacher* ***(Lemon Secondary School)***.

This was particularly true because when group members lost track of the meetings purpose, discussions often wandered off in many directions at once and degenerated into off-task or social conversations.

Teachers often gave inappropriate group activities to pupils. This was also observed by one pupil who said that;

> *We did not understand what was supposed to be done as a result we just started copying from the textbook* ***(Lemon Secondary School)***.

The problem here is that the group had trouble starting and ending, making decisions, moving on, reaching consensus and staying on the task. One possible explanation is that the group was unclear or overwhelmed by the task given to them by the teacher.

Despite the fact that pupils liked group work because they were free to ask their friends for clarification, 4 teachers thought that group work was usually not effective. One teacher expressed the following sentiment:

> *The groups were just too big . I did not divide them well this could have contributed to pupils 'lack of understanding* ***(Orange Secondary School).***

Moreover, one pupil was against the use of group work during lessons and had this to say:

> *In our group we were just copying from the textbook without understanding the stages of mitosis* ***(Mango Secondary School).***

8 teachers also had negative comments about the teacher explanation discourse pattern citing lack of feedback. This sentiment came from one teacher who said that:

> *The lecture method fails to provide teachers with feedback about the extent of pupil learning* ***(Guava Secondary School)***.

Another teacher said that:

> *When the teacher is explaining, pupils are often passive because there is no mechanism to ensure that they are intellectually engaged with the material* ***(Lemon Secondary School)***.

This view was supported by another pupil who said that:

> *Information tends to be forgotten easily when we just remain silently listening to our teacher* ***(Guava Secondary School)***.

The non-availability of teaching materials as well as their use in classrooms despite being inadequate had effects on the learning of pupils. One teacher had this to say:

> *The inadequate charts had an effect on pupils because charts were not as many as to meet all the learners. A lot of pupils were sharing one chart thereby crowding at one point* ***(Orange Secondary School)***.

Another teacher, who accepted that teaching materials had an effect on learning, had this to say:

> *I did not prepare enough specimens for the pupils to see so there was congestion as pupils crowded the few stations where specimens were displayed. Other pupils were simply asking their friends without checking on the few specimens due to limited space of viewing the specimens on display* ***(Mango Secondary School)***.

Some pupils also observed that some charts were not good enough. One pupil had this to say:

> *The drawings on the charts were not very clear. We did not understand anything from the chart* ***(Lemon Secondary School)***.

This shows that some teachers brought to class poorly prepared charts which ended up confusing pupils.

Fast presentation of lessons was reported as one of causes of lack of understanding during the teacher presentation discourse pattern. This was reported by one pupil who said that:

> *The teacher was too fast for me as a result I did not understand the names of the living organisms clearly* ***(Lemon Secondary School)***.

Other pupils attributed the lack of understanding to lack of cooperation among the pupils in their group work assignments. One pupil had this to say:

> *I failed to understand some of the things because of lack of cooperation and a little bit of noise in our class* ***(Guava Secondary School)***.

This indicates that pupils were not very helpful to each other in their groups as a result they ended up making noise during the group work activities.

The classrooms were noisy as was reported by the previous speaker who cited lack of cooperation in groups. Other pupils attributed lack of understanding to overcrowding in classrooms as was observed by one pupil who said that:

> *There was too much overcrowding in the class and the teacher's explanations were not very clear* ***(Mango Secondary School)***.

Other pupils thought that biological terms were difficult to understand. This was reported by one pupil who said that:

> *The biological terms which the teacher used in today's lesson were difficult for me to understand* ***(Lemon Secondary School)***.

Another pupil said that:

> *Most of us did not understand anything and we did not even participate in the lesson. The teacher was not even explaining some of the terms which we did not understand* ***(Mango Secondary School)***.

One teacher accepted this challenge of biological terms and had this to say:

> *This topic is very challenging, the words are difficult to pronounce. The names are difficult to pupils as a result some pupils did not see any sense in classification of living organisms* ***(Orange Secondary School)***.

Another pupil who was in support of the teacher's view on the challenges of biological terms had this to say:

> *The terms are too difficult to pronounce even remembering is difficult, even our teacher does not pronounce them nicely* ***(Guava Secondary School)***.

Furthermore, due to the high number of biological names in classification of living organisms, some teachers confused information as was reported by one teacher who said that:

> *I mixed up ideas when I started the lesson. I only got courageous as the lesson progressed. I made some wrong explanations at first* ***(Mango Secondary School)***.

Teachers used group work to describe the stages of mitosis and meiosis. Some pupils still did not understand the stages of cell division. One pupil had this to say:

> *I cannot explain the stages unless, I spend a lot of time reading on my own. That is when I can describe the stages of cell division* ***(Mango Secondary School)***.

The stages of cell division starting from interphase to telophase confused a lot of pupils. This was reported by many pupils. Some of their views are as follows:

> *I had difficulties in explaining the stages of mitosis and meiosis, I failed to remember anything on the stages immediately after learning the stages* ***(Mango Secondary School).***

This was echoed by another pupil who said that:

> *I did not understand some of the stages of meiosis. I cannot even differentiate between the first meiotic division and second meiotic division* ***(Lemon Secondary School).***

Some teachers failed to clarify issues in class leaving pupils wondering. This was observed by one pupil who said that:

> *The teacher did not clarify whether there are just two kingdoms namely plant and animal kingdom* ***(Mango Secondary School).***

The teacher did not clarify to the pupils that the syllabus only emphasised plants and animals and not any other of these living organisms.

During the teacher led discourse pattern, low level questions were used by teachers. This was observed by one pupil who said that:

> *Our teacher asks simple questions which are not even found in past exam papers when he is teaching us. Therefore, I have been finding it difficult to answer questions in past exam papers* ***(Orange Secondary School).***

This simply indicates that most teachers did not have a strong understanding of the topics as they frequently used low cognitive-level questions to control classroom conversations.

4.4.2 Positive effects of the discourse patterns used during lessons on perceived difficult topics in biology

The discourse patterns used also had positive effects on pupils' learning of topics perceived to be difficult. Enhanced understanding during lessons on perceived difficult topics was

caused by listening to peers, mind capturing introductions and proper organisation of group work.

Discussions in groups also helped some pupils to master the work easily. Pupils developed their understanding through listening to peers. This was shown by one pupil who said that;

> *I will be able to understand if my fellow pupil explains to me. There were a lot of new terms coming from the teacher, so I did not understand anything I am just waiting for some of my friends who understood the topic to explain to me* ***(Mango Secondary School)***.

Group work helped the most able students to support those who were less able. Group work also helped learners to develop their verbal skills in reasoning and justification.

Good introductions captured the minds of pupils. One pupil had this to say:

> *I was able to follow the lesson properly because the introduction captured my attention* ***(Lemon Secondary School).***

This was also supported by another pupil who said that:

> *The introduction of the lesson was interesting and the explanations were very clear, as a result I was able to follow the lesson nicely* ***(Guava Secondary School).***

For introductions to be interesting, teachers strived to show pupils different types of teaching aids. This was reported by one pupil who said that:

> *During the introduction the teacher brought different plants small and big and we got very interested in the lesson* ***(Orange Secondary School).***

The use of various teaching materials that were relevant to the lesson made pupils interested. This was made clear by one pupil who said that:

> *I got very much interested in the lesson because the teacher brought a lot of teaching materials which were related to the lesson (****Lemon Secondary School****).*

Pupils still maintained that they were comfortable with group work as was reported by one pupil:

> *We don't understand everything when the teacher is explaining. We need to consult from friends in groups in order to understand* ***(Mango Secondary School).***

Working as a group gave pupils opportunities to examine different aspects of living organisms as was observed by another pupil who had to this to say:

> *Group work allowed us to explore different avenues of knowledge on living things and reasons why they are grouped in their respective kingdoms* ***(Orange Secondary School).***

This was supported by another pupil who said that:

> *Only the introduction of group discussions and the contributions from my friends made me understand* ***(Guava Secondary School).***

This view of group discussions was held by another pupil who said that:

> *I understood everything through discussion in groups by the pupils and the good explanations from the teacher* ***(Lemon Secondary School).***

4.4.3 Summary on the effects of discourse patterns used by teachers

The negative effects of discourse patterns used by teachers when teaching topics perceived to be difficult included; lack of understanding due to inappropriate group activities, negative effects of group work, negative effects of lecture method, inadequate teaching aids, poorly drawn charts, inadequate cooperation among pupils, noisy classrooms and overcrowding, numerous difficult biological terms, inadequate explanation of stages of mitosis and meiosis, non-clarification of issues and use of low level questions.

The positive effects of the discourse patterns used by teachers during lessons on topics perceived to be difficult in biology included; enhanced understanding due to listening to peers, mind capturing introductions and well organised pupil to pupil activities

In section 4.4, I have presented findings on the negative and positive effects of discourse patterns used by teachers when teaching topics perceived to be difficult in biology. In section 4.5, I will present findings on what could be done to enhance the teaching of topics perceived to be difficult in biology in order to facilitate pupil's understanding.

4.5. Question 5: What could be done to enhance the teaching and learning of topics perceived to be difficult in biology in order to facilitate pupils' understanding?

During post-lesson interviews, participants (teachers and pupils) suggested several ways they thought would enhance the teaching of topics learners found challenging to understand. I first present teachers' views and then pupils' views regarding enhanced learning.

4.5.1 Teachers' suggestions on how to enhance pupils' understanding of topics perceived to be difficult in biology

1.1 Motivation

One teacher proposed that there was need to develop interest in pupils in topics perceived to be challenging to learn and said that;

> *Pupils can only learn effectively if they are motivated to learn. Very little learning can occur if pupils are not motivated* ***(Mango Secondary School).***

Motivation is the most important factor that teachers should target in order to improve learning. This was observed when pupils were motivated they became attentive and they started working on tasks and asking questions.

1.2 Incorporation of practical activities

One teacher suggested that lessons perceived to be difficult should include practical activities and said that:

> *I would make it more practical and allow pupils to make models of cells at each stage using plain papers, cotton threads and glue. I would also use videos on mitosis if available* ***(Lemon Secondary School).***

1.2 Use of a variety of teaching aids

Employing different kinds of teaching aids was also suggested to be one way of improving pupils' learning of some of the topics thought to be difficult to learn. In this regard, one teacher said:

> *There was need to bring more teaching aids for pupils to see, but I was unable to bring a lot of teaching aids to the classroom due to lack of teaching aids in the school, this in itself disadvantaged the pupils* ***(Guava Secondary School).***

Another teacher who was in support of the teaching aids also had this to say:

> *I would provide more charts and also put pupils in pairs to avoid a lot of pupils using one chart* ***(Lemon Secondary School).***

One teacher regretted having taught a lesson without practical examples and he had this to say:

> *I should have improved my lesson by providing good practical examples, this could have enhanced pupil's understanding* ***(Orange Secondary School).***

Other teachers supported the use of pictures and videos during lessons involving mitosis and meiosis. One teacher had this to say:

> *I would make sure that each pupil had a picture showing all the stages of mitosis as this could have helped my pupils to understand mitosis and meiosis* ***(Mango Secondary School).***

The use of Power Point presentations was also mentioned by teachers and one had this to say:

> *I would give the pupils Power Point presentations on mitosis and meiosis because it was difficult for me to draw diagrams on the board* ***(Lemon Secondary School).***

1.4 Use of worksheets

Other suggestions which came out from the teachers, on the improvement of the teaching of topics perceived to be difficult in biology included the use of work sheets. One teacher had this to say:

> *I should prepare worksheets and reduce on the number of pupils in groups, this could have enabled my pupils to follow the lesson easily* ***(Guava Secondary School).***

1.5 Increase time for questions

When one teacher was asked on how he would improve his lessons he said:

> *I would give them more time to ask questions about the topic as well as giving them work cards instead of writing on the board* ***(Mango Secondary School).***

This simply indicates that teachers do not give their pupils chance to ask questions where they are not clear.

4.5.2 Pupils' suggestions

Pupils also echoed the use of videos in lessons. This came to light when one pupil said that:

> *We need to have videos of mitosis and not just stationery pictures, we can understand cell division if it is shown to us in motion pictures* ***(Mango Secondary School).***

2.1 Use of practical work

Other pupils emphasised the use of practical work. This was reported by one pupil who said that:

> *We need more practical work and more specimens in our groups for us to see, demonstrations by the teacher are not enough for us to understand we need to do the practicals ourselves* ***(Lemon Secondary School).***

This idea was supported by another pupil who said that:

> *The size of groups should be reduced and more work sheets given to pupils, because when we are so many in the groups some of us do not even participate* ***(Guava Secondary School).***

One pupil was more particular with the diagrams drawn by teachers and had this to say:

> *Teachers must draw diagrams properly on mitosis which they give us in our groups to discuss, because the diagrams which were drawn by the teacher were a bit confusing to me* ***(Lemon Secondary School).***

2.2 Need for field trips

Classification is more interesting when it is taught outside the classroom right among the organisms. This was reported by one pupil who said that:

We need to go out in the environment and watch for ourselves the living organisms not just listening from our teacher ***(Guava Secondary School).***

However, some pupils suggested that:

The teacher should bring real organisms to show us in the classroom during lessons on classification of living organisms, we need to see the spiders, grasshoppers and many more small organisms and not just drawings of these organisms ***(Mango Secondary School)***

2.3 Giving a variety of examples

One pupil thought that the teacher brought out a lot of examples on classification of living organisms and had this to say:

The teacher should consider using only a manageable number of examples so that we can have time to master them rather than giving us a lot of examples on classification of living organisms. This tends to confuse us ***(Mango Secondary School).***

2.4 Provide more time

Some pupils wanted more time to be allocated to the teaching of cell division. One pupil had this to say:

I need a lot of time just learning this topic for me to understand. This topic of mitosis is very challenging to me so the teacher should spend some good time teaching this topic ***(Lemon Secondary School).***

This idea was also supported by another pupil who said that:

Mitosis should be taught more than once. The teacher should teach this topic again for some of us to understand ***(Orange Secondary School).***

2.5 Give work to pupils to do outside lessons

Some pupils were in support of the homework policy and one pupil had this to say:

The teacher should give us this work so that we go and do it from home and then we come and present our findings to our friends ***(Mango Secondary School).***

Another pupil had this to say on homework:

The teacher should just give me an assignment so that I can do research on my own, because I failed to understand when he was explaining in class ***(Lemon Secondary School).***

2.6 Peer teaching

Other pupils wanted their fellow pupils to explain to them some difficult aspects of the topic and one pupil had this to say:

I will be able to understand if my fellow pupil explains to me. I failed to understand the terms which the teacher was using ***(Mango Secondary School).***

This was supported by another pupil who said that:

I need somebody who has understood this topic to teach me, I had difficulties understanding the topic when the teacher was teaching ***(Orange Secondary School).***

When asked how best they could learn mitosis some pupils suggested that they wanted discussions amongst themselves and one pupil had this to say:

We can only learn mitosis properly through discussions among ourselves and not just depending on the explanations from the teacher ***(Guava Secondary School).***

2.7 Reduction of class sizes and rotation of teachers

One pupil thought that they were so many in the classroom and had this to say:

Learning can only improve in this class by reducing the number of pupils and also by changing the teacher, our teacher does not know how to teach that is why most of us failed to understand what he was teaching ***(Lemon Secondary School).***

Some pupils were not comfortable with their teachers. However, one pupil who was against changing the teacher had this to say:

We as pupils we need to concentrate very much as the teacher is teaching we need to pay attention. We should not only blame the teacher for not understanding what he is teaching ***(Mango Secondary School).***

4.5.3 Innovation

In order to come up with a solution to the teaching of difficult topics in biology the researcher looked at the proposals which were advanced by both teachers and pupils and then developed a discourse engagement reference manual which was based on the data generated by this study to improve the teaching and learning of topics perceived to be difficult in biology in order to facilitate pupil's understanding.

1.1. Discourse Engagement In Biology Classrooms (DEIBC): reference manual

This manual on discourse engagement in biology classrooms has been developed to help teachers of biology use strategies in their classrooms which will enhance achievement in biology. The Discourse Engagement In Biology Classrooms (DEIBC) instructional strategies address both oral and written discourse. The development of the DEIBC is especially timely for two reasons, firstly, Matsubara (2010) has revealed that schools in Zambia struggle to provide science apparatus needed for practical activities and he suggested that educational development in Zambia and Africa at large should focus on verbal scientific interaction which does not require materials. Secondly, there is need to develop a scientific discourse which will improve classroom interaction between teachers and pupils. The DEIBC reference manual considers oral and written discourse as important aspects of biology lessons to increase pupil's understanding. This is because learning science through oral and written discourse has been largely ignored (Hand *et al*, 2003).

The DEIBC was field tested at Lubwe Secondary School and Samfya Secondary School on mitosis, meiosis and classification of living organisms. Five lessons were observed and ten pupils as well as five teachers were interviewed to determine ease of use and trustworthiness of the manual. It was discovered that the DEIBC promotes discourse through questioning and enhances pupil to pupil discussion. The DEIBC assists the teacher in identifying pupil's prior

knowledge, this is because learning cannot be isolated from what pupils already know and that pupil's conceptual knowledge is influenced by everyday experiences with natural phenomena and events (Das, 2013). Therefore teaching and learning should assess pupils' prior knowledge and instructions modified based on pupils' prior knowledge.

The DEIBC is divided into 3 phases namely the introductory phase, the main lesson phase and the conclusion phase as shown in Appendix I.

1.2 DEIBC promotes enhanced understanding of topics perceived to be difficult in biology

After implementing the DEIBC reference manual at two secondary schools, some of the pupils who participated in the focus group discussions after the lessons had this to say:

> *I followed the lesson very well and it was easy for me to understand the stages of cell division due to the well organised group work which was given to us by the teacher.*

On introduction one pupil had this to say:

> *The introduction made me become interested in the lesson because it reminded me of mitosis. So I easily connected mitosis to meiosis.*

Another pupil had this to say:

> *The teacher gave us lesson objectives during introduction, so I easily followed the lesson from one objective to the next.*

On the use of different teaching methods one pupil had this to say:

> *The teacher used different methods of teaching classification of living organisms which was good to me because I enjoyed the lesson. Previously our teacher was just explaining without involving us.*

On the stages of cell division one pupil said that:

> *The work which was given to us by the teacher was very helpful because I could easily describe the stages of mitosis from the diagrams which were provided by the teacher.*

Another pupil had this to say:

The teacher explained all the stages in summary form towards the end of the lesson. This made me remember most important points I forgot during the lesson.

On classification of living organisms, one pupil had this to say:

This is when I have known that algae belongs to kingdom Protista and not kingdom plantae and that protozoa also belong to kingdom Protista instead of kingdom Animalia.

Another pupil had this to say:

I have now known that Plant Kingdom is wide, we were just learning about monocots and dicots. I did not know that we are even supposed to look at bryophytes, ferns and mosses.

Another pupil had this to say:

The teacher prepared the lesson very well because he even brought different types of plants to show us.

On questioning techniques one pupil had this to say:

The teacher gave us enough time to think about answers when he asked us questions. The teacher did not answer his own questions like before, when we wasted time to answer his questions.

Another pupil had this to say:

I enjoyed the lesson today because the teacher asked questions which required us to explain instead of just saying yes or no.

On lesson conclusion one pupil had this to say:

The teacher summarised all the points at the end of the lesson which was good because it assisted me to remember what I had forgotten during the lesson.

The teachers who participated in the implementation of the DEIBC had this to say:

This manual is very useful because it guided me on what to avoid during my lesson presentation.

Another teacher made the following observation:

The manual is very important because it is easy to follow and is very brief and clear.

On the layout of the manual one teacher had this to say:

I enjoyed the lesson presentation because I knew what to do during the introduction, the main body and the conclusion.

Another teacher had this to say on pupil interest:

My pupils enjoyed the lesson very much because they were given clear instructions during group work.

Another teacher had this to say:

The DEIBC has indeed helped me to structure my lesson from the known to the unknown.

Another teacher had this to say:

The DEIBC is very helpful it should even be given to non –biology teachers as well so that they can improve their lesson delivery.

Another teacher had this to say:

It is important that a workshop is organised at our school so that we are taught how to implement the DEIBC.

On interventions one teacher said that:

There is need to come up with a manual of interventions on other topics. The interventions on mitosis, meiosis and classification of living organisms really guided me on how to plan my lesson.

1.3 Intervention

Five teachers were guided on the use of DEIBC based on five interventions on mitosis, meiosis and classification of plants, animals and Protista. The block diagrams in appendix K, L, M, N and O were given to teachers to act as a guide to pupils' group work and subsequent question and answer sessions during lessons on the perceived difficult topics.

4.5.4. Summary on enhancement of the teaching of perceived difficult topics in biology

Suggestions which came from the teachers on the enhancement of teaching perceived difficult topics in biology included; motivation, incorporation of practical activities, use of a variety of teaching aids, use of pictures and videos, use of worksheets and increased time for questions during lessons. Suggestions which came from the pupils included; use of practical work, need for field trips, giving a variety of examples, providing more time for perceived difficult topics, giving pupils homework, peer teaching and rotation of teachers. Based on these findings from teachers and pupils a DEIBC reference manual was devised in order to enhance pupils' understanding.

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.1 Introduction

This chapter discusses the findings of the study. The discussion will be done under the following four themes: classroom discourse patterns of lessons on topics perceived to be difficult in biology; how teachers of biology arrive at the choice of discourse patterns they use for teaching topics perceived to be difficult; effects of discourse patterns used by teachers of biology on pupil understanding and proposals from teachers and pupils for improving learning of some topics perceived to be difficult in biology.

5.2 Discourse patterns used during lessons involving topics perceived to be difficult in biology

The discourse analysis of the teaching and learning patterns suggests that all the 11 transcribed lessons were mainly conducted through teacher-led discourse, where teacher-explanation and interrogations of the pupils' knowledge and understanding was the most common form of classroom interaction.

The excerpts reveal the extent to which the classroom discourse was made up of teacher explanation, question and answer sessions. This is consistent with Beccles (2012) who revealed that science teachers spent most of their lesson time on science instruction, whole classwork and teacher presentation sessions but very little on independent work, practical activities and discussion. Teachers would often ask closed-ended questions requiring recall and the response of a single word. Such questioning and pupils answering took up nearly half of the lesson time.

Beccles (2012) further discovered that science teachers stressed recall of factual knowledge rather than eliciting high order cognitive processes and conceptual, procedural and Meta-cognitive dimensions. Individual pupils were not usually volunteering for turns but were called on by the teacher and then they stood up to answer. Teachers' feedback on responses was rare even where individual pupils were concerned, offering few opportunities for ideas to be developed or examined from other angles. The lack of an explicit feedback move prohibited any systematic build-up on pupils' answers that were often limited to a few words.

Because of the dominance of whole class teaching, tasks were usually undifferentiated in respect of ability and the teacher monitored mostly from the front. Pupils spent a great deal of time listening to the teacher explaining.

In the case of an individual answering, pupils did not bid to answer but were nominated by the teacher. Teachers would also ask questions and provide an answer, thereby further closing down opportunities for more exploratory forms of questioning.

Introductions and conclusions were teacher-led and very brief. The main phases of the lessons were usually combining teacher-explanation with short periods of question and answer this is consistent with (Good & Brophyl, 1997). The lessons appeared to be going over previously taught material, rather than developmental in nature to ensure progression in learning. Most of the learning tasks put a strong emphasis on factual, propositional knowledge (knowing -what) rather than procedural knowledge (knowing- how).

The lesson introduction provides interest and motivation to the students. It focuses students' attention on the lesson and its purposes. It also convinces students that they will benefit from the lesson. In this study lesson introductions were mainly dominated by the teacher-led discourse pattern where teachers asked pupils closed-up questions which required recall of simple facts such as definitions of biological terms. For example, during one lesson on

classification of living organisms, the teacher asked two questions which just required ‘yes’ or ‘no’ as the answer. This did not assist in developing the concept of classification of organisms by merely asking pupils whether animals have cell walls or not and whether plants have cell walls or not.

In some cases, the teachers asked questions which were not related to each other as a result pupils failed to predict the direction of the lessons. During some lessons, teachers asked questions which did not have appropriate responses, which made pupils provide irrelevant answers. This simply indicates that questions should be clear to pupils for them to come up with scientific answers. These introductions did not motivate pupils because they did not promote pupils’ understanding through cognitive reasoning. Some lesson introductions were not appropriate, as pupils kept wondering what they were going to learn. This was evident when teachers kept on asking uncoordinated questions. In some lessons teachers started by dividing the classes into groups without brainstorming on the topic to be delivered, thereby closing down opportunities of finding out pupils’ prior knowledge on the topic to be taught.

During some lesson introductions, pupils were highly motivated to construct knowledge because teachers linked the lessons to pupils’ prior knowledge. This is consistent with Good and Brophy (1992) who claim that construction of knowledge goes more smoothly when learners can relate new content to their existing background knowledge. In some lessons on meiosis, the teachers moved from the known to the unknown by developing the concept of mitosis which pupils had learnt earlier. This was good as it led to the introduction of meiosis appropriately. This is in line with the claim by Das (2013) that before giving the lesson the teacher needs to know the pupils’ previous knowledge. This is to know the background of the class and thus to prepare ground for developing the present lesson. Through proper questioning, the teacher should acquire understanding of the previous knowledge of the pupils and then introduce the lesson linking it with their previous knowledge. This is also

supported by the input component of the transaction model developed by Huitt (1995) which covers qualities or characteristics of teachers and pupils that they bring with them to the classroom experience such as previous knowledge about the subject matter. However, in other lessons on meiosis, teachers started by asking pupils questions on the two types of cell division and straight away introduced meiosis without linking it to mitosis which the pupils had already covered.

Some teachers started their lessons by showing pictures of animals before introducing lessons on classification of living organisms. This coincides with Cimer (2004) who claims that teaching biology through visual materials and tools helps learners retain biological knowledge for a long time and, therefore, remember or recall the information much easily. This motivated pupils very much as they eagerly waited for the full lessons to be unveiled. Other teachers started by telling stories about plants and animals which also made pupils attentive. Some teachers brought out real objects and asked volunteers to classify them before introducing the classification of living organisms. In the last lesson, the teacher brought out the concept of classification from the pupils by displaying a lot of items on the table and asked pupils to classify them in any order. A few pupils stood up and classified the items in accordance with the features they thought were similar. When it came to defining classification of living organisms pupils easily brought out the fact that classification is the grouping of organisms according to similar features.

To the contrary, during some introductions of lessons on classification of living organisms, teachers wanted to find out from the pupils the names of some living organisms which pupils suggested as plants and animals. The teachers defined classification without asking pupils to make suggestions. The teachers went on to define taxonomy, kingdom, phylum, class, genus and species without involving the pupils.

The main phases of the lessons were mainly dominated by the teacher-led, teacher-explanation and pupil to pupil discourse patterns. This is the stage of actual giving of the lesson, the time for the teacher to show his/her ability in selecting, organising and presenting the content matter, engage himself/herself in appropriate activities, such as demonstrating, talking, questioning, supervising and also providing activities to the pupils such as observing, helping in demonstrations, doing individual or group practical work. The pupils should be kept busy with one or the other type of activity.

It was apparent from the video evidence that the quality of the classroom interaction was hampered by the lack of teaching resources and textbooks in many of the classrooms. Better quality teaching aids and textbooks would promote more active forms of learning. There was also very little pupil to pupil discussion or collaboration, except when pupils voluntarily helped each other. This confirms findings from Zoller (2000) who asserts that teacher-centred or traditional lessons can be non-productive and in some cases, detrimental to student learning. In addition, Lanier and Little (1986) claim that traditional lessons are less likely to promote conceptual understanding or facilitate conceptual change and thus are less likely to promote the development of technical skills. Therefore, teacher's competencies and knowledge in both biology as a discipline and its teaching are crucial for enhancing pupils' learning. Breaks in this pattern occurred when pupils were called to the front of the classroom, singly, in pairs or as a group, to work on the chalkboard. Pupil presentation took up nearly ten per cent of the lesson time. Teachers also made few movements, remaining at the front of the room for most of each lesson and occasionally venturing between rows to monitor pupils' written work.

Classroom discourse is not effective unless pupils play an active part in their learning. This view of learning suggests that learning does not take place through the addition of discrete facts to an existing store of knowledge, but that one has to relate new information, new

experiences and ways of understanding to ones existing understanding of the matter at hand. One of the most important ways of working on this understanding is through talk, particularly where pupils are given the opportunity to assume greater control over their own learning by initiating ideas and responses which consequently promote articulate thinking. Pupils were mainly expected to be passive and to recall, when asked, what they had learnt and to report other people's thinking.

Pupil to pupil discourse pattern was mostly used by teachers when presenting mitosis and meiosis. This is an example of active learning because pupils share ideas. Although, teacher training programmes advocated a more active pupil-centred pedagogy in place of the traditional pedagogy that upholds learning and memorisation (Das, 2013), it was found that pupil- centred methods were rarely practised or little understood by teachers due to a culturally defined model of pedagogy that had been learned by pupils and students. Therefore, once in the classroom, teachers would teach as they themselves were taught both at school and in the colleges, thereby perpetuating culturally transmitted and deeply internalised cultural influences.

The fact that the teaching and learning in the classrooms observed were mainly conducted in a second language environment may also have added to the ritualised exchanges (Chibesakunda, 1983). This is often achieved by code switching into the mother tongue of the pupils so that it functions as the language of complicity. In other words, rather than having its origins in traditional cultural patterns of interaction, the recitation routines result from the constraint on learning imposed by the requirement to use a foreign language as the medium of instruction.

It was discovered, in other lessons, that despite the syllabus emphasising the diversity of algae, mosses, ferns, corniferous plants and angiosperms, teachers only taught angiosperms.

This was also seen under kingdom animalia where teachers had to ignore the arthropods and concentrated on the phylum chordata. It was very clear from the lessons observed that some teachers taught kingdoms which were not in the syllabus leaving important aspects of kingdom Plantae, Animalia and Protista which were in the syllabus.

Observation of lessons revealed that classification was not taught practically as a result pupils connected classification with the task of memorising a list of biological names. This is in line with the findings of ECZ (2016) where the chief marker reported that pupils failed to use scientific names of locally known plants and animals.

In most lessons where pupils were divided into groups, they did not know what to do in their groups. As a result some teachers asked them to copy from their text books. This confirms findings from prior research (Good, Mulryan & Mc Caslin, 1992; Mc Caslin & Good, 1992) that when small group tasks are poorly designed, students often spend more time carrying out superficial procedures than thinking about the meaning of the task. In some groups one or two pupils were doing all the work while other pupils were involved in undesirable social behaviour. This resulted in teachers monitoring pupil behaviour rather than their levels of understanding or performance of tasks. This coincides with prior research findings (King, 1993; Mulryan, 1995) that some pupils can monopolise small groups just as they dominate whole-class discussions. Regarding this aspect Good and Brophy (1997) argue that unless teachers monitor pupils carefully in groups, teachers may unintentionally create situations in which some pupils within groups have more power and influence than others. This discovery is in line with Paulus *et al* (1993) who established that pupils produce fewer ideas in interactive brainstorming groups than when brainstorming alone. However, many pupils believed that they were more productive in the group brainstorming situation. This is true because working in the presence of others can improve motivation and performance as pupils can share information. This is supported by Blumenfeld (1992) who revealed that pupils

found small-group work more motivating and enjoyable but noted that active learning declined during small group work. Despite this decline in active learning during pupil to pupil discourse, the knowledge of procedures and content that the group possesses is almost always greater than the knowledge of any individual pupil. Therefore, with more knowledge, group problem-solving strategies can be more varied, fine-tuned and powerful. Moreover, pupils learn how to coordinate work with others and how to obtain information from peers.

Despite the small groups providing useful learning experiences for pupils, problems that develop in some group situations may prevent or minimize constructive learning (Good, Mulryan &Mc Caslin, 1992). Moreover, pupils' misconceptions about academic content may be reinforced during small group interactions (Good & Brophy, 1997).

In some lessons pupils wanted to find out the contents of chromosomes, the teachers, without asking pupils to name the contents of the chromosomes, gave out the answer right away. This prevented pupil to pupil discourse. In other lessons teachers did not bother to ask pupils to differentiate vertebrates from invertebrates; this was necessary because it was going to assist the pupils to come up with their own description on invertebrates and vertebrates. Teachers simply explained that animals with backbones are grouped together in one group and those other animals without backbones are grouped in another group. The teachers classified plants into kingdom, phylum, class, family, genus and species without involving the pupils to contribute to the classification. Some teachers even scared the pupils that classification was a difficult topic thereby putting them off the lessons; this was shown by the pupil's lack of interest in the lessons.

In most lessons teachers only called upon pupils who put up their hands to provide answers to questions during the teacher-led discourse, this made other pupils who did not raise their hands to become inattentive. It should be noted that calling on pupils who do not raise their

hands up may increase pupil attention. During some lessons teachers posed questions to the pupils and answered their own questions without giving a little more time to pupils to answer questions. In one lesson on classification of living organisms, the teacher brought out a chart where he had already classified human beings, lions, maize and wolves and asked the pupils to repeat after him the different kingdoms, phyla, genus and species of the organisms which were on the chart. The teacher asked pupils to give examples of kingdoms. After one pupil gave animal kingdom as an example the teacher did not wait for pupils to suggest other kingdoms. He went on and brought out a chart showing all the five kingdoms, their characteristics and examples. This was also noted by Good and Brophy (1997) who advised that waiting a few seconds for one pupil to answer a question may increase that pupil's motivation but negatively influence the interest of another pupil who would like to respond and slow the pace of the lesson for the rest of the class. In another lesson on classification of living organisms, the teacher asked for a mnemonic which could be used to place taxonomy in the correct order. Pupils remained silent then the teacher suggested one mnemonic as follows; Kings Play Chess On Fine Golden Stools where kings stood for kingdom play for phylum, chess for class, on for order, fine for family, golden for genus and stools for species. The teacher then asked pupils to define nomenclature. There was silence in the class, the teacher asked about binomial system of nomenclature. The pupils had already lost interest in the lesson. The teacher again this time around answered her own question. The teacher stated how a scientific name should be written in print and then asked the pupils to state how the scientific name of an organism should be stated in handwritten form. Pupils had different views on this one. However, the only correct view from the pupils was that it should be underlined. The teacher also explained how a generic name of an organism should be underlined separately from the species name.

During the teacher explanation discourse, teachers often began with good attention from pupils but lost it by spending too much time on minor points. Some teachers deliberately prolonged their explanations in order to use them as time fillers. However, variations in teachers' voices and their movements around the class during the teacher explanation discourse helped to refocus attention of the pupils.

In one lesson, on the classification of living organisms, the teacher confused himself when he said that kingdom Monera was the same as kingdom Protoctista. Pupils wrote this incorrect statement in their exercise books without asking the teacher to clarify. The teacher also disputed the fact that bacteria belong to the kingdom Monera. It also seemed as if the teacher and the pupils did not know that kingdom Monera is the same as Kingdom Prokaryonta.

In another lesson on classification of living organisms, the teacher confused pupils in the lesson because he stated that there are only two kingdoms namely; animalia and Plantae. The pupils knew that there were five kingdoms namely Animalia, Plantae, Monera, Fungi and Protista. The teacher did not clarify to the pupils that despite having five kingdoms the 'O' Level Biology School Certificate syllabus stipulates that teachers discuss the animal and plant kingdoms only.

When it came to the identification keys, pupils seemed not to have ideas as a result the teacher described them as a series of statements about characteristics of organisms which if followed will make one identify organisms.

When pupils were asked to name some of the organisms found in Fungi, Protista and Monera, some pupils seemed not to have understood the organisms found in kingdom Protista. Some pupils even suggested that toads were organisms found in kingdom Protista. This made the teacher to stick a chart which had kingdoms and examples of living organisms found there.

The teacher also asked the pupils to place viruses in any of the kingdoms. One pupil suggested that viruses are found in kingdom Monera. This wrong answer made the teacher to state that viruses are not classified in any of the five kingdoms without even giving a reason why viruses have not been classified into the five kingdoms.

Lesson conclusion is a stage in the lesson when the teacher summarises the lesson and evaluates pupil understanding. Home work should also be given to pupils during this stage. A conclusion is an opportunity for assessment and helps the teacher to decide if additional practice is needed or whether the teacher needs to re-teach or move on to the next part of the lesson. The conclusion can essentially help the pupils review, retain and even remember important points in the lesson.

This stage was mainly dominated by the teacher-led and teacher-explanation discourse. Many teachers allowed their pupils to work on their group work activities until the bell ran, thereby neglecting their pupils' closure on what they had learnt. They did not capitalise on the opportunity to effectively wrap things up in a way that could have benefited their pupils' learning. Some teachers concluded their lessons by answering questions from pupils while other teachers concluded their lessons by explaining points which proved difficult to pupils during the lesson. This is in line with Lewis (2018) who established that a helpful activity when closing a lesson is to engage students in a quick discussion about what exactly they learned and what it meant to them.

The best way to end a lesson is to give students some kind of review activity, so that they may see the progress they have made in just one lesson. This allows the teacher to see where the pupils are in terms of knowledge acquisition and thus assist the teacher to plan for the next lesson. In some lessons on mitosis, after group presentations teachers did not allow pupils from other groups to seek clarification from their friends because they thought it was

time wasting. During some lessons on mitosis, a lot of time had been wasted on other biological concepts (other than mitosis) as a result teachers failed to conclude the lessons due to inadequate time.

In other lessons on mitosis, the teachers concluded the lessons by asking pupils to define mitosis and stating some stages in mitosis. Other teachers described the stages of mitosis without giving pupils chance to describe the stages of mitosis. Due to lack of time, some teachers concluded their lessons by giving homework to the pupils on the importance of mitosis. Some lessons on mitosis were not concluded because teachers failed to find time to develop the concepts of metaphase, anaphase and telophase from the pupils. The teachers did not even talk about the importance of mitosis. Some teachers did not give pupils homework and yet homework makes pupils read more on topics to be presented by the teacher in the next lesson. Most lessons on classification of living organisms were not concluded by teachers due to lack of time. This led to pupils being left without homework.

5.3 Choice of discourse patterns used in teaching perceived difficult topics in biology

The choice of discourse patterns depends on a number of factors such as the non-availability of teaching and learning materials, desire to cover more content, engagement of pupils in the lesson, need to relate lessons to real life situations and need to provide concrete examples, skill in managing groups and pupil participation, knowledge of the learners, classroom environment, experience of the teacher and appropriate number of pupils (Das, 2013).

Teachers decide to use the teacher explanation discourse pattern when teaching biology because of inadequate teaching and learning resources to engage pupils in practical activities. This discourse pattern rarely creates interest in pupils and ignores practical activities as well as pupil participation which are essential for biology learning (Ugwuadu, 2011). The teacher explanation discourse pattern was used by teachers of biology to summarise the essential

points of previous lessons and to introduce lessons. The teacher explanation discourse pattern only became effective when it was accompanied by audio-visual aids. Inadequate teaching resources contribute to ineffective teaching methods in secondary schools. This is confirmed by Chifwa (2015) who revealed that teachers of biology experience budgetary constraints to run laboratory practicals as a result they resort to methods which do not involve the use of teaching aids. This is also in line with Nzewi (2008) who recommended that practical activities should engage the pupils in hands-on and mind-on activities, using varieties of instructional materials and equipment to drive the lesson home. This confirms findings from Nachiyunde (2013) who advised that if the objective of teaching science by practical activities is to become a reality, it is necessary that equipment and situations which allow pupils to use their own hands and conduct investigations are identified. In this vein there is need to encourage creativity in teachers to engage in fabrication and improvisation of equipment for hands on activities.

The amount of work to be covered also determines the choice of discourse patterns employed by teachers. Large volumes of work are properly covered by teacher-explanation discourse, where pupils have very little time to ask questions. Teachers held a view that group work was not appropriate for a lot of content which needed to be covered in a short period of time. Other teachers argued that teacher-explanation discourse pattern was very appropriate when the teacher wanted to capture pupils' minds when introducing new concepts. This is contrary to Ugwuadu (2011) who argued that the authoritative discourse pattern affords little or no interaction between the teacher and pupils during classroom activities and, therefore, cannot be helpful in teaching new knowledge. In addition, pupils are not allowed to share ideas and opinions with the teacher. The main task of the teacher is verbal presentation of facts and principles to pupils while pupils remain passive. The choice of teacher-explanation discourse pattern by teachers of biology is in agreement with Behar and Polat (2007) who revealed that

many times teachers use the excuse of the overloaded science curricula to explain their reliance on strictly didactic methods of teaching were they are the only source of knowledge.

The difficult nature of biological concepts as alluded to by Schimid and Teraro (1990) influences the choice of particular discourse patterns. In the case of teaching unfamiliar concepts, Schimid and Teraro (1990) claim that teachers use direct teaching (teacher exposition) discourse pattern because they are of the view that it is the most appropriate way of teaching challenging content.

Other teachers who were against the teacher explanation discourse pattern argued that pupils learn properly if they are involved in the lesson, such teachers were striving for discourse patterns which involved pupils such as pupil to pupil and teacher led discourse patterns. This finding is supported by Viiri and Saari (2006) who revealed that in a biology lesson, the teacher using the democratic discourse pattern in teaching opens up a discourse on a biology problem for students to verbally and freely contribute ideas that could reveal their knowledge and understanding of the problem. There is no restriction to the direction of the discourse. During the lesson, the teacher also gives reinforcement like praises and encouragement to meaningful contributions from the students. Similar sentiments have also been expressed by Onuachu and Nwankonobi (2009) who advised that in the teaching and learning process the teacher should structure classroom activities in such a way that students are allowed freedom to participate in biology classes using a variety of activities, reinforcement and feedback.

Teachers also preferred discourse patterns which linked lessons to real-life examples. This was authenticated by Meyer (1988) who advised that the biology curriculum should be based on an analysis of the local environment and which should focus on a study of local flora and fauna because this will have immediate relevance. Field trips are preferred for the teaching

of classification of living organisms but they are not conducted because teachers feel that they waste a lot of time.

In most cases teachers wanted to use discourse patterns they were very conversant with. Some teachers could not effectively handle pupil to pupil discourse activities as a result they resorted to the use of the teacher-explanation discourse pattern where pupil to pupil discourse pattern was supposed to be used in the lesson. This is because they could not use pupil to pupil discourse pattern effectively. This clearly indicated that the teachers of biology were using discourse patterns which they could effectively handle. Teachers who thought that they were competent in the use of the teacher explanation discourse pattern regardless of its limitations used it instead of employing discourse patterns which they could not use effectively. They did not want to pick on discourse patterns where they had very little to implement. This corroborates with the expectancy of achievement belief component of the modern expectancy-value theory which regards one's capability to be an important influence in decision or choice making (Eccles, *et al,* 1983; Eccles &Wigfield, 2002).

Many teachers opted for the pupil to pupil discourse pattern where they gave pupils challenging work and went round the groups moderating the discussions to make learning successful. In some instances teachers wanted discourse patterns which involved a lot of pupils in the lesson. The desire for teachers to use pupil centred discourse patterns authenticated other studies (Lindquist, 1995; Slavin, 1996; Hesson & Shad, 2007) which found that most teachers apply the pupil centered approach to promote interest, analytical research, critical thinking and enjoyment among pupils. This is the reason why teachers wanted to use pupil to pupil discourse pattern. Other teachers thought that during pupil to pupil discourse a lot of average pupils were assisted by above-average pupils. Still, other teachers thought that pupils could only be involved in the lesson during the teacher-led

discourse where the teacher directed which pupil to talk during the lesson, thereby involving every pupil in the lesson. However, even when the teacher-led discourse is used for this purpose of involving all the pupils in the lesson, one must be aware of the limitations of the discourse pattern as only one pupil is able to answer each question, the danger being that his or her response is mistakenly assumed to be a representative answer (Hughes, 2005).

The use of teacher-led discourse accompanied by pictures and diagrams during mitosis and meiosis proved effective to teachers because they captured pupils' attention and thereby contributed to successful learning. This thinking is in line with Wellington (2004) who advised that instructions should be given using a variety of visual or aural support materials including drawings, diagrams and pictures as support for the spoken words. This is consistent with the recommendation from ECZ (2007) that candidates should be encouraged to draw neat and clear diagrams which are well labelled. Other teachers preferred the use of practical demonstrations by showing pupils specimens and studying their characteristics.

Pupils held the view that teachers picked on discourse patterns where they had very little to do in the class. Pupils described this as laziness on the part of the teachers who liked using the pupil to pupil discourse pattern. This is particularly true because teachers chose discourse patterns which were less involving on their part. This was also seen when teachers were found without lesson plans such that it was difficult to predict their line of action in the lesson (Chifwa, 2015). Lessons were usually haphazard and different unsuccessful discourse patterns were employed by the teachers.

5.4 Effects of discourse patterns on pupils' understanding of perceived difficult topics in biology

Different discourse patterns affect learning in two main ways namely, lack of understanding and enhanced understanding. The discourse patterns which contributed to lack of

understanding among pupils during lessons on topics perceived to be difficult included the following: Inappropriate pupil to pupil discourse activities, despite the successes of pupil to pupil discourse pattern talked about by the teachers, many pupils were not doing anything meaningful during the pupil to pupil discourse pattern. They were usually doing different things other than the work they were given to do. Poorly planned pupil to pupil discourse attracted inappropriate activities. Pupils were usually lost during pupil to pupil discourse because the activities they were given to do were either so simple that pupils finished the work in a short period of time or so complicated that pupils did not know what to do. This disagrees with the good intentions of pupil to pupil discourse as revealed by Okebukola (2004) who found that the peer discourse pattern is a cooperative learning strategy in which students work collaboratively with their classmates in small groups to solve a common problem there by promoting understanding of perceived difficult topics in biology. Pupil to pupil discourse activities were usually designed by teachers who did not even have lesson plans and failed to find appropriate work to give pupils. In some cases pupils were just told to draw diagrams on mitosis. Pupils were usually left with no alternative but to just start copying everything from the few text books they had on their desks. This practice is discouraged by Hughes (2005) who found that pupils spend the majority of time during lessons writing down notes either from a textbook or from the chalk board which does not translate into meaningful learning.

Pupils usually understood very little during teacher explanation discourse because teachers were merely focusing on dispensing rules, definitions and procedures for pupils to memorise without engaging pupils as primary participants in the learning process. Teachers must realise that learning becomes effective when pupils are tasked to perform rather than just asked to remember some information. The need to involve pupils in the learning process is supported by prior research (Al-Rawi, 2013; Franklin, Sayre and Clark 2014; Miles, 2015)

which found that pupils taught in teacher-explanation discourse based classes learnt less than those taught using activity-based discourse patterns. Teacher-explanation discourse is frequently a one way process which is not accompanied by discussion, questioning or immediate practice that makes it a poor discourse pattern. Usually in a teacher-explanation discourse the teacher tells the pupils what to do instead of activating them to discover for themselves. However, this is in disagreement with the good intentions of the teacher explanation discourse as revealed by Berry (2008) that the teacher-explanation discourse is often used to deliver a large amount of information to the students in a short period of time. This revelation was also supported by Gehlen-Bauum and Weiberger (2014) who found that the teacher-explanation discourse is designed to effectively deliver new information to large groups of students.

The teacher explanation discourse made pupils obtain information from the teacher without building their engagement levels on the topics taught. The frequent use of the teacher-explanation discourse was observed as teachers wanted to complete the syllabus without minding whether pupils had understood or not. Teachers were rushing to complete the syllabus as a result most of them were very fast in their presentations making it difficult for the pupils to follow the lessons. This confirms claims by Reece and Walker (1997) that when lessons are presented in a very fast manner pupils fail to follow the lesson therefore learning cannot take place.

The findings indicated that inadequate teaching and learning materials during the teacher-led discourse hinders effective teaching and learning. This situation often made it difficult for teachers to take pupils through practical work. This observation is consistent with prior research (Chibesakunda, 1983; Kapolyo, 1990; Haambokoma *et al*, 2002) which found that pupils do not do much practical work during the time they are learning biology because some schools do not have facilities or materials for practical work such as apparatus and chemicals.

Some schools may have some materials but usually these are not enough for every pupil to have the experience of carrying out a practical activity. Moreover, in some cases classes were large and this made discussion and practical work difficult.

The numerous biological terms during the teacher-explanation discourse on classification of living organisms impacted negatively on the pupils' learning. Pupils believed that the topic was difficult because they failed to memorise the numerous biological terms involved. Mastering stages of mitosis and meiosis was difficult among pupils because lessons involved rote learning with very little attention to securing pupil understanding. This is in line with Schmid and Teraro (1990) who reported that biology is so difficult to teach and learn because it consists of a myriad of unfamiliar concepts involving complex relations. They identified rote learning as the school's favoured approach to teaching unfamiliar material. However, rote learning fails in the face of complex interactions involved in biology. This also confirms findings of Tekkaya, Ozkan and Sungur (2001) who revealed that the difficulties in learning mitosis and meiosis can be attributed mainly to terminology and abstract level of concepts. The biological terminology used in mitosis and meiosis is very complicated and includes many terms such as chromosomes, genes, alleles, chromatids and DNA. Pupils mix these terms and generally memorise these concepts and forget them after some time.

This study has established that teachers usually failed to clarify issues during the teacher-explanation discourse on the kingdoms of living organisms. Most teachers taught the topic without the guide of the syllabus. They taught materials which were not found in the syllabus such as kingdom Monera and Fungi. However, those who followed the syllabus identified only two kingdoms in the syllabus which they were teaching out of the five kingdoms. The syllabus was also confusing because it fused Kingdom Protista into kingdom Animalia and kingdom Plantae by placing algae under plants and protozoa under animals which are the two groups of living organisms under Kingdom Protista.

Enhanced understanding was promoted by the following classroom practices: The study discovered that teacher led introductions affected learning in a positive way. This discovery is consistent with Das (2007) who advised that during lesson introduction the teacher needs to know the pupils' previous knowledge. Through proper questioning, the teacher should test the previous knowledge of the pupils and then introduce the lesson linking it with their previous knowledge. The teacher should introduce a topic of science in an interesting way and make the content presented meaningful so that the learners find their work interesting and do all the activities willingly. It is the responsibility of the teacher of biology to involve new patterns in teaching to motivate the pupils to learn with zeal and eagerness. This advice is in line with Huitt (1995) transaction model whose input factor covered characteristics of teachers and students that they bring with them to the classroom experience such as previous knowledge about the subject matter. This is very important in motivating the pupils when introducing a biology lesson. The use of various teaching aids during the teacher led discourse to introduce aspects of living things by showing real life organisms brought about interest among pupils. However, the availability of specimens did not guarantee effective teaching. It was their skilful handling by the teacher that rendered these teaching aids useful in facilitating learning.

Pupil to pupil discourse also proved effective as was shown by pupils in their responses during the interviews because they were encouraged to search for knowledge rather than the teacher monopolising the transmission of information to them. This is in line with Tynjala (1998) who revealed that a student-centered learning environment seems to produce higher-level learning outcomes more efficiently than a traditional teacher-centered environment. This confirms findings from Adunola (2011) who advises that bias in the selection of discourse patterns by teachers in areas in which they possess exclusive monopoly knowledge should be avoided to improve students' academic performance. Pupils were happy with the

pupil to pupil discourse pattern because they were able to develop social skills through establishing friendships while working cooperatively in groups.

5.5 Proposals for improving learning of some topics perceived to be difficult in biology

Evidence from this study indicated that without motivation from the teachers to the pupils, effective learning cannot take place. A motivated class even participates in the lesson by answering as well as asking questions. This promotes pupil understanding of the perceived difficult topics in biology. This finding is in line with the claim by Das (2007) that an important prerequisite in science learning is motivation, without interest and incentive, learning does not become meaningful. Motivation may, therefore, be said to be the heart of the learning process. The teacher should introduce a topic of biology in an interesting way and make the content presented meaningful so that the learners find their work interesting and do all the activities willingly. It is the responsibility of the science teacher to evolve new patterns in his teaching to motivate the pupils to learn with zeal and eagerness.

Findings indicated that for a lesson to be successful it must incorporate the practical component. Teachers should make available models of stages of mitosis and meiosis made out of simple local materials. Teachers sometimes fail to improvise teaching aids and models when they can easily make their own and make teaching interesting. This observation is consistent with Monk and Osborne (2000) who advised that practical work is one of the hallmarks of science and many educators argue that a science education without practical work fails to reflect the true nature of scientific activity. This has led to a widespread acceptance in many countries of a strong emphasis on pupils doing practical work. There is now a need to examine carefully the purpose of different kinds of practical activities in order to select appropriate strategies for achieving different aims. Theory and practice are

interrelated. Practical work needs essentially to be about thinking; that is about trying to understand the relations between evidence and theory and to stimulate and challenge pupils.

The use of pictures and videos for teaching mitosis and meiosis was supported by both teachers and pupils. Other teachers even hoped to use power point presentations during their lessons to get the attention of pupils. Some pupils were against stationery pictures and wanted moving pictures such as short documentaries of mitosis and meiosis. This corroborates with Wellington (2004) who suggested that teachers should use a variety of teaching aids such as: drawings, diagrams and pictures as support for visual and spoken words. For some practical activities, preferred pictures with words of different stages in an experiment or certain biological processes such as mitosis and meiosis can be given and pupils asked to sequence them correctly and perhaps label them. However, this suggestion differs with Matsubara (2010) who discovered that there was lack of teaching materials in Zambian schools. Therefore, he recommended that lessons should involve verbal scientific interaction which does not require materials.

Some teachers indicated that charts were supposed to be distributed to pairs of pupils so that there was no congestion on the points where charts had been stuck. In addition, other teachers suggested that groups could be reduced and then worksheets distributed to the groups of pupils so that all the pupils are given an opportunity to observe the charts.

Pupils wanted field trips to be incorporated into their lessons on classification of living organisms. They indicated that they wanted to go out into the natural environment and observe for themselves different types of living organisms in their habitats. Pupils revealed that they were tired of listening to their teachers' explanations. Other pupils advised that teachers should labour to bring some organisms to class to show them. This desire by pupils for field trips is supported by Ozcan (2003) who claims that field trips have effective

instructional role to provide students meaningful understanding and consequently higher achievement in biology. Through fieldtrips, the events and the objects that cannot be brought into class are possible to be observed.

Another alternative, which came from the pupils, was that there was need to give a lot of time to topics such as mitosis and meiosis. Some pupils believed that for them to understand the topic the teacher should teach more than once. This proposal by pupils is supported by Reece and Walker (1997) who asserts that lessons should be presented at a slow pace. Usually many teachers of biology would like to present lessons quickly so that they can cover the wide biology syllabus.

The study has shown that pupils were in favour of the homework policy and that they wanted teachers to give them work which they could do at home and then get to class and present their answers to their friends. Some pupils indicated that they needed their teachers to provide work which they could do at home and do research on their own.

Still some pupils maintained that they could only understand classification of living organisms if they listened to their fellow pupils explaining the topic to them. Pupils really expected their fellow pupils to teach them after the teacher had taught the lesson. Pupil discussions were very much liked by the pupils because they were expecting to get a lot of information from their friends. Slower learners benefited very much because they were able to seek clarification from their peers.

Other pupils suggested a reduction in the number of pupils in their classes. They thought that they were unable to learn properly due to the congestion in their classrooms. Other pupils suggested changing their teachers. However, to the contrary, some pupils who never wanted changing of teachers suggested that as pupils they were expected to pay attention during lessons and not just blame the teachers for not understanding the lesson.

The need for adequate opportunities for pupils to ask questions was recognised as one way of enhancing pupils' understanding of perceived difficult topics. This corroborates with Beccles (2012) who advised that teachers needed to use questions to elicit student thinking, regularly invite questions from students and encourage responses from them. Beccles further advised that teacher questions needed to stress a variety of cognitive levels such as: remember, understand, apply, analyse, evaluate and create cognitive processes as well as factual, conceptual, procedural information and meta-cognitive knowledge dimensions. Beccles observed that the quality of student's answers and thinking is a reflection of teacher questions, therefore, the cognitive processes and knowledge dimensions need to be appropriately stressed.

5.6 Innovation emerging from the study

After the implementation of the DEIBC reference manual at two secondary schools it was discovered that well organised group work was very effective in the teaching of cell division. This is in line with Blumenfeld (1992) who reported that students found small group work was more motivating and enjoyable but noted that active learning declined during group work. It was further discovered that lesson objectives enhance pupils understanding of perceived difficult topics. The study further encouraged the use of different teaching methods. This was supported by Adunola (2011) who advised that teachers need to be conversant with numerous teaching strategies that take recognition of the magnitude of complexity of the concepts to be covered. Onuachu & Nwankonobi (2009) also advised that the teacher should structure classroom activities in such a way that students are allowed freedom to participate in biology classes using a variety of activities. The study discovered that the use of diagrams in the teaching of cell division was found to enhance pupils' understanding. This is in line with ECZ (2007) chief examiner's report where it was

emphasised that candidates should be encouraged to draw neat and clear diagrams which are well labelled.

The study revealed that the Zambian syllabus had placed algae under plant Kingdom and protozoa under animal kingdom. However, the implementation of the interventions embedded in the DEIBC reference manual clarified that both algae and protozoa belong to kingdom Protista. It was further discovered that under plant kingdom pupils were only learning about monocots and dicots and that teachers ignored bryophytes, ferns and mosses. The study reported that pupils appreciated very much when they were given time to answer and ask questions. This is consistent with Petty (1993) who emphasised the need for pupils to ask questions because this is a very important part of learning and contributes positively to the learning process. The study further encouraged the use of higher level cognitive questions. This is also supported by Hughes (2005) who reported that skilfully designed questions of a more open-ended nature are more than just an assessment tool and when executed well can challenge thinking and contribute to learning in their own right. Finally, the DEIBC reference manual encouraged lessons to start from the known to the unknown. This consistent with Wellington (2004) who reported that individual lessons must relate to previous lessons, previous knowledge and previous understanding and must connect to future lessons and future learning.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter concludes the study and also makes recommendations based on the major findings of the study. It also includes suggestions for further research.

6.2 Conclusion

The previous chapter presented a discussion of the findings of this study on the nature of discourse patterns used by teachers of biology, the choice of discourse patterns, effects of the discourse patterns and ways of improving lesson delivery on topics perceived to be difficult.

The major findings of this study have revealed discourse patterns used by teachers when teaching aspects of classification, mitosis and meiosis and their effects on pupils' understanding of these perceived difficult topics. The study has shown that lack of understanding is brought about by inadequate explanations, quick presentation of lessons, lack of practical activities and inappropriate group activities.

The study found that three discourse patterns were used during lessons on topics perceived to be difficult. These are: Pupil to pupil discourse pattern, teacher-led discourse pattern and teacher-explanation discourse pattern. The teacher-explanation and interrogations of the pupils' understanding was the most common form of classroom interaction.

The discourse analysis of the lessons has shown that the introductions of the lessons were usually teacher-led and always very brief. During introductions, teachers used closed questions which appeared like going over previously taught material and usually required recall of knowledge. The main phases of the lessons were usually combining the teacher-explanation discourse with short periods of teacher-led question and answer sessions where

teachers sometimes asked questions and provided the answers thereby closing down opportunities for more exploratory forms of questioning.

The study established that teachers asked low level questions during their lessons and that pupils had very little opportunities to ask questions. The predominant mode of classroom talk during question and answer sessions was Triple **A** which is **Ask, Answer, Accept** or Double **A** and then **R** which is **Ask, Answer and Reject.** Teachers could not clarify why the answer given by pupils was correct they simply accepted it to be correct and they never gave a reason to wrong answers provided by pupils they simply rejected the answers. However, this method of teaching encouraged active participation of pupils in the classroom through exchange of ideas with the teacher.

Most lessons on mitosis and meiosis involved pupil to pupil discourse pattern where pupils were divided into groups to either draw or interpret drawings on stages of mitosis and meiosis. Breaks in this pattern occurred when group representatives were called to the front to present their findings. Teachers usually remained at the front of the classroom for most of the lesson time and occasionally moved around the groups to monitor pupils' written work.

It was discovered in other lessons on classification that despite the syllabus emphasising the diversity of algae, mosses, ferns, corniferous plants and angiosperms. Teachers only taught angiosperms. This was also seen under kingdom animalia where teachers had to ignore the arthropods and concentrated on the phylum chordata. It was very clear from the lessons observed that some teachers taught kingdoms which were not in the syllabus leaving important aspects of kingdom Plantae, Animalia and Protista which were in the syllabus. It was also discovered that the syllabus was confusing because it fused algae into plants and protozoa into animals thereby misleading both teachers and pupils. The study also revealed that classification was not taught practically as a result pupils connected classification with a

task of memorising a list of biological names. Conclusions were usually brief and mainly involved the teachers summarising the lessons. Other teachers failed to conclude their lessons due to lack of time.

It was also apparent from the video evidence and the responses from the teachers that the choice of discourse patterns by teachers usually depended on the availability of teaching and learning aids as well as the intelligence levels of the pupils. The teacher's skill in managing groups as well as the content to be taught also informed the choice of discourse patterns to be used. The study also revealed that the desire to cover more content and the need to relate lessons to real life situations by providing concrete examples also influenced the choice of discourse patterns by teachers. Most importantly the findings have shown that the choice of discourse patterns was also guided by factors such as the preparation of the teacher and the number of pupils in the class. The study established that there was no single method which was best suited for all the topics and for all the teachers and pupils.

The study revealed that discourse patterns affected learning either positively or negatively. Lack of understanding was mainly due to inappropriate pupil to pupil discourse activities as well as the teacher explanation discourse where teachers focused on dispensing definitions and procedures for pupils to memorise without engaging them as primary participants. Moreover, it was clear from the findings that teacher explanations impacted negatively on the pupils' retention of knowledge because pupils remained passive without any chance of asking questions.

Enhanced understanding was promoted by good introductions and the use of various teaching aids in lessons to introduce aspects of living things. Showing real life organisms brought about interest among pupils and affected learning in a positive way. Well organised pupil to pupil discussions encouraged pupils to search for knowledge rather than the teacher

monopolising the transmission of information to them. Pupils developed social skills through establishing friendships while working cooperatively in groups. It was clear from the findings that pupils interpersonal skills were enhanced by the pupil to pupil discourse pattern were pupils tackled problems together and made presentations on the work given to them by teachers.

The study proposed that lessons should be introduced in an interesting way so that pupils are motivated to learn with zeal and eagerness. Findings indicated that teachers were expected to start lessons with an interesting, real-life story or question. It was further suggested that the practical component should be incorporated in the lessons and that teachers should make available models made out of simple materials to make teaching interesting. Pupils suggested that a lot of time should be allocated to the teaching of these perceived difficult topics like mitosis, meiosis and classification of living organisms. Pupils further advocated for group discussions as they were able to seek clarification from their peers. Some teachers were for the idea of increasing question time so that pupils were given more time to ask questions and seek clarification on issues where they were not clear.

Furthermore, the study revealed that teachers tried by all means to incorporate the pupil centred methods by involving learners in pupil to pupil discourse. These pupil to pupil discourse activities affected learning in many ways. Pupil to pupil discourse activities were poorly supervised as a result pupils ended up benefiting very little from their peers. However, some pupil to pupil discourse activities which were organised and supervised properly by the teachers benefited the pupils very much by providing a platform where pupils exchanged and shared ideas. The study revealed that pupils supported the use of homework and group discussions because they were free to consult their friends in groups as well as at home.

In addition, the findings have shown that teachers aspired to have their pupils learn. However, the learning styles of pupils differed making it difficult to satisfy all the pupils with one method of teaching. The study found that teachers employed different discourse patterns to satisfy the different learning styles among the pupils.

The findings of the study indicated that teachers proposed that the practical component should be incorporated in the lessons by either improvising teaching aids or models in order to make the lessons interesting. Pupils and teachers advocated for the use of pictures and videos on mitosis and meiosis. It was clear from the findings that pupils wanted classification of living organisms to be taught through field trips where they would come into contact with the environment.

The study also established that teachers were rushing to finish the syllabus due to the bulk biology content. Therefore, it was suggested that the biology content be restructured so that other contents are removed in order to reduce pressure on teachers who teach at a rapid rate to cover the wide syllabus on time. It is believed that reduced content may motivate teachers to use more effective discourse patterns.

Finally, this study has made a contribution to knowledge in biology education by generating what has been called '*Discourse engagement in biology classrooms (DEIBC)'* reference manual which has not been documented anywhere. The field testing of DEIBC with the teaching approach imbedded in it minimised the difficulties pupils experienced and enhanced their understanding of mitosis, meiosis and classification of living organisms.

6.3 Recommendations

In view of the findings above, the following recommendations are made;

1. Teachers should combine the three discourse patterns namely teacher-explanation, teacher-led and pupil to pupil discourse patterns when teaching biology because these patterns proved effective when they were used together during the lesson observations. Teachers should avoid using one discourse pattern during lessons on topics perceived to be difficult because it is monotonous and does not promote effective learning.
2. Workshops and seminars should be organised internally by schools for teachers to enable them acquire skills of teacher-explanation, teacher-led and pupil to pupil discourse patterns for teaching biology.
3. Biological terms must be explained to pupils in a clear way by using the teacher-explanation discourse pattern so that pupils can understand them as they are learning classification of living organisms and cell division.
4. Pupils should be encouraged to draw diagrams on the stages of cell division during pupil to pupil discourse pattern in order to enable them understand stages of cell division.
5. Teachers must use real life examples of living organisms to help classify them into different kingdoms, phyla/divisions, classes, orders, families, genus and species during the teacher-led discourse pattern.
6. Teachers should encourage their pupils to ask questions during the teacher-led discourse pattern.
7. Teachers should ask more open-ended questions during the teacher-led discourse pattern.

6.4 Suggestions for further research

The following areas are suggested for further investigation

1. Research on discourse patterns in Zambia needs to focus on other difficult topics apart from mitosis, meiosis and classification of living organisms.
2. Studies on the improvement of teaching strategies should focus on large class sizes.

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APPENDICES

APPENDIX A

INTERVIEW SCHEDULE FOR GRADE 10 to 12 PUPILS

The interview questions are based on the topics below

(i)Mitosis

(ii) Meiosis

(iii)Classification of living organisms

1. Did you understand what was taught in this lesson?

2. What made you fail to understand what was taught in today's lesson?

3. What effect do you think the strategy used in today's lesson had on your understanding of the topic?

4. How would you learn this topic better?

APPENDIX B

INTERVIEW SCHEDULE FOR GRADE 10 to 12 PUPILS AFTER IMPLEMENTATION OF DEIBC (Reference Manual)

The interview questions are based on the topics below

(i)Mitosis

(ii) Meiosis

(iii)Classification of living organisms

1. How was today's lesson taught?

2. What made today's lesson successful?

3. What should be done to improve today's lesson?

APPENDIX C

INTERVIEW SCHEDULE FOR BIOLOGY TEACHERS

The interview questions will be based on the topics below

(i)Mitosis

(ii) Meiosis

(iii)Classification of living organisms

1. How did you present today's lesson?

2. Why did you present today's lesson the way you did?

3. What effect do you think the strategy you used in today's lesson had on pupils understanding of the topic?

4. If you were to present this lesson again, what would you do differently to improve the lesson?

APPENDIX D

INTERVIEW SCHEDULE FOR BIOLOGY TEACHERS AFTER IMPLEMENTATION OF DEIBC (Reference Manual)

The interview questions are based on the topics below

(i)Mitosis

(ii) Meiosis

(iii)Classification of living organisms

1. How useful was the DEIBC reference manual?

2. How has DEIBC improved your classroom discourse?

3. How can you improve the DEIBC reference manual?

APPENDIX E

LESSON OBSERVATION SCHEDULE

Lesson information

School----------

Subject---------- Grade----------

Topic/ Subtopic----------

Teacher----------

1. **Lesson introduction**----------

   ---
2. **Main body of the lesson**----------

   ---
3. **Conclusion of the lesson**----------

   ---

4. Other comments

(a) Strengths----------

(b) Weaknesses----------

(c) Recommendations:----------

Monitored by---------- Signature----------

Position----------

APPENDIX F

Consent form for School Head Teachers

INTRODUCTION

I am a Ph.D. student in science education at the University of Zambia. I am conducting a study on discourse patterns of lessons on classification of living organisms, mitosis and meiosis. I have picked your school to participate in this study, therefore I am requesting your school to help with data collection by allowing some pupils and teachers to take part in lesson demonstrations, group interviews and one on one interviews.

PROCEDURE

There will be 3 group interview sessions, each of them lasting one hour which will be conducted after observing the lessons on classification, mitosis and meiosis. With your permission, the sessions will be transcribed. Notes will also be written during the sessions.

BENEFITS

You will not benefit directly from taking part in the study. However, this study will help us understand discourse patterns during lessons on classification, mitosis and meiosis

DISCOMFORTS

I do not expect much discomfort from taking part in the lessons and group interviews. However, I will ensure that group interviews are shortened as much as possible.

CONFIDENTIALITY

The name of the school, pupils and teachers will not be published in any report. Instead, false names will be used. In addition, all recorded information and transcripts will be destroyed after all data has been analysed.

RIGHT TO REFUSE OR WITHDRAW

The schools participation in this study is completely voluntary. If you decide to drop out or refuse to take part in the study, there will be no penalty to the school.

CONSENT

I have read this consent form and have been requested that my school takes part in the study and I have given free consent by signing this form. My consent for my school to participate in the study is voluntary and I may withdraw the school from the study at any time if need be. I am also aware that the information participants in this school will provide, will be treated in confidence and the school will not be personally identified.

I also understand that the group interviews will be audio-taped and video-taped. My initials below certify that I agree to have the lessons and group interview audio and video-taped.

I agree to have the lessons and group interviews audio and video-taped

---

Initials

Name of Head Teacher…….

Signature of Head Teacher……...

I acknowledge that I have witnessed the Head Teacher sign this consent form

Name of HOD……..

Signature of HOD…….

Date…….

APPENDIX G

Consent form for teachers

INTRODUCTION

I am a Ph.D. student in science education at the University of Zambia. I am conducting a study on discourse patterns of lessons on classification of living organisms, mitosis and meiosis. I have picked on you to participate in this study. Therefore I am requesting you to help with data collection by teaching classification, mitosis or meiosis.

PROCEDURE

After teaching one of the topics listed above I will interview you one on one. With your permission, the lesson will be audio and video-taped. Notes will also be written during the lesson.

BENEFITS

You will not benefit directly from taking part in the study. However, this study will help us understand discourse patterns during lessons on classification, mitosis and meiosis

DISCOMFORTS

I do not expect much discomfort from taking part in the lessons and one on one interview. However, I will ensure that the interview is shortened as much as possible.

CONFIDENTIALITY

Your name and the name of the school will not be published in any report. Instead, false names will be used. In addition, all recorded information and transcripts will be destroyed after all data has been analysed.

RIGHT TO REFUSE OR WITHDRAW

Your participation in this study is completely voluntary. If you decide to drop out or refuse to take part in the study, there will be no penalty to you.

CONSENT

I have read this consent form and have been requested to take part in the study and I have given free consent by signing this form. My consent to participate in the study is voluntary and I may withdraw from the study at any time if need be. I am also aware that the information I will provide, will be treated in confidence and I will not be personally identified.

I also understand that the one on one interview will be audio-taped and video-taped. My initials below certify that I agree to have the lesson and one on one interview audio and video-taped.

I agree to have the lesson and one on one interview audio and video-taped

---

Initials

Name of Teacher……..

Signature of Teacher……

I acknowledge that I have witnessed the Teacher sign this consent form

Name of HOD……..

Signature of HOD…….

Date……..

APPENDIX H

Consent form for pupils

INTRODUCTION

I am a Ph.D. student in science education at the University of Zambia. I am conducting a study on discourse analysis of classification of living organisms, mitosis and meiosis. I have picked on you to participate in this study. Therefore I am requesting you to help with data collection by participating in group interviews on classification, mitosis or meiosis.

PROCEDURE

After learning one of the topics listed above I will interview you in a group of ten pupils. With your permission, the group interview will be audio and video-taped. Notes will also be written during the interview.

BENEFITS

You will benefit directly from taking part in the study by learning classification, mitosis and meiosis. This study will also help us understand discourse patterns during lessons on classification, mitosis and meiosis

DISCOMFORTS

I do not expect much discomfort from taking part in the lessons and group interviews. However, I will ensure that the group interview is shortened as much as possible.

CONFIDENTIALITY

Your name and the name of the school will not be published in any report. Instead, false names will be used. In addition, all recorded information and transcripts will be destroyed after all data has been analysed.

RIGHT TO REFUSE OR WITHDRAW

Your participation in this study is completely voluntary. If you decide to drop out or refuse to take part in the study, there will be no penalty to you.

CONSENT

I have read this consent form and have been requested to take part in the study and I have given free consent by signing this form. My consent to participate in the study is voluntary and I may withdraw from the study at any time if need be. I am also aware that the information I will provide, will be treated in confidence and I will not be personally identified.

I also understand that the group interview will be audio-taped and video-taped. My initials below certify that I agree to have the lesson and group interview audio and video-taped.

I agree to have the lesson and group interview audio and video-taped

---

Initials

Name of pupil……...

Signature of pupil…….

I acknowledge that I have witnessed the pupil sign this consent form

Name of Teacher…….

Signature of Teacher……

Date……..

APPENDIX I

Discourse Engagement In Biology Classrooms (DEIBC): reference manual

Introductory phase

ITEMS	WHAT SHOULD BE DONE	WHAT SHOULD NOT BE DONE
Accessing pupils' prior knowledge	The lesson should begin with what pupils already know	Lesson begins without determining what pupils already know
Conceptual integration	The teacher assists pupils in connecting new knowledge with prior knowledge	Lessons presented in isolation without reference to previously learned concepts

Main lesson phase

ITEMS	WHAT SHOULD BE DONE	WHAT SHOULD NOT BE DONE
Promotion of discourse through questioning	The teacher asks a question and gives time to pupils to give the response The teacher chooses questions that are likely to challenge pupils cognitively The teacher encourages pupils to provide extended answers which will interest others in the class The teacher asks pupils to raise their hands or to prepare responses in case they are asked The teacher probes pupils wrong responses and resolve misconceptions	The teacher asks a question and provides the answer The teacher asking pupils to recall simple and predictable facts The teacher allowing limited short answers which are of little interest to other pupils The teacher always asking pupils to raise hands when responding to questions The teacher ignoring wrong responses from pupils
Promotion of pupil to pupil discussion	The teacher organizes small groups The teacher monitors pupil participation in groups	No pupil to pupil discussion The teacher gives pupils work in groups without planning and organizing activities

Conclusion phase

ITEMS	WHAT SHOULD BE DONE	WHAT SHOULD NOT BE DONE
Promotion of teacher explanation discourse	The teacher summarises the lesson by explaining the main points of the lesson to pupils	The teacher ends the lesson without summarizing the main points
Assessment of pupils' understanding	The teacher conducts lesson evaluation	The teacher ends the lesson without evaluation
Provision of home work	The teacher gives pupils home work at the end of the lesson	The teacher ends the lesson without giving pupils homework
Provision of next topic	The teacher announces the topic for the next lesson	Teacher ends lesson without announcing next topic

APPENDIX J

Expected knowledge on mitosis, meiosis and classification of living organisms from the biology syllabus (CDC, 2013)

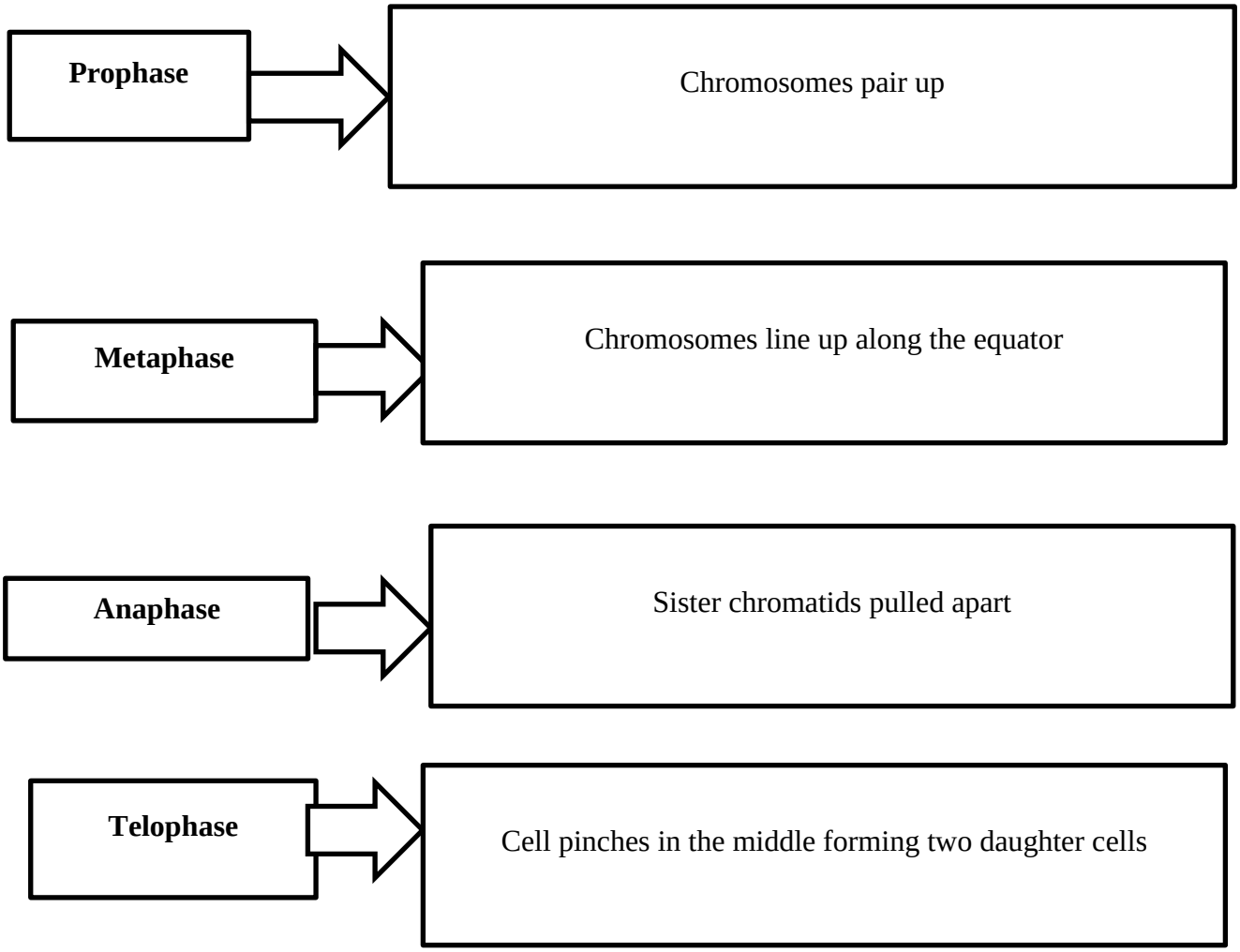
1. Stages of cell division in mitosis and meiosis (Refer to chromosomes and double strand of DNA).
2. Importance of mitosis and meiosis (Refer to growth and reproduction include uncontrolled cell division (cancer).
3. Types of plants- Chlorophytes (algae), Bryophytes (mosses, ferns), Coniferous plants and flowering plants.
4. Types of animals-Reptiles, amphibians, birds, arthropods and protozoa.
5. Simple keys for classification (Refer to dichotomous keys).
6. Identify classes of vertebrates and common invertebrates using simple classification keys.

Source: Curriculum Development Centre, 2013

APPENDIX K

1. Intervention on Mitosis

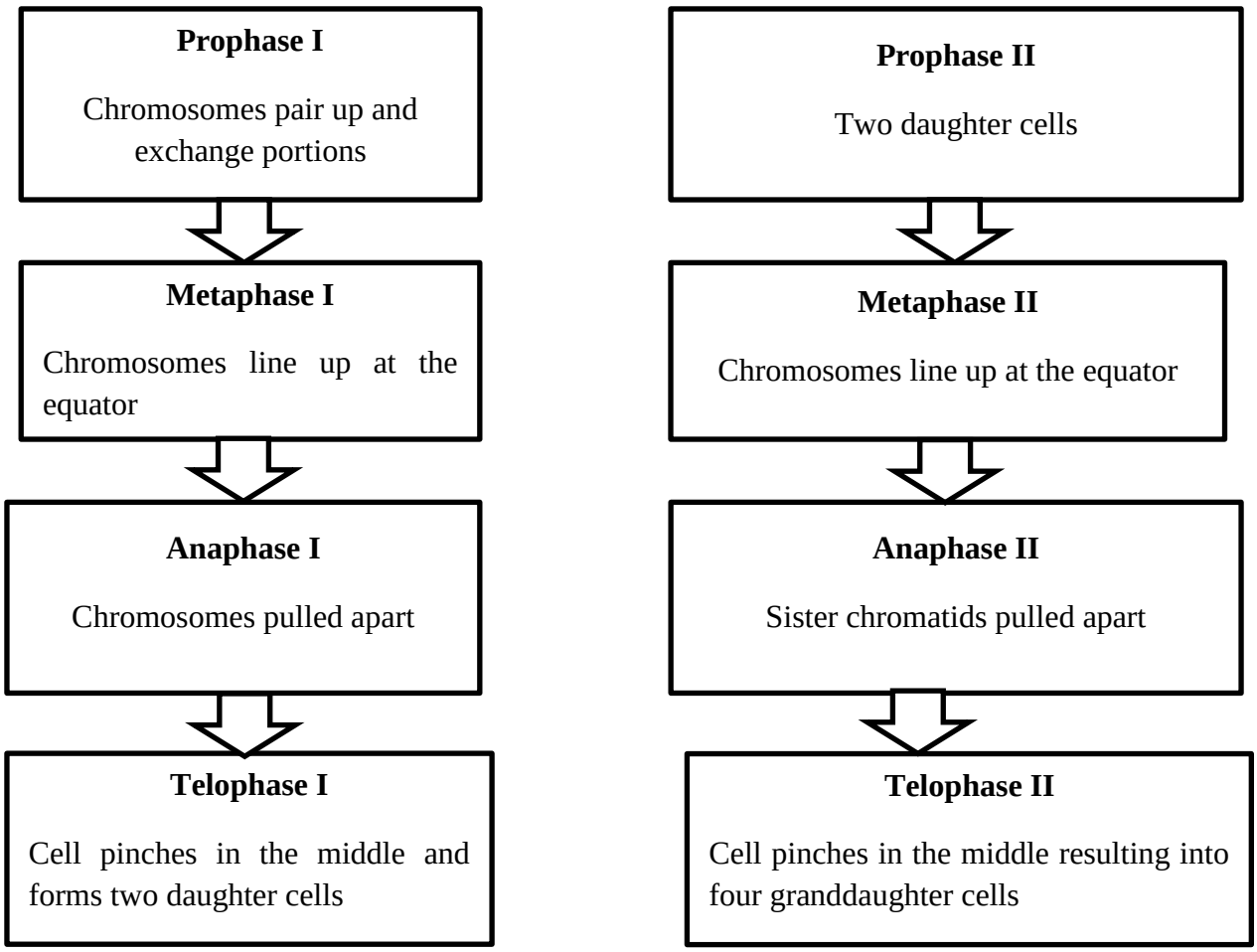
Appendix K shows the intervention which was given to one teacher to prepare a lesson plan on mitosis during the pilot of DEIBC.



APPENDIX L

2. Intervention on Meiosis

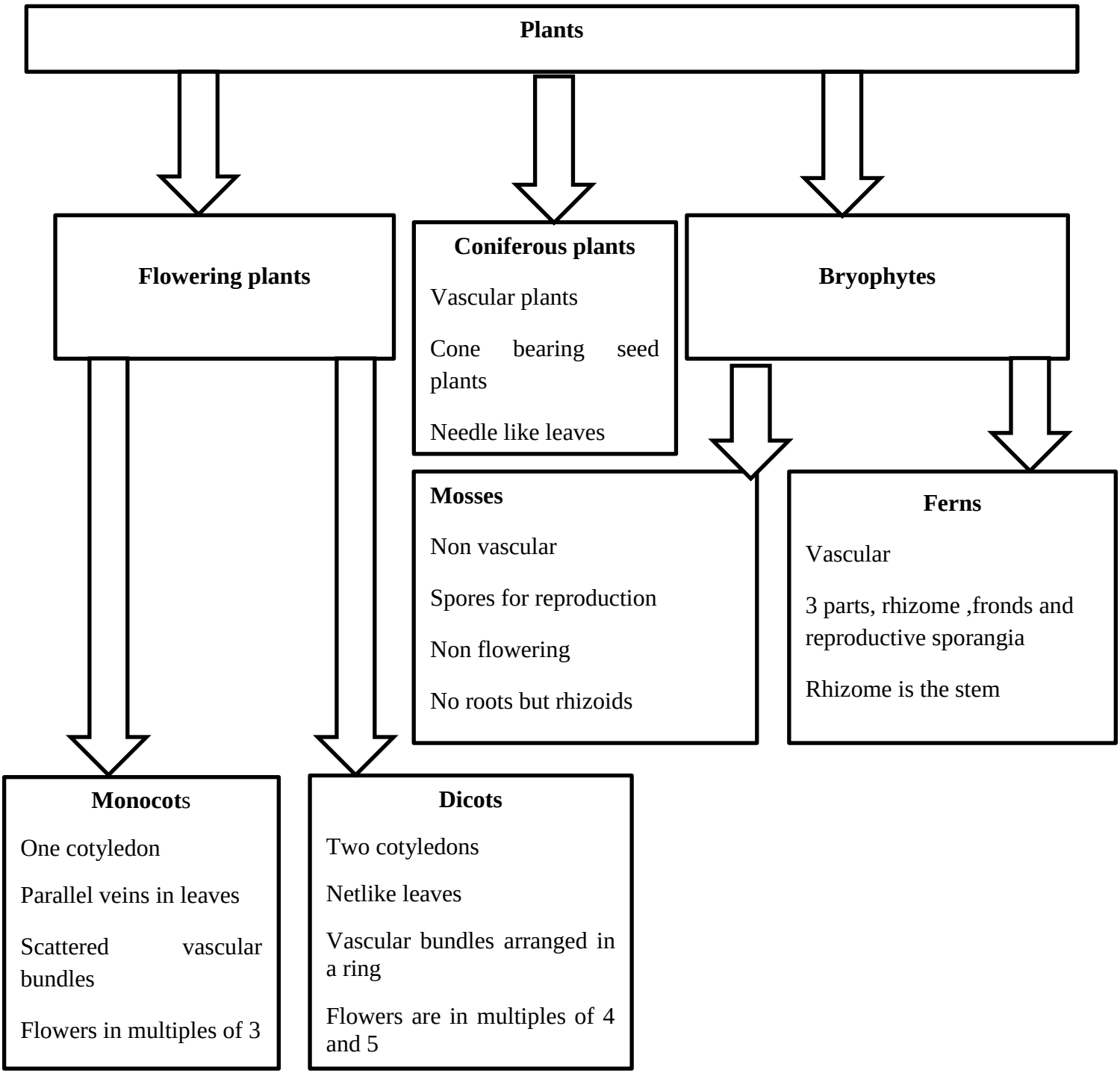
Appendix L shows the intervention which was given to one teacher to prepare a lesson plan on meiosis during the pilot of DEIBC.



APPENDIX M

3. Intervention on classification of plants

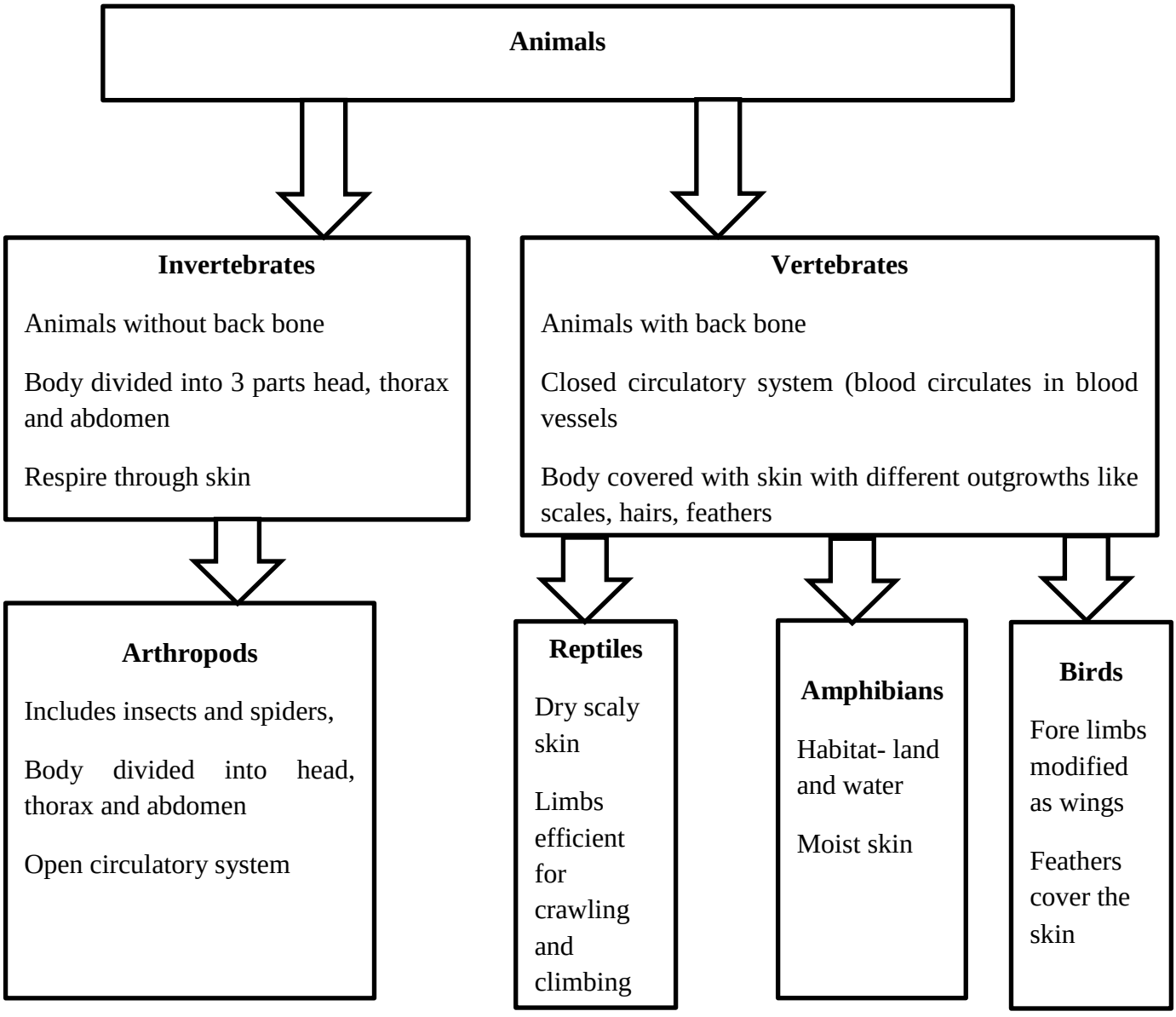
Appendix M shows the intervention which was given to one teacher to prepare a lesson plan on classification of plants during the pilot of DEIBC.



APPENDIX N

4. Intervention on classification of animals

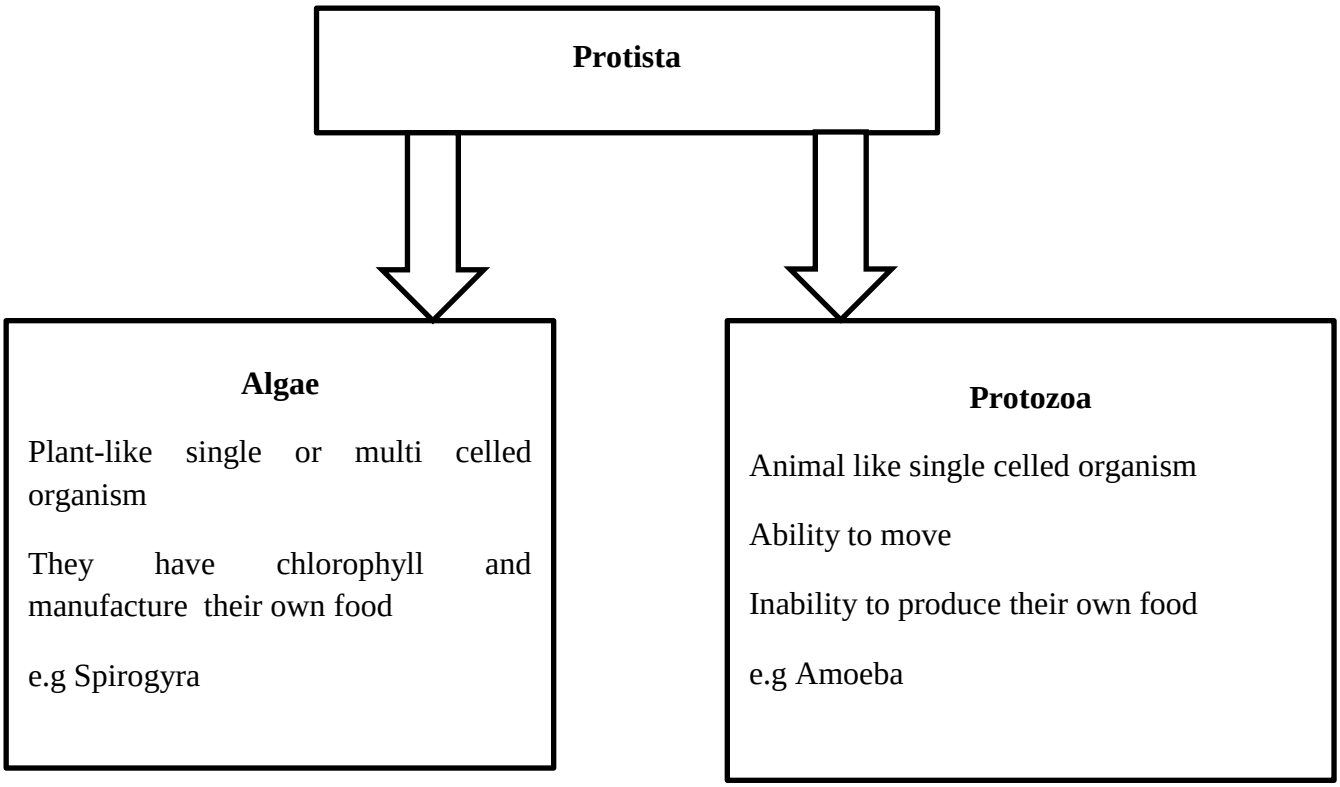
Appendix N shows the intervention which was given to one teacher to prepare a lesson plan on classification of animals during the pilot of DEIBC.



APPENDIX O

5. Intervention on classification of Protista

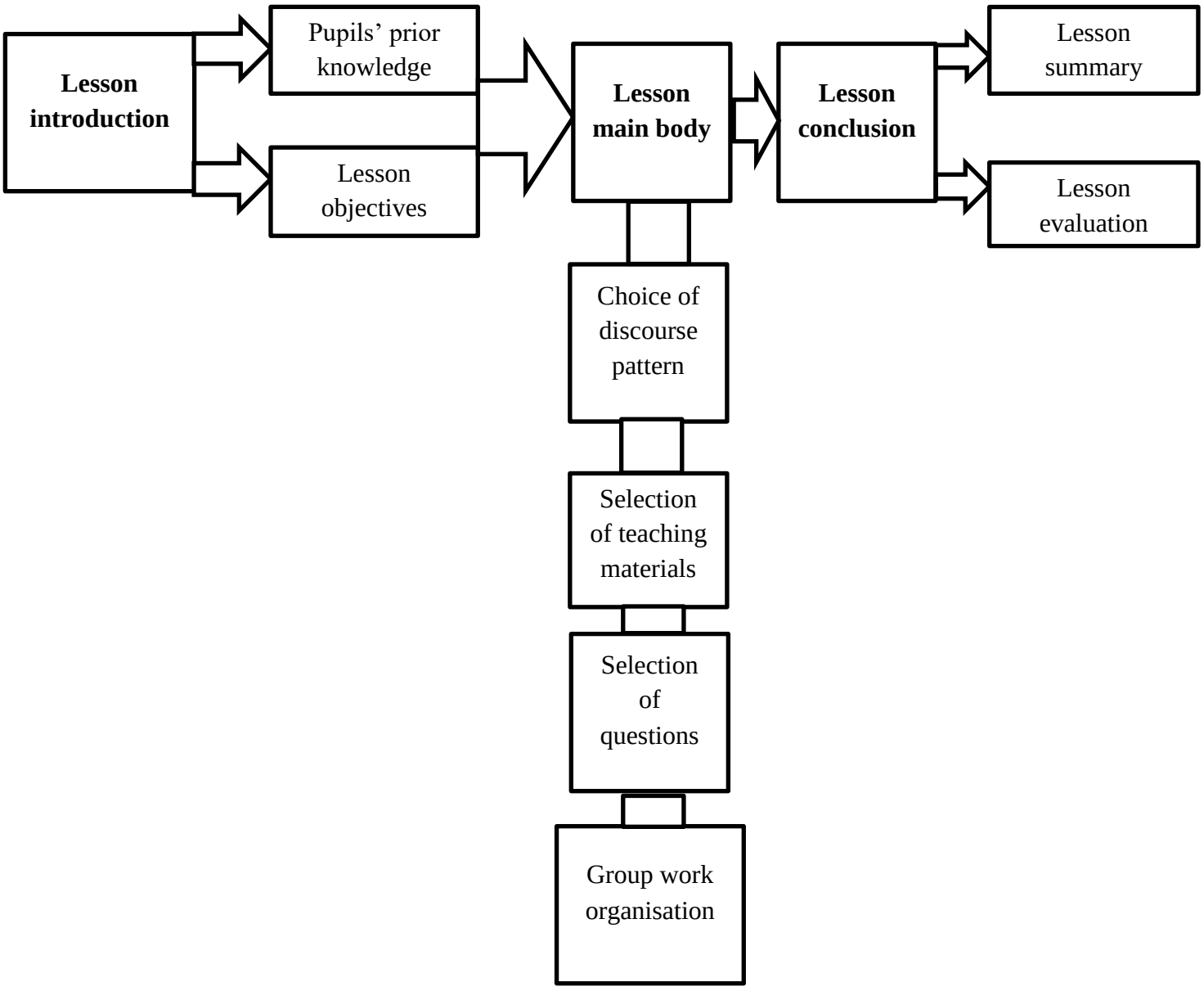
Appendix O shows the intervention which was given to one teacher to prepare a lesson plan on classification of Protista during the pilot of DEIBC.



APPENDIX P

6. Classroom discourse instruction system

Appendix P shows the classroom instruction system which emerged from the study.



Appendix Q

Publications

1. Discourse pattern choices of lessons on topics perceived to be difficult in biology at selected secondary schools in Luapula province of Zambia- *International Journal of Science and Research*. Volume 6, Issue 9, September, 2017, 1914-1919.
2. Discourse patterns of lessons on topics perceived to be difficult in biology at selected secondary schools in Luapula province of Zambia- *International Journal of Humanities Social Sciences and Education*. Volume 4, Issue 11, November. 2017, 26-42.
3. Effective use of discourse patterns during lessons on topics perceived to be difficult in biology-*The International Journal of Multi-Disciplinary Research*. Paper ID: CFP/187/2017, ISSN: 3471-7102.
4. Discourse analysis of lessons on mitosis, meiosis and classification of living organisms at selected secondary schools in Luapula Province, Zambia- *International Journal of Humanities Social Sciences and Education*. Volume 4, Issue 7. July, 2018, 36-55.