

Chemistry topics perceived as difficult to learn by secondary school pupils of Kasama, Luwingu, Mbala and Mungwi districts of Northern Province of Zambia

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ABSTRACT

Senior secondary school pupils have, for some time now, exhibited unsatisfactory performance in some chemistry topics that are perceived as difficult to learn in their school certificate and General Certificate of Education (GCE) Examinations.

This study was a survey and aimed at identifying topics pupils perceived as difficult to learn in secondary school 'O'-Level chemistry. It was conducted in 8 secondary schools in Kasama, Luwingu, Mbala and Mungwi districts. The study also established reasons for pupils' learning difficulties. Eight heads of departments, 16 chemistry teachers and 221 secondary school pupils constituted the sample. Data were collected through questionnaires and semi-structured interviews. Heads of departments, chemistry teachers and pupils completed questionnaires. Sixteen (16) chemistry teachers and 68 pupils attended follow-up oral interviews. Qualitative data were analysed by noting patterns, themes and categories (Cohen & Morris, 2008). Quantitative data captured in this study were analysed by making use of software, Excel. This analysis made use of descriptive statistics which involved: frequency tables, charts and percentages. Cohen & Morris (2008) recommend this and state that numeric data analysis can easily be performed using software packages such as SPSS, Minitab or Excel. Results of the study revealed that the most difficult topics were: mole concept and stoichiometry, electrolysis, organic chemistry and Redox.

The reasons for pupils' challenges included: general learners' difficulties referring to poor pupils' mathematical skills, complex scientific terms and language, lack of teaching and learning resources, lack of practical work or activities and pupils' poor attitude towards chemistry as a subject; teacher's incompetence which embodies inadequate explanation, unsuitable pace of delivery, lack of knowledge, difficult language and terminology used and inexperience; inadequate infrastructure referring to lack of laboratories and equipment, apparatus and other materials, and unsuitable teaching methods used as the only teaching methods used were 'question and answer' sessions, group discussions, demonstrations and lectures.

Key words: Perception, difficult topic, reason.

1.0 INTRODUCTION

Various scholars have investigated difficulties pupils face in learning chemistry in countries such as, Uganda, Ethiopia, Scotland, Nigeria, Turkey and Israel (Johnstone and Mahmoud, 1980). In their findings, Johnstone (1991) suggested that chemistry was among the most challenging subjects for secondary school

pupils. Some of the difficulties highlighted included, among others, language of chemistry being complex, complex terms and symbols and failure to manipulate mathematical aspect of chemistry.

While adequate research has been conducted in other countries of the world as named above in relation to chemistry topics perceived as difficult, and pupils' learning challenges, very little research of this nature has been carried out in Zambia. Despite the teachers' full knowledge of the difficulties that pupils face in learning some of these topics in chemistry which actually lower their overall performance in chemistry, teachers have taken no serious steps to address the situation. This study will therefore establish the topics in chemistry which are perceived as difficult and establish reasons as to why pupils perceive such topics as difficult to learn.

1.1 Statement of the problem

Results of past Examination Council of Zambia (ECZ) school certificate and General Certificate of Education (GCE) Examinations have indicated poor performance in science subjects especially in chemistry. The senior secondary school pupils have exhibited unsatisfactory performance in some chemistry topics that are perceived as difficult to learn, and the reasons for their learning challenges are not known.

1.3 Objectives

This study sought to address the following objectives:

1.3.1 Primary objective:

The primary objective of this study is to establish ways in which the education of chemistry at secondary school level can be improved in order to improve the pass rate of this subject.

1.3.2 Secondary objectives:

1. To identify topics in chemistry that are perceived to be difficult for secondary school pupils to learn.
2. To establish why the topics identified above are perceived to be difficult.

1.3.3 Significance of study

This study may help Policy makers and curriculum designers to make changes to teaching methods. It may also be useful to institutions, teachers, pupils, parents and other stakeholders who may desire to improve classroom practice. The study may also motivate teachers to attend conferences, seminars or refresher courses focusing on handling difficult chemistry topics. It may equally motivate other scholars to scale up this study.

1.3.4 Theoretic framework.

1.3.4.1 Theoretical framework

This study is premised on the theory of constructivism. The formation of this theory is generally attributed to Jean Piaget who explained the mechanism by which knowledge is internalised by pupils. He suggested that through the process of accommodation and assimilation, individuals construct their own knowledge from their experiences and during assimilation they incorporate the new experiences without changing the already existing frame work. This occurs when the individual's experiences are aligned with their internal representation of the world. The exponents postulate that pupils construct their own knowledge, ideas and meaning from their experiences (Bennett, 2002; Vygotsky, 1978).

The theory of constructivism holds that:

- Learning outcomes depend not only on the learning environment but also on the knowledge of the pupil;
- Learning involves constructing meaning;
- Construction of a meaning is influenced to a large extent by existing knowledge;
- The meanings constructed are evaluated and can be accepted or rejected;
- There are patterns in the types of meanings pupils construct due to shared experiences with the physical world and through their natural language (Bennett, 2002; Vygotsky, 1978).

This theoretical framework is appropriate because it explains why pupils would fail to understand the difficult scientific concepts as their complexity bears no relationship with the student's existing knowledge. Simply put, the strange and difficult 'specialist vocabulary' that characterise some concepts or topics in chemistry will cause a failure on the part of the student to construct their ideas or meaning of these concepts as the relevant knowledge is absent. Construction of meaning depends upon the already existing knowledge in the pupil and their experience with the learning environment. The complex scientific terms and concepts such as electronegativity, stoichiometry, atomicity, dynamic equilibrium, polymerisation, and other related concepts would be deemed as not being part of the learning environment with which the pupils have had experience.

There is considerable research evidence to support the notion that children construct their own explanations for scientific phenomena and that such explanations may differ from the accepted scientific explanations. (Bennett, 2012. p.34).

2.0 REVIEW OF LITERATURE

2.1 General learning problems

2.1.1 Impact of language

Language plays a role in understanding of scientific concepts. language is the medium of instruction and a vehicle that conveys meaning and thoughts to learners. If the language used is complex, high-flown, there will be communication break down and learning will not take place. Learners will not get explanations; they will fail to read test items. They will not understand the questions. In the same vein, if the learners' language is poor, they will fail to communicate their thoughts, hence they will perform poorly. (Lemke, 1990 in Bennett, 2003; Knippels ,2002; Young, 1999).

2.1.2 Effect of gender

Some studies have indicated that girls tend to exhibit a more positive attitude than their male counterparts (Ajayi and Ogbeba 2017)). On a contrary, a study conducted by Tinklin, Croxford, Ducklin&Frame (2001) showed that there were more girls than boys who perceived more scientific concepts as difficult to learn. There is no clear-cut position as to the effect of gender on perception of learning difficulties by learners. . (Shamai, 1996; Tinklin, Croxford, Ducklin&Frame, 2001).

2.1.3 Lack of practical work

Absence of practical activities and over reliance on theoretical work will lead to poor pupils' performance in chemistry. By its very nature, chemistry is a practical subject and should be taught practically. Practical work brings reality into the classroom, Links theory to reality, clarifies unclear theoretical concepts, it is Motivational, and teaching is efficiently done (Czerniak & Lumpe, 1996; Riggs & Enochs, 1990; Tschannen-Moran et al., 1998).

2.1.4 Teacher qualification

Teachers are deemed to be critical assets with regard to quality of learning. Well qualified teachers are vital tools in determining not only the quality of knowledge that pupils will acquire but the character of development of a Nation in the final analysis. There is need to realise that poorly qualified teachers are very likely to transmit wrong descriptions of observations, misconceptions, misinformation and misapplication of content taught and scientific terminologies (Harris and Sass, 2008).

2.1.5 Teaching strategy

There are some features about science that have implications on how it should be taught. Science is about constructing meaning out of knowledge. (Corno & Snow,

1986). Musonda (2017) augments the foregoing and states that use of effective, active methods, promotes deep understanding as an individual is rigorously engaged in constructing meaning and sharing knowledge. This way, the pupils become *their own teachers, and teachers begin to see learning through the pupils' eye*. Hattie (2009, p.22) com

2.2 Specific learning problems

2.2.1 Specialist vocabulary of Chemistry

Learning chemistry can be daunting as it is characterised by a vocabulary which is not only vast but also technical. Bennett (2003) observes that technical vocabulary associated with scientific concepts has proved to be responsible for reducing the readability and understandability of the scientific text which very often results in poor conceptualisation. It uses strange symbols. For example, Sodium, is Na (from natrium), Potassium is K (from Kalium). Looking at the names (sodium and potassium) and the symbols (Na and K), one would see that the symbols have no relation with names.

2.2.2 Pupils' motivation

The scholars have also shown that there is a significant relationship between study habits and pupils' interest in chemistry. The pupils that perceived some topics as difficult had very little or no interest in studying such topics, and if they ever studied them, they normally employed poor study habits. Consequently, pupils failed to comprehend the concepts involved and their performance remained poor (Ogunkola & Samuel, 2011; Ejidike and Oyelana ;2015).

2.2.3 Mathematical background

It is observed that topics in chemistry such as stoichiometry, mole concept, kinetics, energetics, and many others that pupils find difficult to learn have mathematical aspects. (Knippels, 2002; Osborne *et al.*, 2003). Marie (2018) explains that pupils with poor mathematical skills will fail to grasp chemistry topics that are mathematical in nature, not that the concepts are complex but that their mathematical skills are poor.

2.2.4 Effect of pupils' pre-instructional conceptions

Scholars have asserted that pupils will always come to chemistry lessons with already existing "chemistry knowledge" which may or may not be correct. If the existing knowledge is correct, it then forms a positive and helpful basis for understanding new information as the links will be meaningful. Conversely, misconceptions already existing in the pupils' minds prior to instruction will be a barrier and will impede further learning (Clement *et al.*, 1989).

2.2.5 Ineffective formative assessment in chemistry

Scholars have argued that , if the desire is to increase and raise pupils' achievement then the key is formative assessment (Black & William, 1998; in Brookhart, 2009). *“There is a body of evidence that formative assessment is an essential component of classroom work and that its development can raise standards of achievement. We know of no other way of raising standards for which such a strong prima facie case can be made.”* (Black and William 1998 ; Brookhart, 2009).

3.0 METHODOLOGY

3.1 Research Design

The study was a survey. It sought to interpret the information gathered to capture the respondents' views in order to explain pupils' learning difficulties in chemistry.

3.2 Target Population

All chemistry teachers, all pupils taking chemistry, all HODs of Natural sciences Department in Mbala, Mungwi, Kasama and Luwingu districts constituted the population.

3.3 Sample Size

The sample for the study was drawn from 8 secondary schools. The sample included 16 chemistry teachers 8 HODs of Natural Sciences Department and 221 chemistry learners. A total of 221 pupils answered the questionnaire and 68 pupils were orally interviewed.

3.4 Sampling Techniques

The purposive sampling technique was used to hand pick a class of grade 12 pupils at each school to answer the questionnaires as these secondary schools only had one grade12 chemistry class each. The pupils were drawn only from grade 12 as these were assumed or deemed to have long and adequate experience of, and interaction with, the chemistry curriculum.

Ten (10) grade 12 pupils (5 females and 5 males in case of co-education schools where total enrolment was between 30 and 40) were picked using systematic random sampling from among the pupils who answered the questionnaires. This was done by picking every 4th student from each of the girls' - boys' class list. But as few as 4 pupils were randomly picked for interviews where the total enrolment of pupils was as low as 13 by picking every 3rd student from class list.

3.5 Data Collection Instruments

The following instruments were employed to collect data:

3.5.1 Questionnaires

These were of three types, one for teachers, another for (HODs) of Natural Sciences and the other for pupils.

3.5.2 Interview Schedules

Interviews were conducted with teachers and with pupils respectively as follow-ups to help fill in gaps or clarify any unclear matters from questionnaires.

3.6 Data Collection Procedures

The actual procedure began with questionnaires being distributed by the researcher to teachers, pupils and HODs. Interviews were conducted soon after the respondents had filled in their respective questionnaires.

3.7 Data analysis

Data captured in this study were analysed by making use of software, Excel. This analysis made use of descriptive statistics which involved: frequency tables, charts and percentages.

4.0 RESULTS

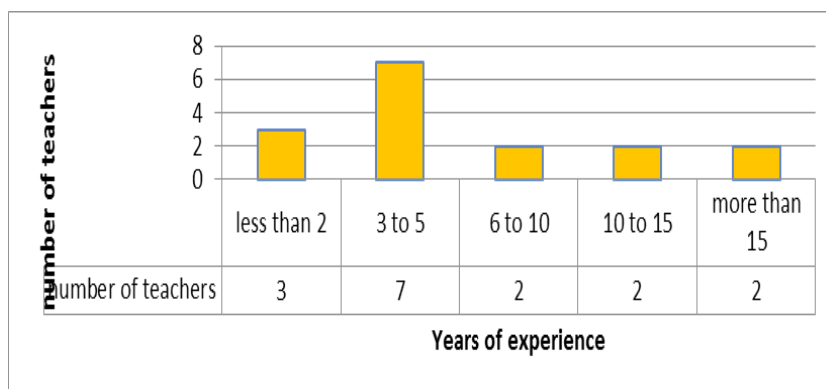
4.0 Introduction.

This chapter presents findings on the research conducted to establish why chemistry is perceived as difficult for secondary school pupils to learn.

4.1. Teachers' experience

The study sought information on the teachers' experience as this was deemed to have a bearing on the pupils' performance in chemistry. The data obtained on this were presented in Figure 4.1

Figure 4.1 Teachers' experience.



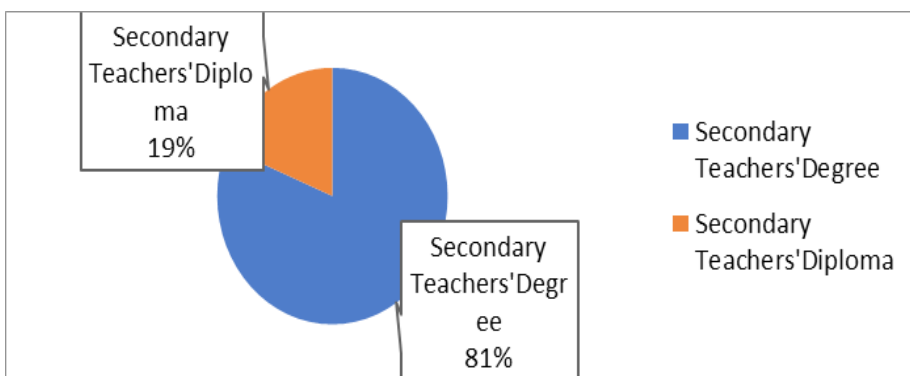
Source: Field data, 2019.

Figure 4.1 indicates that, of the 16 chemistry teachers involved in this study, three (18.75%) had only taught chemistry for less than 2 years, nine (56.75%) had taught for 3 to 10 years. It also shows that only four (25%) of the teachers had taught for at least ten years. It was generally discovered that among teachers of the same qualification, those who had longer experience taught better and produced better pass rates as they, over the years, had improved their pedagogical skills including improvisational skills, and demonstrated a better psychological understanding of learners than their counterparts.

4.2 Teachers' qualifications

Data were collected on teachers' qualifications so as to see a nexus between performance and teacher quality. Data is presented in Figure 4.2

Figure 4.2 Summary of Teachers' qualification.

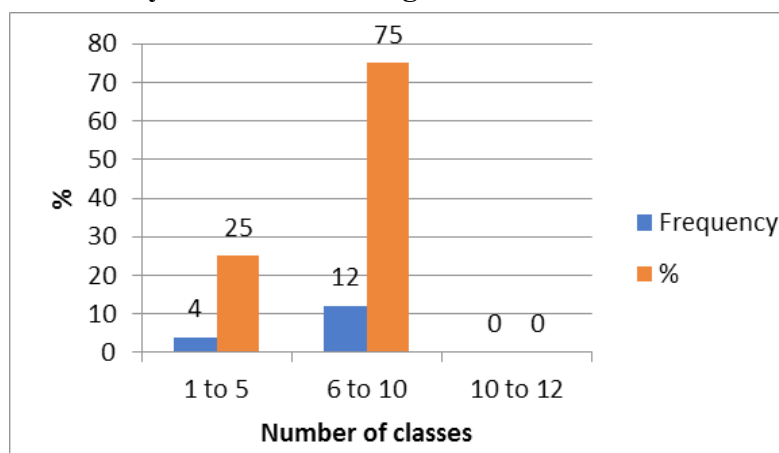


Source: Field data,2019.

Figure 4.2 shows that the majority (81.5%) of the chemistry teachers were degree holders, and a smaller proportion (18.75%) of them had a secondary teachers' diploma. It is clear from the findings that although 18.75% of the respondents taught chemistry to senior pupils, they did not qualify to do so. Only teachers with a secondary teachers' degree officially qualify to handle senior pupils (grades 10-12) in secondary schools. The implication is that, intellectual competence of the teacher is a primary asset in the quality of learning the students acquire in schools. There is also need to realise that poorly qualified teachers are very likely to transmit wrong descriptions of observations, misconceptions, misinformation and misapplication of content taught and scientific terminologies.

4.3 Chemistry teachers' teaching load

The information about the teaching loads of the chemistry teachers was sought as it was assumed that this could have had a relationship with the pupils' performance in chemistry. Data were shown in Figure 4.3

Figure 4.3 Chemistry teachers' teaching load

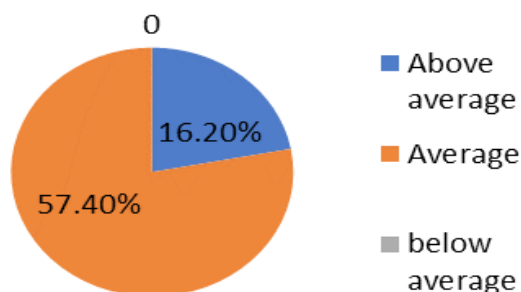
Source: Field data,2019.

According to Figure 4.3, a total of 16 chemistry teachers gave responses about their teaching load. The results indicated that 12 (42.1%) of the chemistry teachers taught between 6 to 10 classes while four (25%) had between 1 and 5 chemistry classes. The high teaching loads as indicated for some teachers could be attributed to the fact that the same teachers taught other sciences in addition to chemistry

4.4 Pupils' profile

4.4.1 Pupils performance in chemistry

The information on the pupils' performance in chemistry was sought from the chemistry teachers and the pupils themselves in order to establish, firstly, whether or not there was a relationship between the perception of difficult topics in chemistry and the pupils' actual performance. Secondly, whether or not the teachers' perception corresponded to the learners' perception of the difficult topics in chemistry.

Figure 4.4: Pupils' responses about their performance in chemistry

Source: Field data,2019.

Figure 4.4 shows what the pupils said about their performance in chemistry. It indicates that more than half (57.4%) of the respondents said their performance was average (scoring between 40 and 50 percent) while 26.4% said they were below average (scoring less than 40 percent). A small proportion (16.2%) of the pupils said their performance was above average (scoring more than 50 percent).

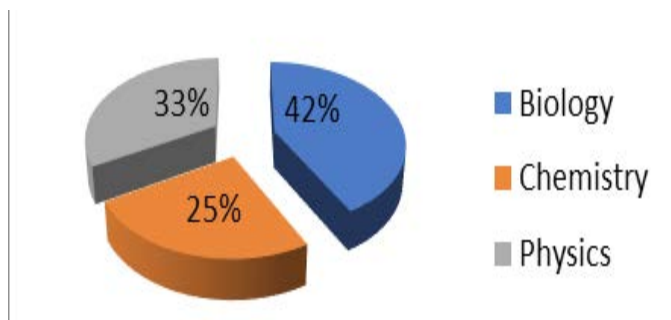
4.5 Pupils' responses

The study sought information on the chemistry topics perceived to be difficult from pupils in the secondary schools by use of questionnaires and interviews. The study also sought information on the pupils' favourite subjects.

4.5.1 Pupils' favourite science subject

Information was obtained on the favourite science subject of the research population to try and establish their perception of chemistry. The data obtained were analysed and presented in Figure 4.5.

Figure 4.5 Pupils' responses about their favourite science subject.

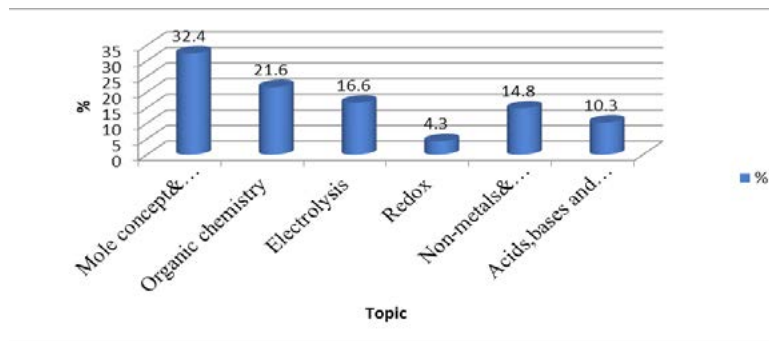


Source: Field data, 2019

Figure 4.5 indicates that the majority (42%) of the pupils said their favourite science subject was biology, 33% mentioned physics and a relatively small proportion (25%) of the respondents said chemistry. The Figure suggests that chemistry is the least popular science subject among pupils and this is an indication that there is a negative perception of chemistry subject.

4.5.2 Topics in chemistry perceived to be difficult for pupils to learn

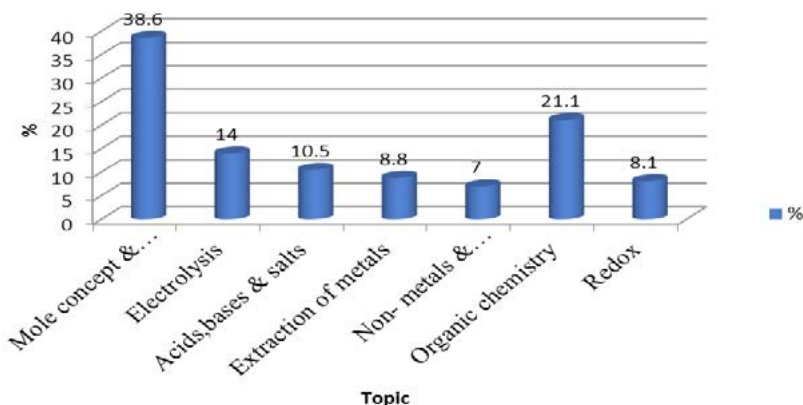
Data were collected on the chemistry topics that they perceived to be difficult to learn, and these data were presented in Figure 4.6.

Figure 4.6: Topics in chemistry perceived to be difficult for pupils to learn.

Source: Field data, 2019.

The data shown in Figure 4.6 were obtained from the pupils who completed the questionnaires. Results indicated that 32.4% of the pupils said mole concept and stoichiometry was most difficult of the difficult topics, followed by organic chemistry (21.6%), electrolysis (16.6%), non-metals and preparation of gases (14.8%) and acids and bases (10.3%). Redox ranked last

The follow-up interviews were conducted to seek data on topics in chemistry perceived to be difficult for pupils to learn. 68 pupils were interviewed and the data obtained were presented in Figure 4.7.

Figure 4.7 Topics pupils perceived as most difficult.

Source: Field data, 2019.

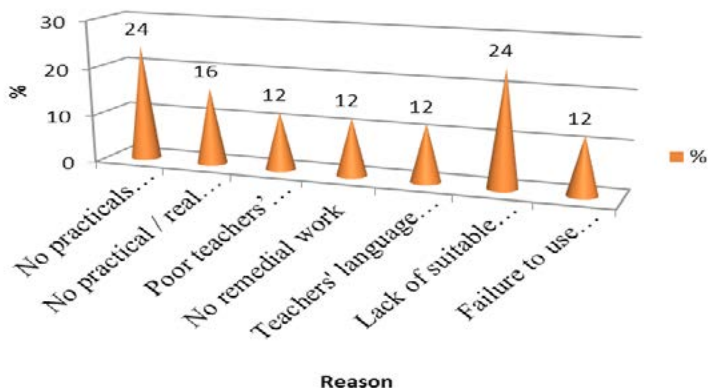
Figure 4.7 shows the data collected from the pupils who were orally interviewed. Results indicated that the majority (38.6%) of the pupils said that Mole concept and Stoichiometry topped the list of topics that they perceived as most difficult, followed by organic chemistry (21.1%), electrolysis (14.0%) and acids, bases and salts (10.5%). The figure also indicates that extraction of metals, redox and non-metals and preparation of gases ranked lowest and were represented by almost

identical proportions of 8.8 %,8.1 % and 7.0 % respectively.

4.8. Reasons why some chemistry topics were perceived to be so difficult

Data on why topics were difficult were indicated in Figure 4.8 below.

Figure 4.8: Reasons why some chemistry topics were perceived to be so difficult



Source: Field data,2019

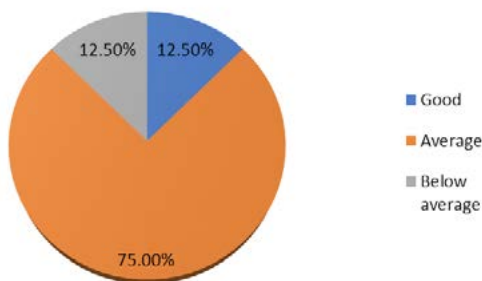
Figure 4.8 shows the data collected from the oral follow-up interviews. The figure indicates that the commonest challenges that respondents cited were that the teachers were not conducting practical work or experiments and lack of suitable books or reading materials.

4.9 Teachers' responses

4.9.1 Teachers' responses about the pupils' performance in chemistry.

The findings on this theme were based on 16 teachers who attended follow up interviews. The data obtained were presented in the Figure 4.9

Figure 4.9: Teachers' responses about the performance of pupils in chemistry



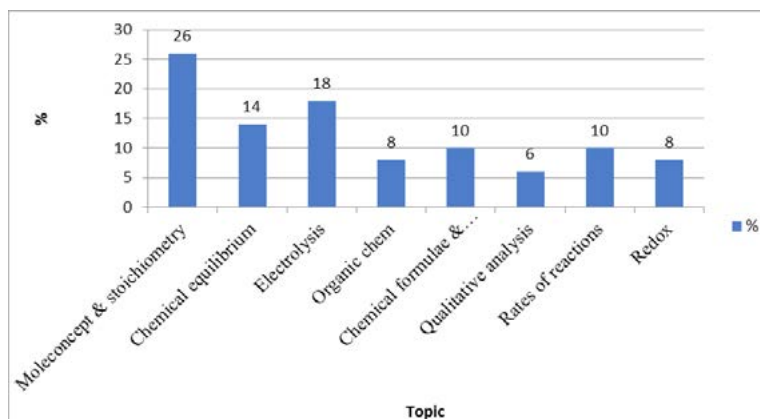
Source: Field data,2019.

Figure 4.9 shows that the majority (75.00%) of chemistry teachers described the pupils' performance in chemistry as average. It also indicates that 12.50 % of the teachers considered their pupils' performance as being below average. Another 12.50% of teachers described the pupils' performance in chemistry as being good.

4.10 Topics in chemistry perceived to be difficult for pupils to learn

The findings on this theme were obtained using the questionnaires and interviews.

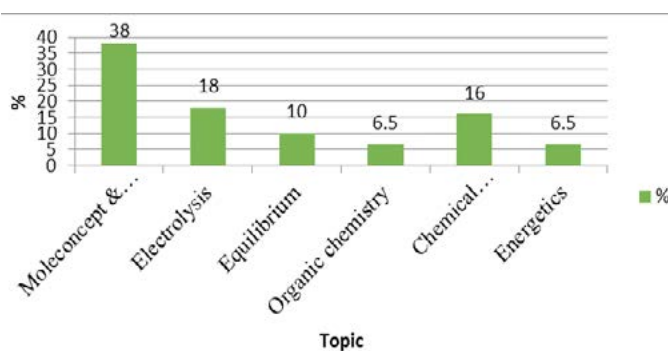
Figure 4.10: Topics teachers thought pupils perceived as most difficult



Source: Field data,2019.

The data presented in Figure 4.10 were obtained from questionnaires. It is clear from the data in the figure that the largest proportion (26%) of respondents said mole concept and stoichiometry was the most difficult topic followed by electrolysis (18%).

Figure 4.11: Topics teachers thought pupils perceived as most difficult



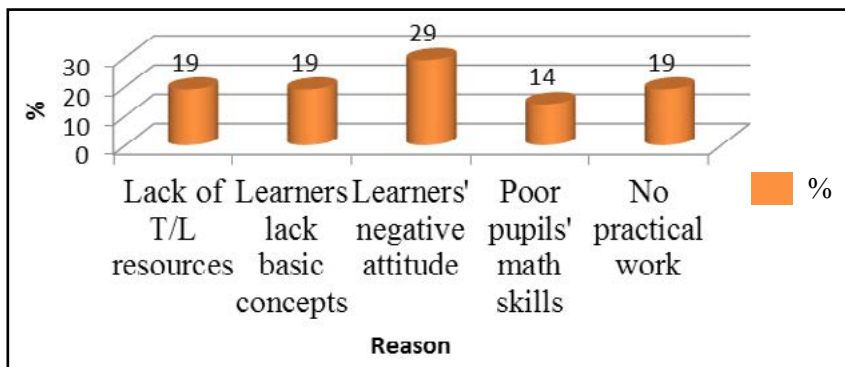
Source: Field data,2019.

The data presented in Figure 4.11 were obtained from oral follow-up interviews. Mole concept and stoichiometry represented by 38%. A significant proportion of 18% respondents cited electrolysis.

4.12 Reasons why the topics were perceived to be so difficult.

The study sought information on the reasons why the topics were perceived to be difficult from chemistry teachers.

Figure 4.12 Reasons why the topics were perceived to be so difficult.

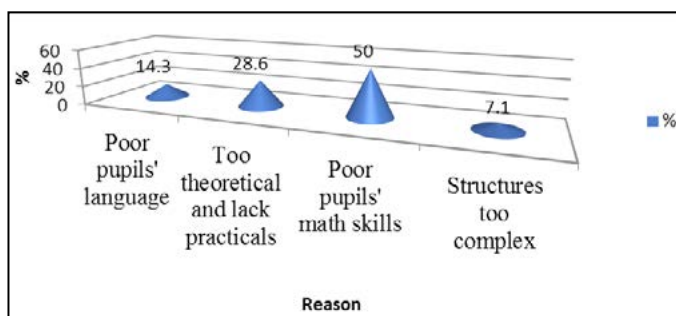


Source: Field data, 2019.

Figure 4.12 shows data obtained from the questionnaires and indicates that majority (29%) of chemistry teachers indicated that learners' negative attitude towards the subject was the greatest challenge that they ever faced when teaching difficult topics in chemistry. Some teachers cited lack of teaching resources, absence of laboratory practical work. These were represented by equal proportions of 19%.

The study sought information on the reasons why topics were perceived to be difficult from chemistry teachers through follow-up interviews. The data were analysed and presented in Figures 4.13 and 4.14.

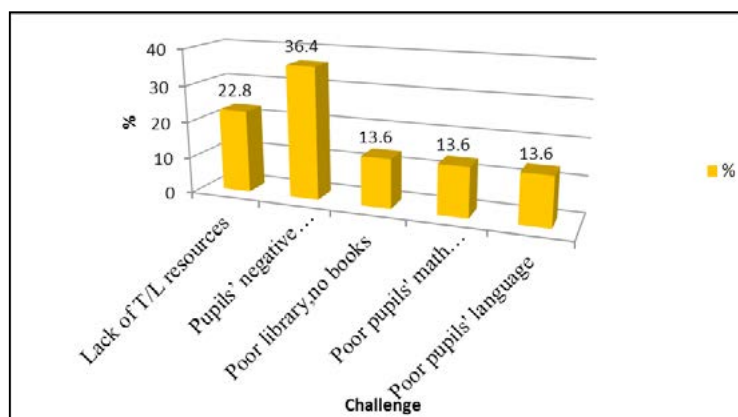
Figure 4.13: Teachers' reasons for the topics in chemistry pupils perceived as most difficult



Source: Field data, 2019.

The findings in Figure 4.13 were collected from the oral follow-up interviews. The figure shows that half the number (50%) of respondents said that the challenges that pupils experienced as they learned chemistry were as a result of their poor mathematical skills. A significant proportion (28.6%) of teachers cited the fact that the topics that were perceived as difficult in chemistry were too theoretical, and that the situation was compounded by teachers not conducting practical activities related to such topics.

Figure 4.14: Teachers' challenges when teaching topics in chemistry perceived as difficult.



Source: Field data, 2019.

The data in Figure 4.14 were obtained from the follow-up interviews indicate the various challenges that chemistry teachers. About 36.6% of the chemistry teachers said pupils' negative attitude towards the subject. A proportion (22.8%) of respondents cited lack of suitable teaching resources and lack of suitable text books. The Figure also shows that other learning challenges included lack of modern libraries, poor pupils' mathematical skills and limited pupils' language, each represented by an equal proportion of 13.6%.

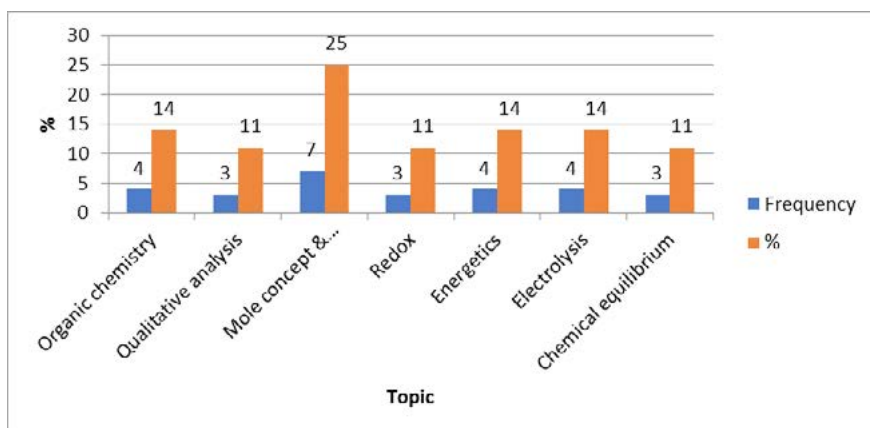
4.15 Heads of Departments' (HODs') responses

The researcher obtained data based on pupils learning difficulties from 8 HODs.

4.15.1 Topics in chemistry perceived to be difficult for pupils to learn

The findings on this theme were obtained from HODs using the questionnaire.

Figure 4.15 Topics that HODs think pupils perceive as most difficult.



Source: Field data,2019.

Figure 4.15 which shows the data collected from HODs indicates that the majority (25%) of HODs said that the topic, mole concept and stoichiometry, was the most difficult followed by organic chemistry (14%), energetics (14%) and electrolysis (14%).

4.15.2 Reasons why the topics were perceived to be so difficult

The study sought information on the reasons why the topics were perceived to be difficult from HODs. The information was sought from the HODs through the questionnaire. Data were indicated in Table 4.1 below.

Table 4.1: HODs’ reasons for the topics in chemistry pupils perceived as most difficult

Teachers’ responses		N	%
Topic	Reason		
Organic chemistry	Too theoretical& Complex.	2	8.0
Qualitative analysis	Too abstract and theoretical.	2	8.0
Mole & stoichiometry	Poor pupils’ mathematical skills	8	32.0
Redox	Too theoretical.	2	8.0
Energetics	Too abstract	3	24.0
Electrolysis	Poor pupils’ mathematical skills	4	16.0
Chemical equilibrium	Topic too abstract	4	16.0
Total		25	100

Source: Field data, 2019.

Table 4.1 indicates that the majority of HODs (32%) said that mole concept and stoichiometry was perceived as a difficult topic as this topic was characterised by many mathematical concepts yet the learners had poor mathematical skills. The

implication is that the mathematics associated with this topic seemed to hinder or weaken the pupils' ability to grasp concepts. Another significant proportion (24%) of HODs indicated that energetics was difficult as it was too abstract.

5.0 DISCUSSION

The results of the study presented in chapter four were analysed and the following conclusions vis-à-vis the objectives of the study were drawn.

5.1 Topics in chemistry secondary school pupils perceived to be most difficult

With respect to topics that pupils perceived as difficult, the study concluded that there were only four topics that pupils perceived as most difficult. Namely: *mole concept and stoichiometry, electrolysis, organic chemistry and redox.*

The study established that the topics pupils perceived as difficult to learn, and the topics HODs and chemistry teachers referred to as most difficult topics for the pupils to learn were basically the same.

According to the findings, the most difficult topics were ranked in the descending order of degree of difficulty based on their average percentage score as follows: Mole concept and stoichiometry (32%), electrolysis (16.12%), organic chemistry (14.29%) and redox. (6.25%)

5.2 Reasons why the topics were perceived to be difficult.

In terms of reasons as to why the aforesaid topics were difficult, it was concluded from the findings that the following accounted for the learning difficulties. The reasons have conveniently been grouped into four main issues. These include: general learners' difficulties, teacher's competence, inadequate infrastructure and teaching methods used. These categories have further been split to give comprehensive explanations.

5.2.1 General learners' difficulties

General learners' difficulties have been divided into the following main points: poor pupils' mathematical skills, complex scientific terms and language, lack of teaching and learning resources, lack of practical work or activities and pupils' poor attitude towards chemistry as a subject.

This study has established that poor pupils' mathematical skills was one of the main reasons for their learning difficulties. The findings in this study indicated that teachers explained poor pupils' performance in the topics perceived as most difficult such as mole concept and stoichiometry, electrolysis, redox and many others in terms of pupils' failure to apply their mathematical skills. This deficit on the part of the pupils was well acknowledged by the pupils themselves, and it really accounted for their learning challenges. The study confirmed that topics that involved calculations were not popular among pupils who, at the same time,

did not perform well in Mathematics. The chemistry concepts involved may not necessarily be complex but the failure on the part of the pupils to solve the mathematical aspect of the concepts was what made pupils perceive such topics as difficult. The findings were consistent with what Knippels (2002) and Osborne (2003) who observed that mathematical knowledge was key in grasping chemistry concepts.

It was established that topics were characterised by complex scientific terms and language that created a barrier so that pupils' understanding was restricted if not distorted. "Chemists communicate in a highly elaborated alphabetic and symbolic language" (Sliwka, 2003, p. 24). The fact that pupils were put off by the 'specialist vocabulary' meant that there would be communication breakdown leading to failure to grasp concepts on the part of the pupils. This situation arose if the teacher did not help the pupils familiarise themselves with the *jargon* or terms associated with that particular topic. The study also confirmed that there were some teachers who failed to use the associated terms simply because they too were not comfortable with the vocabulary in question. The implication is that the inability of the teachers to explain 'specialist vocabulary' surrounding scientific concepts was an indication of their inadequacies (Bennett, 2002). The study indicated that due to the abstract nature of the difficult topics and the fact that they were taught theoretically, pupils found getting the concepts a big challenge. Admittedly, studying the language of chemistry could be daunting. For example, Sodium, is Na (from natrium), Potassium is K (from Kalium). Names (sodium and potassium) and the symbols (Na and K), have no relation. The symbols do not show any relation with names of elements. This surely is confusing. No wonder Bahar and Polart (2007) as cited by Ogunkola and Samuel (2011) point out that the many difficult terms and symbols used in the teaching of chemistry are so new that they cannot be linked to the pupils' cognitive structures. This consequently makes it difficult for pupils to grasp the concepts.

The study has further established that Natural Sciences Departments in most secondary schools under study lacked adequate suitable teaching and learning resources to teach the difficult topics. In addition to this, the secondary schools lacked other essential facilities such as well stocked libraries, computer laboratories and internet connectivity which both teachers and pupils would use for their research and study.

If there are no proper teaching resources in secondary schools, teaching chemistry becomes meaningless. Ogembo (2009) and Ikechukwu (2015) support the findings of this study as they indicate that learning chemistry would really be a *nightmare* if relevant teaching and learning resources were not available. These scholars have also argued that in schools where there were no relevant chemistry textbooks or materials, pupils did not adequately demonstrate deep understanding of concepts they learned as evidenced by their poor performance in tests and examinations. If secondary schools do not strive to acquire necessary teaching

and learning resources to promote active learning, performance among learners will invariably be low

The study established that pupils struggle because of **a lack of practical work**. Teachers of chemistry do not conduct practical work to enhance and concretise pupils' understanding. As a result, pupils do not form a grasp of the practical applications of the field of chemistry, leading to losing interest and value they attach thereto. Pupils can only adequately acquire scientific concepts and skills through the actual engagement in practical work or activities. This is particularly important in the sciences because the hands-on approach to learning has demonstrated to play a crucial role in the understanding of concepts and retention of content taught, as well as developing the ability to think scientifically. Practical work brings reality into the classroom and serves as a link between real life and theory, a situation that greatly aids pupils' understanding of the abstract terms. Experiments promote relevant basic skills and competences that pupils need in order to comprehend complex concepts. The study showed that lack of practical work due to paucity of equipment and other materials was one of the significant factors impeding pupils from grasping the concepts especially as regards difficult topics. A professionally qualified science teacher, no matter how well trained he or she could be, would be unable to put his or her ideas across if the school setting lacks laboratory practical work necessary for him or her to translate his or her competence into reality (Adlikwu & Iorkpilgh, 2013).

The study also established that pupils' attitude towards chemistry was negative. Almost all schools under study indicated that the pupils exhibited poor attitude towards chemistry and other sciences indeed. This was evidenced by their poor study habits as the teachers of chemistry confirmed, reporting late for lessons, poor attention span in class, either failing to do assigned work in class or doing it rather lackadaisically, and some could not even write notes. HODs confirmed that pupils studied other subjects more frequently than chemistry despite their full knowledge of their learning difficulties in the subject. One would expect pupils to fully commit their time to studying chemistry as a way of covering up for their deficits, and in a bid to improve own performance. This argument draws strength from Bevins and Brodie (2005) whose revelation of the findings of their study of UK secondary school pupils' perceptions of science education confirm that lack of interest in the subject accounted for pupils' low performance. In further support of the findings of this study, scholars like Ogunkola and Samuel (2011) have also demonstrated that there is a significant relationship between study habits and pupils' interest in chemistry. The pupils that perceived some topics as difficult had very little or no interest at all in studying such topics, and if they ever studied them, they ordinarily employed poor study habits.

5.2.2 Teacher competence

Teacher competence shortcomings have been split into the following main points: inadequate explanation, pace of delivery, lack of knowledge, language and terminology and inexperience.

The study established that the pupils also attributed their failure to learn the difficult topics effectively to what they termed as teacher's inadequate explanation. The failure on the part of the teacher to explain clearly the necessary concepts to the pupils only goes to explain the depth of incompetence on the part of the teacher. For pupils to get the concept clearly especially challenging concepts, they need a good explanation because this is what will stimulate construction of knowledge and meaning of the material they are learning.

The study further concluded that teachers failed to determine a suitable pace of delivery of information as the lesson progressed. Teaching at a pace pupils described as "too fast"—does not do anybody any good. Besides that, failure on the part of a teacher to suitably determine the pace at which to deliver concepts to pupils in the course of teaching and learning will not only result in pupils missing out on important points or concepts but also disrupt their logical and hierarchical linking of ideas, a situation that puts them in a confused state. This scenario disjoins and disrupts understanding of concepts. A Teacher is expected to move with learners in thought so as to tell exactly where they are in terms of knowledge acquisition, and to determine when the pace is to be adjusted in order to suit the absorption rate of learners.

The study established that some teachers exhibited a lack of knowledge required to teach chemistry effectively. Put in another way, the teachers in question did not officially qualify to teach senior classes. Only teachers with a secondary teachers' degree officially qualify to handle senior pupils (grades 10-12) in secondary schools. Refer to Figure 4.5 which shows a proportion (18.75%) of teachers with a secondary teachers' diploma only. The findings showed that although 18.75% of the respondents taught chemistry to senior pupils, they did not qualify to do so. The implication is that, intellectual competence of the teacher is a primary asset in the quality of learning the students acquire in schools. Teachers are recognised as critical factors in the delivery of quality education, and this is why there is a need for improvement in the level of abilities in teachers for them to effectively teach chemistry in schools. If the teacher does not have the suitable qualification to offer chemistry to the grade level she or he is teaching, their difficulties would *spill over* to the pupils. It is difficult for the pupils to grasp the concepts that the teacher fails to understand well. There is also need to realise that poorly qualified teachers are very likely to transmit wrong descriptions of observations, misconceptions, misinformation and misapplication of content taught and scientific terminologies.

The study further established that in more cases than not, the teacher's language and terminology used during the execution of lessons proved to be unsuitable or inappropriate for the grade level as the pupils complained that they could not

completely understand what was being explained. Pupils failed to understand concepts not because explanations were not clear but that the level of language was way beyond them. Teachers used high-flown language. The complexity of the language and the nature of terminology being employed by the teacher may not necessarily constitute poor or inadequate explanation on the part of the teacher. The explanation may be clear except that it is offered at an intellectually or academically high level so much that it creates an impression in the pupils that the concepts being learned are beyond their comprehension or are poorly explained. Yet, this is not the event. This is what will, consequently, make learners tune out as they fail to grasp the material.

Teachers of chemistry should realise that language is a 'vehicle' that delivers meaning to learners. It is a medium through which the teacher will communicate his thoughts and information to learners. If the language that communicates ideas, concepts and knowledge is not understood, it then becomes a barrier that obstructs learning. Language in the classroom should not be used for the sake of it, nor spoken for prestige, it should help learners construct knowledge and meaning of what the teacher is communicating to them. Language plays a cardinal role in determining the degree of understanding of scientific concepts.

Some scholars such as Lemke (1990) in Bennett (2003), in support of these findings, emphasize that language is what communicates the ideas to the pupils, and that if the language is not pupil-friendly, how will the pupils grasp the concepts? They will inevitably experience learning difficulties in chemistry. This is why Heron (1996) as cited by Bennet (2003) further contends, that if the language being used to deliver content and convey meaning has unfamiliar words, pupils would fail to grasp concepts because they would not "read chemistry fluently". This is a similar argument to that postulated by Johnstone and Cassels (1983) who conclude that low examination marks in sciences were as a result of pupils failing to understand the language used to phrase the questions.

The argument is that pupils will fail to answer chemistry questions not that they fail to comprehend the scientific concepts involved perse but that the nature of the language used is what impedes them from getting the concept.

An analysis of the findings in chapter four led to the conclusion that more than half (62.5%) of the chemistry teachers were not adequately experienced, and had only taught chemistry for a period of between 1 to 5 years. In practice, teachers are deemed to be adequately experienced when they have taught the same subject for more than five years. If the teachers are not experienced enough their teaching is thwarted by a number of teaching difficulties, they encounter which, otherwise, could not have been issues had they had enough experience in their teaching profession. For example, it was established that among teachers of the same qualification, those who had longer experience taught better and produced better pass rates. This is because they, over the years, had improved their pedagogical skills including improvisational skills, practical manipulative skills as they will

have handled equipment and apparatus as well as conducted practical work for a long time. Moreover, they demonstrated a better psychological understanding of learners than their counterparts with shorter teaching experience.

5.2.3 Inadequate infrastructure

The inadequate infrastructure can be summarised into two main issues, namely: Laboratories, Equipment, apparatus and other materials

In terms of laboratory rooms, the study established that some schools under study did not have subject-specific laboratories. For example, some schools did not have a chemistry laboratory. Chemistry lessons were conducted in an ordinary classroom that was poorly lit, poorly ventilated and lacked water reticulation system, heating system, fume chamber (or a hood) and other specific infrastructure unique to a chemistry laboratory which are critical to practical work. This means that teachers could not conduct practical work as the laboratory facilities were both not adequate and conducive. The Findings also confirmed that some schools under study had only two laboratory rooms against five science subjects (Chemistry, biology, physics, Agricultural sciences and integrated science). Sometimes, even teachers with the zeal to conduct practical work would be dispirited by this lack of adequate laboratories as they find it challenging to organise and conduct experiments or laboratory work in rooms that are not designed for this purpose.

The study also established that some schools under study were poorly stocked and lacked suitable equipment, apparatus and other materials needed to conduct practical work. The study concluded that the equipment and apparatus lacking in some schools under study which were commonly and frequently used included: Power packs, accumulators, radiation detectors, electrolysis equipment, common glassware (beakers, test tubes, gas jars ,bell- jars, conical flasks, flat- and round-bottomed flasks, delivery tubes, troughs, hive-shelves, and measuring cylinders) and necessary chemicals. It was also established that teachers found it difficult to improvise these laboratory materials, and so they simply shunned practical work. In some of these schools under study, pupils only learnt theoretical work and this negatively impacted on their performance in practical work especially at the point they were obliged to write practical examinations.

5.2.4 Teaching methods teachers employ

The study concluded that the teaching methods used were not effective and did not actively engage pupils in learning. *A teaching method is considered as effective if it puts learners at the centre stage of all learning activities, defines the teacher's role as a mere facilitator but allows pupils to be their own teachers , makes a teacher see learning from learners' perspective ,and yields the intended result that is visible to both the learner and the teacher.*

The most predominantly used methods in schools under study, as established by this study, were ‘question and answer’, group discussion and demonstration, and lecture method. The study established that though the group discussion was quite often used, it was not effectively used as the groups formed tended to be too large, and pupils were given too little time to discuss ideas as the teachers were racing against time to complete the chemistry syllabus. HODs confirmed that teachers normally curtailed the group discussion to serve time. So, one might ask, why use this method if it cannot be exhaustively and conclusively used to yield intended results? Musonda (2017) augments the foregoing as he suggests that use of other active teaching strategies apart from the traditional would be ideal to teach chemistry in a more practical, engaging and meaningful manner.

6.3 CONCLUSION

The study has established that the chemistry topics in the ‘O’ level chemistry syllabus that pupils perceive as most difficult to learn are: mole concept and stoichiometry, organic chemistry, electrolysis and redox.

The study has concluded that the aforesaid topics were perceived to be difficult due to the following reasons: to poor pupils’ mathematical skills, complex scientific terms and language, lack of teaching and learning resources, lack of practical work or activities and pupils’ poor attitude towards chemistry as a subject; inadequate explanation, unsuitable pace of delivery, lack of knowledge, difficult language and terminology used and inexperience; lack of laboratories and equipment, apparatus and other materials and unsuitable teaching methods.

6.4 RECOMMENDATIONS

In view of the findings presented and conclusions drawn in this study, it is recommended that:

- (i) There should be a rigorous regular monitoring of the teaching of chemistry by external authorities who may include the Senior Education Standards Officers District Education Standards Officers, and Education Standards Officers so that the teachers of chemistry intensify their lesson preparation and formative assessment.
- (ii) School boards through fundraising ventures or Government grants should renovate and restock chemistry laboratories.
- (iii) Schools should strive to marshal their local resources to restock school libraries with adequate latest chemistry text books or reference books as well as providing internet connectivity for pupils and teachers.

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