CHAPTER ONE: INTRODUCTION

1.0 **Overview**

This chapter introduces the study. In this chapter the background to the study, which is aimed at establishing the problem that leads to the study, is explained. The background also bears information obtained from the initial review of literature. Furthermore, the introduction also identifies the study area and explains the significance of the study.

1.1 **Background**

The Government of the Republic of Zambia (GRZ) aspires to transform the nation into a medium income nation by 2030, as articulated in the policy document "Vision 2030". The attainment of medium income status implies a reduction in national head count poverty as well as income inequalities. It further implies equitable access to safe water and other social services like education and health (GRZ, 2006). These milestones can only be realised if the different sectors of the economy undergo economic improvement. The government recognises education as critical in enhancing economic development. One educational discipline which is recognised for contributing to economic development is science and technology education. The Government of the Republic of Zambia emphasises this when it points out that in order to accelerate economic growth, "the country needs to intensify the development and application of science and technology in its socio-economic development" (GRZ, 2006).

This recognition of science for development is based on the fact that a difference exists between knowledge which is obtained scientifically and other knowledge which is achieved by experience. Due to its curiosity and love for sensationalism, scientific knowledge finds applicability to practical business of life (Schrader, 1976). In addition to that, since science seeks to proclaim the truth it follows laws which are based on the human capacity for logical thinking and this is why scientists are critical and invariably recognise the virtue of intellectual honest. Furthermore, scientific thought has an impact on many aspects of the economy such as policy development and social behaviour. This is why if scientific information is handled and organised intelligently, it has the potential to create a sound and health scientific atmosphere within a community (Schrader, 1976).

Since practical work is the basis of teaching in all science subjects, it implies that science education can only be effectively taught under conditions where there is an adequate provision of teaching and learning materials. The Ministry of Education (MoE) realised the need for adequate provision of science teaching and learning materials as early as 1992 when it indicated that the priority in resource allocation, in secondary school be given to the rehabilitation of science laboratories and specialist rooms; provision of text books and other miscellaneous science teaching aids; and re-equipping science laboratories and providing consumables (MoE, 1992).

According to the Directorate of Standards of the Ministry of Education, the recommended pupil-text book ratio, in high schools, is 2:1. The same ratio applies to the pupil-apparatus ratio. With regard to laboratory space, the standard internal measurements of a high school laboratory are 11.3m x 9m. This translates into a pupil-laboratory space ratio of 35 pupils per $102m^2$. As for class size, the directorate recommends thirty five (35) pupils per class for all the high school grades.

In order to enhance the provision of teaching and learning materials, the management and functions of the MoE were decentralised under the Public Service Reform Policy (PRSP) which was launched in 1993 by the government. Decentralisation entailed devolution of power and control of education delivery from the national and provincial headquarters to the points of delivery, which are the districts, colleges and schools. This policy led to the creation of Education Boards (EBs) at the district, college and high school levels. With reference to the provision of teaching and learning materials, the high school board was the legal structure set up to ensure that national education standards are maintained through such national indicators as pupil-text book ratio and availability of other teaching and learning materials in high schools (MoE, 1995). Therefore, the High School Board was charged with the task of mobilising and allocating educational resources on the basis of need.

However, the pupils' academic performance in science subjects does not reflect well on the teaching of high school science. Alluding to the poor in-school performance in mathematics and science, the MoE indicated that "the deficiency may be in the facilities, the resources, the teaching or the balance in the curriculum" (MoE, 1996:

54). To underscore the above observation, the Government also indicates that science and technology in the nation is currently underdeveloped as reflected by the science and technology index based on the low Gross Domestic Product (GDP) expenditure on science and technology as well as the low level of human resources involved in science and technology development (GRZ, 2006).

It is against the above background that an audit of the adequacy of provision of science teaching and learning materials in high schools was conducted to assess the extent to which the available teaching and learning materials could support science education.

1.2 **Statement of the problem**

The Government of the Republic of Zambia through the Ministry of Education recognizes the potential for science education in promoting technological development. To underscore this recognition, the government has advocated for the enhancement of the provision of the teaching and learning materials in practical, scientific and technology disciplines in most of the policy documents. However, notwithstanding the above recognition, we do not know if high schools are adequately provided with the necessary teaching and learning materials to enable them teach science effectively in order to establish a scientific and progressive society which can contribute to the advancement of technology as articulated in the Vision 2030.

1.3 Purpose of the study

The purpose of this study was to establish the current provision of teaching and learning materials in science subjects in high schools in Northern Province.

1.4 Specific objectives

The specific objectives of the study were:

i. to identify the current practices in the provision of teaching and learning materials in science subjects in high schools.

ii. to assess the state and adequacy of the existing physical infrastructure for teaching science in high schools.

iii. to establish the availability and adequacy of science teaching and learning materials through such indicators as pupil-book ratio; pupil-laboratory space ratio; and pupil-equipment ratio.

iv. to find out the challenges which schools face in the provision of teaching and learning materials in science subjects.

1.5 Research questions

The study was guided by the following research questions.

i. What are the current practices in the provision of teaching and learning materials in science subjects in high schools?

ii. What is the current state and adequacy of the existing physical infrastructure for teaching science in high schools?

iii. How available and adequate are the science teaching and learning materials through such indicators as pupil-book ratio; pupil- laboratory space ratio; and pupil-equipment ratio.

iv. What challenges do schools face in the provision of teaching and learning materials in science subjects?

1.6 **Significance of the study**

It is hoped that the findings of this study will provide information to the educational policy makers on how adequately the high schools are provided with teaching and learning materials in science subjects so that they can know the areas of need in terms of teaching and learning materials provision. Apart from that, it is hoped that the educational policy makers will make use of the findings to formulate a policy for the systematic provision of teaching and learning materials in science subjects. Furthermore, the findings of the study will go a long way in improving how high schools manage their programmes for the provision of teaching and learning materials in science subjects. It is also hoped that the study will add to the body of knowledge on the educational policy regarding provision of materials for science education.

1.7 Delimitations of the Study

This study was conducted in the Northern Province of Zambia. The sample comprised only government high schools.

1.8 Limitations of the Study

The study was characterised by the limitations which are related to generalisation. One of the limitations was that the generalisation of the study was limited to rural high schools since the research was conducted in Northern Province which is rural a province. The other limitation was that it was not easy to generalise the availability or rather non-availability of the teaching materials because it was difficult to take stock of each and every teaching and learning material in the science department. Only selected teaching and learning materials, for the sake of convenience, were investigated.

1.9 Operational Definitions

The following concepts are used in this study as defined below.

Curriculum:	The subjects that students study at a particular school or college.
Decentralisation:	The process of taking power from a central government and giving it to several smaller and more local authorities.
Gross Domestic Product:	The total value of all goods and services produced in a country in a year, except for income received from money invested in other countries.
Policy:	A set of plans or actions agreed on by a government, political party or other group.
Science:	The study and knowledge of the physical world and its behaviour that is based on experiments and proven facts and is organised into a system.

Teaching and Learning Materials: Apparatus, equipment, reagents and laboratory space and text books needed to teach science.

Laboratory: A room or place with appropriate equipment for teaching science or scientific work.

Botanical garden: An area, often open to the public in which exotic, rare or scientifically interesting plants are grown and studied.

Model: A copy of an object, especially one made on smaller scale than the original.

First generation school: Secondary/high school built before and during the period shortly after independence.

Secondary generation school: Secondary/high school created by upgrading a basic school.

Improvisation: Making a substitute for something out of the materials that happen to be available at the time.

ORGANISATION OF THE STUDY

This dissertation is divided into six chapters. The first chapter is the introduction and aims at establishing the problem that leads to the study. This chapter also identifies the study area, explains the significance of the study and bears information obtained from the initial review of literature.

The second chapter reviews related literature on the provision of teaching and learning materials in science subjects. Chapter two, basically, comprises the literature which was reviewed to identify and refine the research problem.

Chapter three discusses the methodology employed in the study. It outlines how the research was conducted in terms of its design, target population, research sample and sampling procedure, research instruments, data collection and analysis procedures as well as ethical considerations.

In the fourth chapter, research findings are presented in both qualitative and quantitative ways. Tables are used in the quantitative presentation of data. The fifth chapter is the interpretation and discussion of the research findings presented in chapter four.

Finally, chapter six presents the conclusion and recommendations based on the findings of the study. The recommendations are directed to relevant authorities and interested persons. The chapter ends with a suggestion for future research to prospective researchers. The subsequent pages consist of the references and appendices.

CHAPTER TWO: LITERATURE REVIEW

2.0 **Overview**

This chapter begins by outlining the context under which science education is taught in Zambian high schools. Furthermore, it explores the literature documented on the availability of teaching and learning materials in science subjects in secondary schools on the global, continental as well as national levels. It also outlines the challenges associated with the provision of learning and teaching materials. The chapter ends by discussing policies with reference to the provision of teaching and learning materials.

2.1 **The Context under which Science Education is provided in Zambian high schools**

2.1.1 **The High School Science Curriculum and Assessment**

The Zambian High School course is a three (3) year programme running from Grade 10 to Grade 12. At the end of this course of study, candidates are expected to sit for the School Certificate Examination which is equivalent to the General Certificate of Secondary Education Ordinary Level (GCSE O' Level) in the United Kingdom.

The high school science curriculum which was reviewed in 2003 offers a number of science disciplines which include physics, chemistry, biology and agricultural Science (MoE, 2003). The fact that agricultural science is an applied science sets it apart from other sciences. Agricultural science is usually taken as an optional subject and currently, very few schools are offering it.

As for the other three subjects, they are spread over two broad syllabi namely the Pure Science syllabus and the Science syllabus. The pupils who take the Pure Science syllabus are required to study chemistry, physics and biology. The chemistry and physics content, in this syllabus, have more challenging topics and activities to be learnt as compared to the other syllabus. The candidates are also expected to sit a practical examination in addition to the theory one. The practical examination is also there in biology. The Curriculum Development Centre, (CDC) has identified a number of practical laboratory skills in which pupils are expected to be examined. According to the Science and Technology Conference of 1982, it was recommended that the Pure Science syllabus be offered to learners who possess high intellectual capability in science as reflected by their performance in science and mathematics in the Junior Secondary School Leaving Examination (JSSLE) taken at the end of Grade 9 (Mwale, 1986). In essence, the candidates who study Pure Science at high school are being prepared to take up advanced studies in such fields as engineering, mechanics, medicine, mining, agriculture, computer science, and technology as well as advanced academic studies in physics, chemistry and biology in institutions of higher learning.

With regard to the Science syllabus, pupils study chemistry, physics and biology. Though practical work is meant to be the basis of teaching in all the science subjects, candidates who follow this syllabus do not sit practical examinations in chemistry and physics. However, they too write a practical examination in biology. In fact, the biology syllabus is the same as the one under the Pure Science option. This science syllabus is recommended for pupils whose performance in the Junior Secondary School Leaving Examination, in science and mathematics, is just satisfactory. Such pupils end up studying non-specialised programmes in science or other fields in higher learning institutions.

With reference to the science practical examinations, an alternative to practical examination is available. 'Alternative to Practical' is a written paper which examines the knowledge of practical work. It is meant for candidates in schools which do have the facilities, chemicals and equipment for hands-on practical work (Mwale, 1986). This examination is only available in Chemistry and Physics.

The preparation of the Zambian high school curriculum is the mandate of the Curriculum Development Centre. This institution formulates the curriculum and later breaks it down into syllabi in line with the Ministry of Education policies on education. The Curriculum Development Centre also recommends and approves the necessary text books for use in high schools.

The current High School science curriculum was documented in 2003 (MoE, 2003). The syllabi, too, were outlined at that time. In fact, these syllabi are the first syllabi to be prepared by the Ministry of Education. Prior to 2003, high schools were advised to follow the GCSE Syllabi University of Cambridge Examination syndicate. Teachers were, however, advised to leave out some topics from the syllabi. The teaching was inconsistent and haphazard because teachers were not sure of which sections to leave out. In fact, teachers only taught the sections of the syllabus which were examined most frequently. The current science syllabi are, however, precise and most of the content is localised.

With regard to assessment at Grade 12, it is the mandate of the Examinations Council of Zambia (ECZ) to set the examinations in all the science subjects. The Examinations Council also certifies the candidates.

2.1.2 **Organisation of Science Education in Schools**

The organisation of science education in high schools is such that each school should have a department of Natural Sciences in which chemistry, physics, biology and agricultural science are offered. This department is headed by the head of department whose minimum professional qualification is a Bachelors' degree in a science subject. In large schools, the department is subdivided into sections for chemistry, physics, biology and agricultural science. Each section is, thus, supervised by the head of section who reports to the head of department. In small schools, however, the organisational structure is such that all the teachers in the department report directly to the head of department.

The head of department supervises all the science activities in the department. He/she chairs departmental meetings and advises the school head teacher on the current status of the department with reference to science teaching and learning materials so that the school can institute school policies which will help to improve the teaching of science in the school.

The department of Natural Sciences is expected to hold regular meetings to review the performance of the department. It is at such meetings that the members of staff review the successes scored in the teaching of science over a particular period of time. The challenges faced by individual teachers and the department as a whole are also discussed. A departmental meeting also serves as a forum for planning for activities to be undertaken at departmental level such as Continuing Professional Development (CPD) activities. Policies relating to the efficient utilisation of the available science teaching and learning resources are also formulated during such meetings. Examples of such policies include guidelines on lending of text books to pupils as well as time tables for utilisation of laboratories by different classes. Furthermore, departmental meetings are also called so that members of staff can draw up budgets for the cost of running the activities and the procurement of teaching and learning materials. It is recommended that teaching and learning materials be replenished regularly to avoid disruptions in the provision of quality science education in the school.

Every high school in Zambia is expected to have a minimum number of four (4) science laboratories, that is, the chemistry, physics, biology and agricultural science laboratories. According to the current establishments, each school should be served by at least one Assistant Laboratory technician who is competent not only in scientific knowledge, at high school level but also in practical skills to enable him/her conduct special experiments as well as laboratory servicing and ensuring laboratory safety and security. The Assistant Laboratory technician is also expected to carry out maintenance, repair and construction in the science laboratory.

Policies with regard to the provision for science education vary from school to school. While some schools prefer to prepare annual estimates of departmental needs, other schools draw up estimates to cover a one term period. However, whatever the nature of the policy which characterise a particular school in terms of preparing estimates for departmental needs, all high schools have similar requirements. These requirements include the estimates of the global sum, which are the needs of the departmental sections put together. Apart from that, they budget for equipment costs which include items of a non-consumable nature. Furthermore, science departments also budget for running costs required to replenish stock of reagents and other expendable materials. The cost of stationery and that of text books is also taken care of. Other areas of concern are the cost of running Continuing Professional Development (CPD) activities as well as local purchase fund or petty cash to meet the cost of purchases of small items and perishable goods. Science departments also need to budget for living organisms to be used as specimens and also replacement of apparatus which have been destroyed and those which have become dysfunctional. Lastly, the department should prepare estimates of the cost of practical examinations.

2.1.3 **Provision of Teaching and Learning Materials in Science Subjects**

The Government of the Republic of Zambia (GRZ) is committed to adequate provision of science teaching and learning materials. MoE (1992) notes that the priority in resource allocation, was to be given to the rehabilitation of science laboratories and specialist rooms, provision of text books and other miscellaneous teaching and learning materials, and re-equipping science laboratories and providing consumables.

The procurement of science teaching and learning materials, in high schools, was prior to decentralisation the role of the procurements unit at the Ministry of Education headquarters. The policy later changed in order to enhance efficiency and effectiveness in the teaching and learning materials provision. The management and functions of the Ministry of Education were decentralised under the Public Service Reform Programme (PRSP) which was launched in 1993 by the Government of the Republic of Zambia. Decentralisation implied the devolution of power and authority from a more central office to the local authorities in the districts (MoE, 1995). This further meant shifting of power from the national and provincial Headquarters to the points of delivery which are the districts, colleges and schools. The decentralisation policy brought about the creation of Education Boards (EBs) at the district, college and high school levels. With reference to the provision of teaching and learning materials, the high school board was and is still the legal structure established to see to it that national educational standards are maintained through such educational indicators as pupil-text book ratio and pupil-teacher ratio (MoE, 1995). In other words, the high school board has been charged with the task of mobilising and allocating educational resources for the school for which it was established, on the basis of need.

Mwale (1986) observes that the government is the largest source of education finances. The other sources are aid agencies, Parents and Teachers Associations (PTAs), donations as well as revenues generated through fundraising ventures undertaken by the School Boards.

With regard to the Ministry of Education expenditure on education, most of the financial resources are spent on remuneration to the employees in the ministry. Only a negligible share of the resource is allocated for teaching and learning materials (MoE, 2006).

The majority of the science teaching and learning equipment which are utilised, in high schools, are manufactured in countries abroad and overseas. Schools are only able to access them when the ministry procures them, or when they are made available by private suppliers of educational materials. However, one wing of the Ministry of Education, the National Science Centre, is mandated to produce science equipment from local resources. This institution manufactures low cost equipment and apparatus through its satellite centres located in Lusaka, Choma and Mungwi districts under the auspices of aid agencies.

In 1977 and 1992 the government recommended the liberalisation in production of educational materials (MoE, 1977; MoE, 1992). Consequently, a good number of privately owned firms have been manufacturing educational materials for science, especially consumables like laboratory reagents.

With regard to science text books, the Ministry of Education has from time to time organised a number of projects to produce recommended text books under the auspices of Aid Agencies like the Danish International Development Agency (DINIDA), the Swedish International Development Agency (SIDA) and the Overseas Development Agency (ODA). Such text books, once published, are distributed freely to High Schools. On the other hand, the Zambia Education Publishing House (ZEPH) also publishes a number of text books authored by individuals as well those written under the Ministry of Education projects. These books are made available for sale to schools. Some recommended text books are, however, authored and published in other countries and so they are only stocked by private suppliers of educational materials from which individual schools can purchase them.

2.2 Studies on the availability of teaching and learning materials in science subjects

The need for the provision of adequate teaching and learning materials in science subjects, in high schools, is not unique to developing countries like Zambia. This section outlines the literature which was reviewed on the availability of teaching and learning materials in science subjects on a global level, in Africa as well as at national level.

2.2.1 **Global statistics on the provision of teaching and learning materials in science subjects**

In Brunei Darussalam, a study conducted to assess science education provision in secondary schools revealed an appreciable provision of teaching and learning materials in a developing economy. The survey studied the availability of teaching and learning resources in science subjects in four categories of schools namely science schools, government schools, non-government schools and Arabic schools. The survey reported that there were variations among the schools in terms of the availability of resources in science subjects. Government schools had the largest laboratory space followed by non-government schools, and then science schools with the least laboratory space found in Arabic schools (Sharifah, 1999). Furthermore, the study indicated that equipment for practical work was most adequate in science schools followed by non-government schools and then the Arabic schools. As for the supply of consumables, again the science schools were found to have had the highest supply followed by government schools and then Arabic schools with non-government schools recording the lowest supply of consumables.

Generally, 95% of the teachers found the laboratory space adequate with a small percentage from science and Arabic schools reporting that it was inadequate. As for equipment and consumables 89% of the science teachers in the schools studied indicated these materials were adequate with a small percentage from Arabic schools reporting that they were not sufficient. These findings point to the fact that teachers were satisfied with the availability of laboratory space as well as the equipment and consumables for teaching science.

With regard to text books, the survey revealed that all the schools had libraries though the availability of science books varied from one school to another. Sharifah (1999: 157) observed “despite the government providing a free text book loan to students, in one school there were no text books for combined science”. And to go round this problem, the teachers were using books for chemistry and biology. The revelation from the above findings shows that science text book provision in Brunei Darussalam secondary schools was below the schools’ requirements.

In a similar study conducted to investigate the advances and obstacles to reform in science education in secondary schools in Mexico by the World Bank, Garritz and

Talanquer (1999) reported that between 25% and 33% of the schools studied lacked laboratories or workshops for the teaching of natural sciences. The report added that 33% of these schools did not have teaching aids related to televisions and even worse still 10% did not have libraries. Therefore, though the education system of Mexico is advanced as compared to that of most emerging economies, the problem of provision of science education materials is evident.

A survey on the availability of science text books in junior and senior high school conducted in South America in 1990-1 revealed that only 32% of the pupils had text books (Montagnes, 2000). The survey noted that variations among countries ranged from 64% in Chile to 20% or less in Ecuador, Peru, and Venezuela. In Mexico the figure rose to 75% due to a national text book programme. On the other hand, in Brazil it was estimated at about 33%. The survey also brought out the fact that generally, text book provision was better in cities than in rural areas.

Another study conducted in Bulgaria to assess the availability of text books and other teaching and learning materials, in secondary schools, showed that the country was facing challenges in educational materials provision. Kingham (1998) reported that Bulgaria found itself in this situation because the nation was in its economic transition from the after-effects of the Soviet socialism. The book sector and other teaching and learning materials' availability had suffered particularly as a result of the collapse of the centralised distribution, subsidised low pricing and the absence of commercial criteria. The report of this study indicates that national educational policies have a direct influence on the availability of teaching and learning materials in schools.

2.2.2 **Statistics on the provision of teaching and learning materials in science subjects in Africa**

Studies conducted, in African countries to evaluate the provision of teaching and learning materials in science subjects have provided varied results in terms of materials availability.

A study conducted to investigate the resources allocated to science in secondary schools, in Nigeria between 2003 and 2006, indicated that the resources allocated to the aforementioned subject disciplines were inadequate irrespective of the subject (Uche et al, 2011). The study recommended an increase in the allocation of teaching and learning materials, laboratory equipment, text books and experienced teachers so that inadequate resources do not hinder the provision of quality education in the schools. Furthermore, the study also revealed that the total cost of materials, which are laboratory materials, teaching aids and supplies, to which students were exposed in the sciences, over a three year period they were taught these subjects, indicated a low mean material cost per student. These findings show that the schools were far from being equipped with the necessary materials to teach science, technology and mathematics. In addition to the above, this study also revealed an inadequate book per student ratio. The study concluded by indicating that the Nigerian government's emphasis on science, technology and mathematics education (STME) has not been matched with adequate resource allocation to the STME subjects.

A pilot survey of schooling conditions in eight least developed countries of Africa conducted by UNESCO and UNICEF found that half the pupils in secondary schools had no text books (Montagnes, 2000). The study reported that few books were available in Angola, Tanzania and Zambia; in Kenya, Nigeria and Sierra Leone the pupil: text book ratios were between 10:1 and 28:1 implying that one or two text books per class. Furthermore, the survey noted that rural schools generally fared worse than urban ones in terms of how they were equipped with science materials and that the conditions were far from being adequate. Now this is a dismal picture because science teachers depend heavily on text books as science concepts are generally challenging.

Legotho, Maaya and Sebogo in their studies of causes of poor performance in science among pupils in the matriculating students, in a rural province in South Africa, found that the major causes included problems concerning the implementation of the educational policies, inadequate parental involvement, lack of pupil discipline and poor attitude towards science as well as inadequate facilities for science teaching in the schools (Legotho, Maaya and Sebogo, 2002). These findings point to the fact that secondary schools in rural South Africa are not adequately provided with teaching and learning materials.

In Botswana, the picture is somehow bright. Some secondary schools are provided with the resources needed to teach science while the science facilities in other schools are not adequate. In a study conducted by Yandila, Komane and Moganane to investigate the implementation of the Learner Centred Approach (LCA) in the Botswana General Certificate of Secondary Education (BGCSE) syllabus in science lessons, most of the teachers effectively used a variety of teaching and learning aids in their lessons and were successful in achieving their objectives (Yandila, Komane and Moganane, 2001). These teaching and learning aids were both commercially and teacher-made. However, the same study revealed that most of the school laboratories were not fully equipped in terms of equipment, furniture, specimens, apparatus, chemicals and other consumables. Apart from that, most of the school laboratories were either in a state of disrepair or under construction and as a result some lessons were conducted in inappropriate rooms. Teachers from such schools were not making an effort to inculcate the recommended science process skills of using and organising apparatus and/or materials, collecting data, handling experimental observations and planning for investigation.

2.2.3 **Statistics on the provision of teaching and learning materials in science subjects in Zambia**

Studies conducted, in Zambia, on the provision of teaching and learning materials in science subjects, in high school, are quiet few. In fact, even those that have been done, none has clearly documented quantitative information on the availability of science teaching and learning materials in high schools.

In a comment on the state of the science facilities in high schools MoE (2004) notes that, the laboratories and other practical rooms have fallen into a state of disrepair. The Ministry of Education further observes that "almost no investment has been made in the last 10 years to counter the situation" (MoE, 2004:26). In other words, the above observation points to the fact that the poor state of the laboratories and lack of equipment and chemicals have greatly contributed to low level of quality in science education in high schools. Further, GRZ (2006) points out that the poor investment in education has led to high text book-pupil ratio of 1: 1.3 at primary school level and 1:7 at high school level in different subjects.

The study carried out to describe the experiences of grade 12 pupils in the School Certificate Biology Practical examinations, at a certain high school in Central Province, revealed that the examinations were characterised by a provision of inadequate materials and facilities, and a lot of improvisation (Mudenda, 2008). The materials and facilities being referred to here include laboratory space, equipment, reagents, and specimens as well other consumers. The findings indicated that inadequate provision of materials impacted negatively on the respondents' academic performance in the practical paper. Apart from that it also acted a catalyst for examination malpractice as candidates were very often in contact with each other and could thus consult one another. The study, furthermore, reported that the candidates failed to use improvised equipment to obtain results that were consistent with the examination setters' prescribed materials. In addition to the above, the study also discovered that the candidates did not display competency in basic manipulative skills involved in practical work such as manipulation of variables and observation. This observation is evidence that candidates were not given enough experience in practical work in the biology lessons.

In her study to investigate the relationships between school managers and teachers and its effect on the teaching of science in high schools, Phiri (2007) notes that 96.3% of the teachers indicated that the good relationship they enjoyed with the school managers inspired them to teach science better. However, 78.8% of the teachers pointed out that the equipment in their science laboratories was inadequate and this discouraged them from teaching effectively. In fact, the study reported that in one school a teacher indicated that one of the problems characterising science teaching in high schools was lack of prompt response by head teachers to departments' requests for materials needed in the science laboratories. The head teachers, on the other hand, pointed out that apart from lack of laboratories and apparatus, the science teachers' performance and consequently poor pupil performance in science was a result of a number of factors which included lack of preparation by the teachers, poor pupil background and sheer laziness on the part of the pupils. With regard to science facilities, the respondents attributed lack of these facilities to inadequate funding from the government. These findings suggest that some high schools operate without proper laboratories and even where they exist, these facilities are not adequately equipped forcing teachers to resort to improvisation of materials to facilitate science teaching.

In a study conducted to investigate the problems of teaching science, in Zambia, with special reference to the language of instruction Chibesakunda (1983) also notes that the language of instruction plays an important role and remains a critical issue in most developing countries. The study observed that secondary school teachers have to teach science but with the added difficulty of doing so in a foreign language especially that emphasis is placed on grasping scientific concepts which do not exist in the local language. Furthermore, the study revealed the fact that in addition to language of instruction, the other challenges faced by science teachers include heavy teaching loads, low pupil motivation, low salaries, lack of school policy as well as lack of science equipment, books and poor facilities. This study also emphasised the fact that high schools have been experiencing the problem of shortage of teaching and learning materials for some time now. 8

2.3 **Challenges associated with the provision of educational resources in science subjects**

The provision of teaching and learning materials in science subjects in high schools has been faced with different kinds of challenges depending on the strength of a nation's economy. However, these challenges are more pronounced in developing economies. Generally, the following factors have impeded the provision of teaching and learning materials in science subjects in high schools:

- Financial constraints
- Lack of production capacity
- Difficulties in distribution
- Lack of human resources with knowledge of production
- Problems of donor coordination

2.3.1 **Global Statistics on challenges associated with science materials provision**

In a global survey on teaching and learning environment, Montagnes (2000) observed that "globally, the supply of educational materials was impeded by lack of funding, conflicting government priorities, difficulties in distribution, and lack of trained personnel. The provision of materials in many countries still depended on cyclic infusions of external aid that concentrated on production of a commodity without building the related infrastructure".

Montagnes (2000), furthermore, reporting in an EFA assessment observed that the Baltic countries (Luthiana, Latvia and Estonia) whose economies have been improving are still fragile and the shortage of disposable income affects the production and dissemination of educational materials (EMs). The same report observed that for the Visegrad countries (Czech Republic, Hungary, Poland and Slovakia), the production and provision of educational materials (EMs) has been strongly influenced by educational reforms of those countries. In the same way, central and eastern Europe has been affected by the political changes which brought in widespread initiatives for economic and social reforms. Generally, distribution of educational materials is a common problem to most countries in the region (Montagnes, 2000). This observation implies that though these countries have the capacity to produce the needed teaching and learning materials, they face challenges in distributing them to needy schools.

2.3.2 **Statistics on challenges associated with materials provision in science subjects in Zambia**

In Zambia, Kalumiana (2007) reported that the provision of educational materials has suffered setbacks too as a result of many factors such as lack of adequate financial resources, lack of capacity by the local personnel to produce the educational materials, absence of clear educational materials policy as well as the over-dependence syndrome. The capacity to produce educational materials refers to the presence of printing and publishing houses, for text books, as well as firms to produce science equipment and chemicals. On the other hand, the dependence syndrome refers to reliance on the aid agencies who may wish to support an area of their choice such as curriculum design as opposed to educational materials production and distribution.

2.4 **Policies regarding provision of teaching and learning materials in science subjects**

2.4.1 **Global statistics on policies regarding provision of teaching and learning materials in science subjects**

Montagnes (2000) indicated that the standard of provision of teaching and learning materials in science subjects in countries outside the industrialised north deteriorated during the 1970s and the 1980s due to economic changes and inefficient government policies on educational materials provision. He added that in 1990, in Africa, Latin America and Asia, it was far below the acceptable standards though matters improved in the 1990s under the auspices of funding from international agencies.

Most countries in the developing world operated a centralised system of educational materials provision. This system is characterised by monopoly educational materials provision and in based on a central authority deciding what teaching and learning materials should be purchased for each school in the country (Lewin and Stuart, 2003). However, due to the fact that the centralised system of educational materials provision resulted in wastes because of the inertia and bureaucracy, Montagnes (2000) notes that three significant trends were observed worldwide in educational materials provision and these are:

- Decentralisation of selection and procurement
- Economic liberalisation with a greater role for the private sector, and
- Increased cost recovery to achieve systematic sustainability

In the Philippines, for example, a congressional commission reported that the department of education was highly centralised.... and its complex procedures in asset management resulted in loss and waste (Montagnes, 2000).

A report by Kingham (1998) noted that the collapse of the Soviet socialism which had practised centralised production and distribution of educational materials and subsidised low pricing resulted in a government which could no longer sustain the former structure resulting in the collapse of the educational materials infrastructure. This led to a shortage of all forms of educational materials.

On the other hand, decentralised supply of educational materials entails multiple choice educational materials and requires that a school orders what it requires. However, it has been observed that in most of the transitional economies, finances are so sufficiently constrained that some limitations are imposed either in the allocation of central procurement funds or through annual per capita budgets for individual schools (Lewin and Stuart, 2003). Generally, decentralised ordering by individual schools tends to be a more accurate reflection of school needs and is less wasteful of scarce resources than a centralised system. Montagnes (2000) indicated that liberalisation in educational materials provision which took root in the 1990s implied increased participation by private commercial entities in the production and distribution of teaching and learning materials with more and more parastatal companies closing down.

In Bulgaria, Kingham (1998) noted that the new system of privatisation opened up markets and a number of suppliers of educational materials came up. He indicated that the system is good in that schools can procure the materials they want though there are, still, problems associated with distribution.

Increased cost recovery, on the other hand meant the existence of a sustainable and competitive system of educational materials provision which can originate, produce and deliver the materials along commercial principles. The resulting inequalities can be addressed through increased educational budgets and subsidies (Montagnes, 2000).

The lack of clear policies regarding educational materials (EMs) provision has resulted into inconsistent supply of teaching and learning materials for science subjects in secondary schools in some countries. This problem was observed in Bulgaria where the provision of educational materials (EMs) in the country was facing difficulties because of lack of national policy as well as international legislation relating to educational materials (EMs) many of which had recently been signed, and are poorly understood by those who are supposed to implement them (Kingham, 1998).

The situation is different in Brunei Darussalam where the government has a policy of providing a text book loan to students. Sharifah (2000) noted that the reason why shortages exist in science books is because these materials are just imported from Singapore as the two nations follow similar syllabi. In addition to student loans, resource centres have been set up in selected schools and centres where teachers can borrow teaching and learning aids as well as materials to prepare science teaching materials.

2.4.2 **Statistics on policies regarding provision of teaching and learning materials in science subjects in Zambia**

In Zambia, the Ministry of Education (MoE) procures materials through two systems namely the decentralised procurement system (DPS) and the centralised procurement system (CPS) (Kalumiana, 2007). In the former system, the educational materials are procured by schools. Under this system, decisions are made by the teachers as they are the direct users of the materials and so they determine which materials are to be procured. In the latter system, the ministry headquarters purchases teaching and learning materials and then distributes them to schools. Kalumiana (2007) observes that prior to the Public Service Reform Policy (PSRP), the centralised procurement system was used more often but at the moment, the decentralised system is preferred.

In a study which was conducted to investigate the management of educational materials in basic schools, Kalumiana (2007) noted that 75.5% of the teachers and 90.9% of the head teachers interviewed favoured the decentralised procurement system citing the following advantages among others:

- Efficient delivery of educational materials (EMs)
- Enhancement of spirit of ownership and
- Procuring according to school's needs

Those who were not in support of the decentralised system cited insufficient government funding for their opinion.

With regard to the educational materials policy, in Zambia, MoE (1996: 88) indicated that the Ministry of Education would work together "with publishers and suppliers to ensure adequate supply of text books and other educational materials for use in schools. Further, the ministry would encourage the development of a strong and competitive local book industry". A study by Kalumiana (2007) revealed that there was collaboration among the different partners. For instance, the Book Publishers of Association of Zambia (BPAZ) and the Book Sellers Association of Zambia (BAZA) collaborated well with the Curriculum Development Centre (CDC).

Summary

The review of literature has shown that the availability of teaching and learning materials in science subjects, in high schools, varies from one country to another depending on the economic performance of that nation. In countries with good economic standing, the provision of teaching and learning materials in science subjects was better than in underdeveloped economies. The challenges associated with science educational materials provision include constraints related to financial resources, lack of local capacity to produce and distribute educational materials as well as absence of coordinated educational materials policies. In terms of educational materials policy, it was evident from the literature that most educational systems, especially in developing countries, are moving from centralised to decentralised systems of educational materials provision as well as towards economic liberalisation to allow for private sector participation in educational materials provision. As for Zambia, no study has been conducted in the Northern Province to investigate the provision of teaching and learning materials in science subjects so as to evaluate the adequacy of these materials for effective teaching of science in high schools.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 **Overview**

This chapter of the research describes the research design which was used as well as the target population, sample size and sampling procedure. It also outlines the data collection and data analysis procedures. The research instruments which were used are also described.

3.1 **Research Design**

The main objective of this study was to establish the adequacy of provision of science teaching and learning resources in high schools of the Northern Province. Therefore, in this study, a survey and descriptive study research designs were employed. A survey was chosen because surveys are appropriate for obtaining information that describes existing phenomena as well as obtaining information for exploring the existing status of one or more variables. Surveys are self-report studies which can be used for obtaining descriptive quantitative and sometimes qualitative data from the sample (Mugenda and Mugenda, 1999). The descriptive study techniques allowed for an accurate reporting of the findings.

3.2 **Target Population**

This research targeted all the high schools of the Northern Province. These schools included government, grant-aided as well as private schools. The study also targeted all the deputy head teachers and science heads of departments in the twenty five (25) schools.

3.3 **Research Sample and Sampling procedures.**

Since the study was a survey of high schools, the researcher thought it prudent to sample more schools and a limited number of respondents to provide information on policy and practices in science materials provision. Simple random sampling was used to sample twenty five (25) high schools from a total of thirty two (32) schools in the province. This procedure gave each school, in the province, an equal chance of being included in the sample. All the twenty five (25) schools which made up the sample happened to be government schools. The participants comprised fifteen (15) deputy head teachers and twenty five (25) heads of science departments from the same schools the schools bringing the total number of participants to forty (40).

3.4 **Research Instruments**

Since quantitative and qualitative data was to be collected in this research, and for the sake of triangulation, data was collected by means of questionnaires and observation schedules. Anderson (1990: 209) observes that "if well structured, a questionnaire permits the collection of reliable and reasonably valid data relatively simply, cheaply and in a short space of time". On the other hand, (Mugenda and Mugenda, 1999) notes that a researcher uses observation schedules to record what he/she observes during data collection.

3.5 **Data Collection Procedure**

Before going to schools to collect the needed information for the study, permission was sought from the relevant authorities who included the Provincial Education Officer, as well as the school head teachers.

Primary data was collected by means of questionnaires and observation schedules. The questionnaires were administered to the heads of the science departments to complete. The researcher used observation schedules to collect objective data by conducting a physical observation of the available science teaching and learning materials and the existing science infrastructure. During the observation process, the researcher recorded each item observed on the schedule as appropriate. The observational method of collecting data has the advantage of overcoming the limitations of the self-report methods of collecting data (Mugenda and Mugenda, 1999). On the other hand, secondary data was sought from library books, periodicals, lecture notes, published as well as unpublished dissertations and websites. Some of the secondary data was also obtained from institutions such as the Ministry of Education Headquarters and Curriculum Development Centre.

3.6 **Data Analysis Procedure**

The data, in this study, was analysed by employing both quantitative and qualitative data analysis methods. The Statistical Package for Social Sciences (SPSS) was used to analyse quantitative data as it can easily compute frequencies and percentages.

Qualitative data, on the other hand, was analysed by grouping it into categories according to emerging themes and then analysed critically and objectively in order for the researcher to interpret the information beyond the data gathered and, hence, make conclusions which are valid and reliable.

3.7 **Ethical Considerations**

In this study, the researcher took cognisance of ethical concerns. The researcher adopted an open and honest approach in which the respondents were asked to participate voluntarily and the information they provided was treated as confidential. Permission to conduct research in a given school was sought from the relevant educational authorities. The information obtained was strictly used for the purpose of research (see Appendix M).

CHAPTER FOUR: PRESENTATION OF RESEARCH FINDINGS

4.0 **Overview**

This chapter presents findings of the research on the provision of teaching and learning materials in science subjects in the high schools of Northern Province. The presentation of the findings is done under the headings drawn from the objectives of the research. The information presented in this chapter is organised into two that is, the findings from the questionnaires and the findings obtained by the use of observation surveys. The first category of findings comprises views from deputy head teachers and science heads of departments on the provision of science teaching and learning materials in high school. On the other hand, findings from observation surveys comprise information on the availability of science teaching and learning materials.

4.1 **Findings from questionnaires**

This section presents findings which were obtained, using questionnaires, from the deputy head teachers and science heads of departments on the provision of science teaching and learning materials in the high schools of Northern Province. The section includes the demographic characteristics of the respondents, the availability and adequacy of science teaching and learning materials. Furthermore, the findings describe the current practices in the provision of teaching and learning materials in science subjects in high schools; the challenges faced by schools in the teaching of science and the measures taken to cope with the challenges.

4.1.1 **Characteristics of respondents**

Fifteen (15) deputy head teachers and twenty five heads of science departments participated in the survey bringing the total number of participants to forty (40). Of these only 8 (20%) were females. Four of the participants had Bachelor of Education (Secondary) degree, 2 had advanced diplomas, while 5 had secondary science teachers' diploma. Twenty nine had Bachelor of Arts degrees. On the other hand 7 had been teaching for 6 – 10 years while 33 (82.5%) of them had been teaching for more than ten (10) years.

4.1.2 **Current practices in the provision of teaching and learning materials in science subjects in high schools**

Table 1 below shows that very few schools regularly procured teaching and learning materials for science subjects, other than those meant for practical examinations, since the advent of the decentralisation policy.

Table 1**:** Year when the school last purchased science materials

Response	Frequency	Percent
Can't remember	14	56.0
2011	1	4.0
2010	4	16.0
2009	2	8.0
Before 2009	4	16.0
Total	25	100.0

4.1.2.1 **System of procurement of science teaching and learning materials**

On whether their school had a consistent programme of procurement of science teaching and learning materials to replace those that were used up as well as those that were breaking down, 22 (88%) respondents indicated that they did not have such a programme in place; 1 (4%) indicated that there was a replenishing programme in the school while 2 (8%) indicated that they were not sure. Furthermore, on who is in charge of procuring science teaching and learning materials, 14 (56%) respondents indicated that officers other than the head teacher, science head of department or procurement officer were in charge of procuring science teaching and learning materials. These officers included ordinary teachers appointed to take up the role of procuring school requisites among others. The study also revealed that 22 (88%) participants responded that they were not satisfied with the procurement system in their schools. Most of the respondents were of the view that the science heads of department or any science teacher should procure science materials. Furthermore, the study revealed that only one school purchased most of the science apparatus, equipment, reagents and text books from the National Science Centre. Twenty four (96%) of the surveyed schools purchased the science materials from private suppliers.

However, all the 15 (100%) deputy head teachers had indicated that they knew about the existence of the National Science whose mandate they had said was to produce low cost science teaching and learning aids. On whether there were some science teaching and learning materials that were still centrally procured for their school by the Ministry of Education headquarters, the study revealed that 16 (64%) of the respondents indicated that there were no such materials whereas 9 (36%) indicated that they were not sure.

Table 2**: Who procures school science materials?**

Title of officer	Frequency	Percent
Head teacher	1	4.0
Head of Department	3	12.0
Procurement officer	7	28.0
Other	14	56.0
Total	25	100.0

4.1.2.2 **Views as to whether practical work plays a significant role in assisting the pupils to understand science concepts more meaningfully**

The study revealed that all the 25 (100%) heads of departments indicated that practical work played a significant role in assisting the pupils to understand science concepts more meaningfully. However, 17 (68%) indicated that they rarely engaged pupils in practical work while 8 (32%) of them responded that they did not engage pupils in any practical work at all. The reasons for not conducting practical work included lack of apparatus, equipment, reagents and over-enrolments in classes. As a result most of the teachers resorted to demonstrating experiments in front of the whole class.

4.1.3 **Challenges faced in the teaching of science and measures taken by schools to cope with the challenges**

The participants indicated that the main challenges faced in the teaching of science were lack of government funding towards science materials. Others included lack of quality science apparatus, equipment, reagents, text books and laboratories. The other main challenge was over-enrolment of pupils as shown in tables 3 and 4. To cope with the above challenges, some schools had embarked on constructing laboratories using schools grants while some were encouraging science teachers to improvise teaching and learning materials. On the other hand some schools were holding school-based in-service activities on science materials production. Furthermore, some respondents indicated that teachers have also resorted to improvising apparatus and equipment. With regard to suggestions about the ways in which schools could improve the provision of science teaching and learning materials under the decentralisation policy, the participants suggested that the government and school administrations should allocate sufficient funds towards procurement of science equipment, apparatus and chemicals in schools. Furthermore, schools should discuss with Parents and Teachers Associations (PTAs) to allocate a portion of the user fees towards the procurement of science apparatus and equipment, chemicals, text books and the construction of laboratories to supplement government funding. Furthermore, in-service training programmes (INSET) for the production of teaching and learning materials for science subjects must be encouraged in schools. It was also suggested that the government should consider introducing special incentives such as allowances to motivate science teachers.

Table 3 below shows that the maximum number of classes for each grade was ten (10) while the minimum was 2 classes. The largest number of classes was among the first generation schools. These are high schools which were built before and shortly after independence. They were built with all the facilities that go with a high school. On the other hand, second generation schools are high schools which have recently been created after upgrading basic schools.

Table 3**: Number of classes per grade per school**

Grade	N	Minimum	Maximum	Mean
Grade 10	25	2	10	5.52
Grade 11	25	2	10	5.68
Grade 12	25	2	10	5.54

Key
N = number of schools
Minimum = minimum number of pupils per class per grade
Maximum = maximum number of pupils per class per grade
Mean = average class size per grade per school

Table 4 below shows that, generally, classes for all the three grades were large with the largest being grade 12 classes. This indicates that there was over-enrolment of pupils above the standard number of thirty five (35) pupils per high school class. All the average numbers of pupils per class for all the grades were higher than thirty five (35).

Table 4**: Size of class per grade per school**

Grade	N	Minimum	Maximum	Mean
Grade 10	25	46	65	53.12
Grade 11	25	43	73	56.36
Grade 12	25	41	71	57.12

Key
N = number of schools
Minimum = minimum number of pupils per class per grade
Maximum = maximum number of pupils per class per grade
Mean = average class size per grade per school

4.1.4 **Availability of teaching and learning materials in science subjects**

Thirty nine (97.5%) of the participants indicated that teaching and learning materials in science subjects in the schools were inadequate. Similarly, all of the 25 (100%) heads of departments described the pupil-text book ratios, in the science subjects, as very high. The ratios of pupils to science apparatus and equipment such as beam balance, microscope, pipette, etc were also described as very high. This was confirmed by the researcher from the observation survey in which it was established that the availability of the teaching and learning materials in science subjects was generally low (see Appendix A). Even where they were available, these materials were inadequate.

4.2 **Findings from Observation surveys**

These findings describe the information which was obtained using observation schedules on the provision of teaching and learning materials in science subjects in the high schools of Northern Province. This information comprise the actual quantities of some selected science apparatus and equipment, in the high schools, as well as all the science text books which have been approved and recommended by the Curriculum Development Centre (CDC) for use in Zambian high schools. The pupil-text book and pupil-apparatus ratios are also reported.

4.2.1 **Quantities of selected science apparatus and equipment per school**

The findings from the observation surveys revealed that the schools did not have adequate apparatus and equipment. As shown in Appendix A, all the schools surveyed did not have voltameters, insect/mammal cages as well as botanical gardens. Appendix A also shows that the most abundant piece of apparatus was the hand lenses which had an average number of 61.60. Though this mean is bigger than the average number of pupils per class, it is still insignificant considering the fact that the average number of classes was 5.52 for grade 10 classes, for example. 61.60 hand lenses translate into a pupil-apparatus ratio of 14:1. The other pieces of apparatus which were relatively abundant were optical mirror and conical flask which had average numbers of 30.12 and 26.64 respectively. However, these too were far below the average number of pupils per class.

Table 5**: Quantities of approved and recommended Chemistry text books per school**

Title	N	Minimum	Maximum	Mean
Chemistry 10 Pupil's book	25	0	71	12.72
Chemistry 11 Pupil's book	25	0	66	8.60
Chemistry 12 Pupil's book	25	0	75	21.00
GCSE Chemistry	25	0	5	1.12
Certificate Chemistry	25	0	9	1.08
O' Level Chemistry	25	0	0	.00
Chemistry Made Clear	25	0	1	.08
Beginning Science-Chemistry	25	0	0	.00
Coordinated Science-Chemistry	25	0	0	.00
Balanced Science 1	25	0	3	.80
Balanced Science 2	25	0	3	.72
Science in Zimbabwe	25	0	0	.00

Key
N = number of schools
Minimum = minimum quantity of each title per school
Maximum = maximum quantity of each title per school
Mean = average quantity of each title per school

Table 5 above shows that chemistry text books were generally inadequate. The highest average number of text books which was recorded was for Chemistry 12 (21.00) and Chemistry 10 (12.74). These figures are very low considering the average number of pupils per class for grade 12 (57.12) and grade 10 (53.12) as shown in Table 4 above. 21:00 copies of Chemistry 12 translate into a pupil-text book ratio of 23:1. The school with the highest number of chemistry text books had seventy one (71) copies of Chemistry 10. However, this figure also indicates inadequate supply of this text book against the average number of grade 10 classes which was 5.52 with an average pupil number of 53.12 pupils per class, as indicated in Table 3. The study also revealed that there was no school which had a copy of Science in Zimbabwe, O' Level Practical Chemistry, Beginning Science-Chemistry and Coordinated Science-Chemistry.

Table 6**: Quantities of approved and recommended Physics text books per school**

Title	N	Minimum	Maximum	Mean
Physics 10 Pupil's book	25	0	93	12.36
Physics 11 Pupil's book	25	0	0	.00
Physics 12 Pupil's book	25	0	0	.00
Physics for Life	25	0	4	.44
GCSE Physics-4th Edition	25	0	5	1.64
Principles of Physics	25	0	6	2.20
Explaining Physics	25	0	3	1.52
O' Level Physics	25	0	0	.00
New Coordinated Science- Physics	25	0	0	.00
Beginning Science-Physics	25	0	1	.08
Senior Physics 8	25	0	2	.08
Senior Physics 9	25	0	0	.00

Key
N = number of schools
Minimum = minimum number of pupils per class per grade
Maximum = maximum number of pupils per class per grade
Mean = average class size per grade per school

Table 6 above shows that there was low availability of physics text books in the schools. The school which had a relatively high number of physics books had ninety three (93) copies of Physics 10. Table 8 above shows that this number is equivalent to an average number of 12.36 books per school and it translates into a pupil-text book ratio of 23:1. All the other schools had less than ten (10) copies of the other physics text books. Taking into consideration the average number of pupils per grade 10 class (53.12), for example, ninety three (93) copies would only be enough for one and half classes. This implies that the other classes would not have any Physics 10. The findings of the study also revealed that there was no school which had Physics 11 and 12, New Coordinated Science-Physics, O' Level Physics, Physics for Life and Senior Physics 9.

Table 7**: Quantities of approved and recommended Biology text books per school**

Title	N	Minimum	Maximum	Mean
Biology 10 Pupil's book	25	0	263	40.72
Biology 11 Pupil's book	25	0	78	17.24
Biology 12 Pupil's book	25	0	175	40.56
GCSE Biology	25	0	4	1.44
Biology "Jones and Jones"	25	0	6	.64
Biology-A Modern Introduction	25	0	35	2.56
Beginning Science-Biology	25	0	0	.00
Coordinated Science-Biology	25	0	0	.00
Biology For Life	25	0	21	1.16
The Living World	25	0	0	.00

Key
N = number of schools
Minimum = minimum number of pupils per class per grade
Maximum = maximum number of pupils per class per grade
Mean = average class size per grade per school

Table 7 above shows that there was no single school which had copies of Beginning Science-Biology, Coordinated Science-Biology and The Living World text books. The copies of the other titles were also in short supply. Only two schools had relatively sufficient quantities of Biology books. One school had 263 copies of Biology 10 while the other had 175 copies of Biology 12. However, the average number of Biology 10 (40.72) was lower than the average number of pupils per grade 10 class (53.12). This number of Biology 10 books translates into a pupil-text book ratio of 7.2:1. Similarly, the mean number of Biology 12 (40.56) was less than the mean number of pupils per grade 12 class (57.12). This indicates that the two books were also in short supply.

Table 8 below summarises the statistics for the most abundant teaching and learning materials.

Table 8: **Summary statistics for the most abundant teaching and learning materials in science subjects**

Item	Average quantity
Magnifying lens	61.60
Optical mirror	30.12
Conical flask	26.64
Biology 10 pupils' book	40.72
Chemistry 10 pupils' book	21.00
Physics 10 pupils' book	12.36
Pupil-apparatus ratios	
Item	**Ratio**
Magnifying lens	14:1
Pupil-book ratios	
Title	**Ratio**
Biology 10 pupils' book	7.2:1
Chemistry 10 pupils' book	14:1
Physics 10 pupils' book	23:1

4.2.2 Adequacy and state of physical infrastructure for teaching science

The findings of the study revealed that 13 (52%) of the schools had no science laboratories while only 12 (48%) had laboratories. Eight (66%) of these laboratories were in a dilapidated state and lacked essential apparatus, equipment, storage facilities and furniture. This fact partly explains why 8 (32%) of the respondents had indicated that they did not engage pupils in practical work at all. The school with the largest number of laboratories had five (5) laboratories (see Appendix A).

Summary

The data presented in this chapter was organised into two parts that is, findings from the questionnaires and findings from observation surveys. The findings from the questionnaires revealed that most of the participants were males and very few of them had Bachelors' degree in Science Education. Furthermore, it was clear from the questionnaires that majority of the respondents strongly felt that some of the science teaching and learning materials, in schools, were not available and even those which were available where inadequate. This fact was confirmed by the findings from the observation surveys where it was established that such apparatus and resources as voltameters, insect/mammal cages and botanical gardens were not available in all the schools. Most schools did not also have science laboratories. The pupil-apparatus ratios for those apparatus which were available were also very high. Similarly, the ratios for the approved and recommended text books were very high. All the schools did not have copies of O' Level Practical Chemistry, Coordinated Science, Science in Zimbabwe, Beginning Science, Physics 11 and 12, Physics for Life, O' Level Physics, Senior Physics 9 and The Living World.

The findings from the questionnaires also revealed that most schools did not have programmes to replenish science materials. Furthermore, though it was established that most teachers rarely engaged pupils in practical work, most participants strongly felt that practical work plays an important role in the teaching of science. The findings from questionnaires also revealed that most schools purchased their science materials from private suppliers as opposed to the National Science Centre. The findings from the observation surveys also established that most schools were over-enrolled.

In order to cope with the challenges faced in the teaching of science, schools which did not have laboratories had embarked on constructing science laboratories, teachers were improvising the apparatus and equipment, and some schools were holding school-based is-service activities on science materials production. The participants strongly recommended that the government should increase funding for teaching and learning materials, build science laboratories as well as extra classrooms so that the standard class size of thirty five (35) pupils per class can be maintained in schools.

CHAPTER FIVE: DISCUSSIONS OF FINDINGS

5.0 **Overview**

This chapter presents a discussion of the findings on the provision of teaching and learning materials in science subjects in the high schools of Northern Province. The discussion follows the key variables upon which data was collected which include the current practices in the provision of teaching and learning materials in science subjects in high schools; the challenges faced in the teaching of science and measures taken by schools to cope with the challenges; the availability and adequacy of teaching and learning materials for science subjects and the adequacy and state of physical infrastructure for teaching science.

5.1 **Current practices in the provision of teaching and learning materials in science subjects in high schools**

It was evident from the findings that the majority of the high schools had not procured science teaching and learning materials in a long while even with the advent of the decentralised procurement policy. However, 11 (44%) of them indicated that since the advent of decentralisation, their school had purchased some science materials other than those meant for practical examinations. Decentralisation is the process of taking power from a central government and giving it to several smaller and more local authorities. This implies that though decentralisation of procurement of teaching and learning materials was meant to allow school boards to procure the teaching and learning materials more efficiently, most schools have not benefited from this policy. In fact, 28 (70%) respondents indicated that the decentralisation policy had done nothing to improve the provision of science teaching and learning materials in their schools. On the other hand, only 12 (30%) respondents felt that the decentralisation policy had, actually, improved the adequacy of science teaching and learning materials in their schools. The reason why the decentralisation policy had not benefited schools could be that schools were not receiving sufficient funds from the government. Even if the funds were available, the Ministry of Education does not have a science policy which would be used as a guide in allocating funds for the procurement of teaching and learning materials. It can be assumed that the schools which indicated that decentralisation had improved adequacy of science materials were using other financial sources such as school fees to procure science materials for the school.

The Ministry of Education, therefore, must support the decentralised procurement system by formulating a science education policy which can be used as a guide in the provision of teaching and learning materials science subjects.

5.1.1 **System of procurement of teaching and learning materials for science subjects**

It was evident from the findings that most schools had not formulated deliberate programmes for restocking science teaching and learning materials. This was reflected in the responses from 22 (88%) science heads of departments. In other words, they purchased science materials in the same way they procured materials for other academic disciplines. However, this contradicts the observation by World Bank (2002) who noted that acquisition of educational materials (EMs) was recurrent as well as capital expenditure because of the short life span of these materials. It is for this reason that the World Bank recommends that as soon as the procured educational materials (EMs) were delivered to schools, the relevant authorities should begin to procure replenishing stock. Science materials are specialised in nature, they are needed in large quantities and are not easily found in sales outlets as most of them are not locally manufactured. For this reason, schools should plan for these materials in advance by putting in place a systematic programme for procuring science materials to replace those that are used up and those that have broken down.

The lack of science policy in the schools was also revealed when 14 (56%) of the respondents indicated that science materials, in their schools, were procured by officers other than the science head of department, head teacher or procurement officer. This is a serious anomaly because science materials should only be procured by people who have a good understanding of science education as the materials are specialised in nature.

With reference to where schools purchased science materials, 24 (96%) schools procured them from private suppliers with only one respondent indicating that their school procured most science materials from the National Science Centre. Therefore, most schools purchased science materials from private suppliers. This implies that with the advent of economic liberalisation, the government has abdicated its role of facilitating the stocking of science materials by institutions which high schools can easily. For instance, science text books can adequately be stocked by the Zambia Educational Publishing House (ZEPH). Instead, this responsibility has been left in the hands of private suppliers who do not have established outlets and can not supply all that a school may require and are quite exploitative in terms of prices. Their area of specialisation is reagents and simple apparatus like test tubes, beakers and reagent bottles. Nevertheless, private suppliers are credited for being efficient in terms of supplying what schools need in good time when schools submit quotations of purchase.

Therefore, it is incumbent upon the government with the help of the private sector in ensuring that schools can access science teaching and learning materials at an affordable price. One way this can be done is by restructuring and streamlining the functions of the National Science Centre. The National Science Centre is a specialised unit established in 1991 and falls under the Directorate of Teacher Education and Specialised Services (TESS) in the Ministry of Education. Its mandate is “to enhance the teaching of science, mathematics and technology through the design, development and production of low-cost teaching and learning materials” (NSC, 2011:2). Its source of finances are the government, from where it receives a monthly grant and also aid agencies such the UNESCO and Service Delivery Improvement Fund (SDIF) through cabinet office. However, the centre currently produces mobile science laboratories which contain only a small range of science materials and in small quantities (see Appendix L). In effect, a science mobile laboratory can only be conveniently used by one pupil in a school. In other words, a school with 500 pupils would need to procure 500 mobile laboratories. So if the government is to increase funding to the National Science Centre and restructure its workforce to include engineers and technicians, it would enable the centre to increase the output of the science materials that are currently produced there and also to produce other science materials that are not locally manufactured. This would greatly increase the availability and adequacy of teaching and learning materials for science subjects in schools.

5.1.2 **Views on the performance of the book industry in Zambia**

With reference to the Zambian book industry, all the fifteen (15) deputy head teachers were also of the opinion that the book industry, in Zambia was not doing much where publishing of school text books was concerned. On the contrary, MoE (1996) noted that the Ministry of Education would work together with publishers and suppliers to ensure adequate supply text books and other print educational materials (EMs) for use in schools. Furthermore, the Ministry of Education would encourage a competitive book industry. On the contrary, this has not been done. To this effect, the government should encourage and support the book publishing industry in an effort to improve the provision of science text books in high schools. This can be done through promoting collaboration among the Book Publishers Association of Zambia (BPAZ), the Book Sellers Association of Zambia (BSAZ) and the Curriculum Development (CDC) so that they can publish and make available, for sale, locally authored science text books. Zambians can also be encouraged to write science books if incentives are introduced to authors.

5.1.3 **Views as to whether practical work plays a significant role in assisting pupils to understand science concepts more meaningfully**

It was brought to the attention of the researcher that all the 25 (100%) heads of departments indicated that practical work played a significant role in assisting the pupils to understand the science concepts more meaningfully. However, 17 (68%) heads of departments indicated that they rarely engaged the pupils in practical work with 8 (32%) of them holding the view that they had not engaged the pupils in practical work at all. Furthermore, when asked as to whether lack of apparatus was an impediment in carrying practical work, all the heads of departments indicated that indeed lack of apparatus was an impediment in carrying out practical work with the pupils. This implies that in as much as the teachers would want to engage the pupils in practical work, they were limited by lack of the necessary apparatus and equipment and reagents to use. Even the few apparatus and equipment which were available could not carter for all the pupils as most of the schools had many classes all of which were over-enrolled.

Considering that practical work is the basis of teaching in all science subjects, it becomes imperative, therefore, that science is taught under conditions where there is an adequate provision of teaching and learning materials. Monk and Osborne (2000: 68) noted 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 fact is supported by Oyeniran (2003) who points out that pupils learn best if they are given the opportunity to see and make observation of what they are taught. This is because a good teaching and learning material acts as a substitute for real life objects in the classroom as against the use of exploratory method. It is, therefore, incumbent upon the Ministry of Education (MoE) to put in place and upgrade infrastructure required for teaching science and technology in high schools. Schrader (1976) observed that a country which wishes to devote adequate financial funds to the promotion of science should be very much concerned about the improvement of scientific education at secondary school level in order to ensure that the future intellectual leaders possess a positive attitude toward the need for science.

5.2 **Challenges faced in the teaching of science and measures taken by schools to cope with the challenges**

The challenges faced by the schools in the teaching of science as revealed by the findings of the study, included lack of funding towards science materials, lack of quality science apparatus, equipment, reagents, text books and laboratories and over-enrolments. These challenges were in harmony with the findings of Chibesakunda (1983) and Montagnes (2000). However, the two did not allude to pupil over-enrolment and lack of laboratory. Lack of funding from the government incapacitates the schools to procure the teaching and learning materials which are not available as well as those which may be inadequate.

With regard to over-enrolment, the standard class size for high school, currently, is 35 pupils but the findings of this study revealed mean class sizes of 53.12, 56.36 and 57.12 for grades 10, 11 and 12 respectively. This indicates over-enrolment in these grades and so basing on these figures and the average numbers of apparatus, equipment and text books reported in this research, the Ministry of Education should direct high schools to adhere to the standard class size of 35 pupils per class so that high school learners can be given a good foundation in science. Learners leaving high school, ideally, are the ones who will eventually take up different roles requiring scientific knowledge in the national economy, while some of them will be required to pursue further studies in science in tertiary institutions. On the other hand, teachers find it difficult to teach science to classes which are over-enrolled because they can not give individualised attention to pupils as they are too many. Furthermore, an over-enrolled class creates problems of furniture shortages in the science laboratory as it is meant for only 35 pupils. Over-enrolment also brings about shortage of apparatus and equipment in the laboratory among pupils in the same class and also among other classes which may want to use the same materials at that particular time. Demonstrating experiments to over-enrolled classes also become a challenge as pupil control is difficult. Consequently, science teachers resort to theoretical teaching of science at the expense of practical work. They also adopt teacher-centred teaching approaches which are suitable for handling large classes as opposed to pupil-centred teaching approaches which allow pupils to actively participate in the learning process.

Science and technology education are two academic disciplines which have been recognised for contributing to national development. “Therefore, any nation which aspires to accelerate economic growth needs to intensify the development and application of science and technology in its socio-economic development” (GRZ, 2006:19). The link which exists between science and national development lies in the nature of scientific knowledge. Scientific knowledge has a practical feature which enables science to find applicability in many areas of our everyday life such as agriculture, mining, forestry, and medicines. When scientific knowledge is applied to a relevant field, it constitutes technology. Therefore, technological advancement is very much dependent on the science that is taught in schools.

5.3 **Availability and adequacy of teaching and learning materials for teaching science**

5.3.1 **Availability and adequacy of science apparatus and equipment**

Encarta Dictionaries (2008) defines availability as a condition of being able to be used, obtained or relied on. It also defines adequacy as a condition of being sufficient in quality or quantity to meet a need**.** It was evident from the findings of the study that the majority of the respondents felt that some of the science teaching and learning materials, in the high schools, were not available. Even those that were available were not adequate. This is evidenced by the responses which were elicited from the deputy head teachers and heads of departments where 39 (97.5%) of them indicated that they rated the availability of science and teaching materials as not adequate with only 1 (2.5%) of them indicating that they were fairly adequate. Furthermore, it was clearly stated by all the respondents that the number of pupils for every science apparatus and equipment such as beam balance, microscope, pipette, etc was not satisfactory to them.

The findings from the observation surveys also revealed that all the schools surveyed did not have animal cages, botanical gardens and voltameters which are very important apparatus and resources in the teaching of science. The average number of hand lenses, which were the most abundant apparatus, was 61.60. Though this number was greater than the average number of pupils per class in all the three grades, it is insignificant because the mean number of classes were 5.52, 5.68 and 5.54 with an average enrolment of 53.12, 56.36 and 57.12 for grades 10, 11, and 12 respectively. If the average enrolment for grade 12 (57.12), for example, is multiplied by the average number of classes for the same grade (5.54) it translates into a pupil-apparatus ratio of 14:1 for magnifying lens which is the most abundant piece of apparatus.

The above findings confirms the observation by the Government of the Republic of Zambia (2006) where it was noted that the provision of educational facilities remains limited and unsatisfactory due to the increasing pressure on educational infrastructure, poor maintenance and increase in the school-going population. Furthermore, the government indicated that "improvement of quality in secondary schools, and improvements in student performance in science, depend heavily on there being sufficient text books, science equipment and other teaching aids in secondary schools", (MoE, 1992:16). However, the findings of this study indicate that the Ministry of Education has done nothing to mitigate the non-availability and inadequacy of the teaching and learning materials in science subjects. This observation points to the fact that if high schools are not supplied with adequate teaching and learning materials, the practical aspect of science will be ignored at the expense of theoretical teaching. The availability of teaching and learning materials, in science subjects, increases learner participation in the learning process. This consequently increases their motivation and minimises the abstraction associated with science concepts. Adebanjo (2007) supported this view when he observed that instructional materials in the teaching and learning of science make students to learn more and retain better what they have been taught and that it also promotes and sustains students' interest.

The situation highlighted above could partly be attributed to the limited corresponding investment in educational infrastructure to match the ever-increasing population among the school-going age. Lack of science materials also poses a serious challenge to schools which are offering pure sciences in which candidates are required to sit a practical examination in the school certificate examinations. Schools offering pure sciences experience shortages of science materials more so during examinations forcing those administering the examination to conduct several sessions of the same examination. Therefore, it is imperative that the government starts to invest in educational infrastructure and more so in science teaching and learning materials because science concepts can not easily be explained theoretically   This will ensure that more of the necessary science teaching and learning materials are supplied to schools to reduce the ratios of pupil to apparatus so that the ratio is closer to the standard 2 pupils to 1 apparatus or equipment.

Furthermore, the government should increase the capita per pupil for teaching and learning materials and direct schools to allocate more funds towards science teaching and learning materials. Apart from that the government should encourage the parents and teachers associations (PTAs) to use part of the PTA fees for science teaching and learning materials. Schools should also encourage school-based in-service programmes (INSET) in teaching and learning materials production to stimulate the concept of improvisation in science teachers. The corporate world can also be called upon to partner with the government, under private public partnership (PPP), in sharing the necessary heavy expenditures through such initiatives as financing the construction of science laboratories in high schools as well as donation of teaching and learning materials for science subjects. This is because the industries reap by far the greatest benefits from science and technology education and training.

(Schrader, 1976: 26) observed that "nowadays, progress in technology is almost entirely based on advances in science". Therefore, there is a very great need to improve science teaching at all levels of education in underdeveloped countries like Zambia. Schrader (1976) further notes that in order to produce future leaders who will appreciate science, a country which wishes to devote adequate financial resources to the promotion of science, should be very much concerned with the improvement of science education at secondary school level.

5.3.2 **Availability and adequacy of science text books**

With reference to the availability and adequacy of approved and recommended science text books, the study revealed that these materials were in short supply as was indicated by the high pupil-text book ratios in science subjects. All the schools did not have copies of O' Level Practical Chemistry, Coordinated Science, Science in Zimbabwe, Beginning Science, Physics 11 and 12, Physics for Life, O' Level Physics, Senior Physics 9 and the Living World. The text books which were relatively adequate in number were Biology 10 and Biology 12 pupil's books which had average numbers of 40.72 and 40.56 respectively. However, these figures were far less than the average numbers of pupils per grade 10 and grade 12 classes which were 53.12 and 57.12 respectively. With reference to the standard pupil-text book ratio of 2 to 1, it means that these 40.72 books are equivalent to a pupil-text book ratio of 7.2:1.

In a similar way, the largest number of chemistry text books was for Chemistry 10 whose average number was 21.00 and Chemistry 12 which had an average number of 12.74 books. These numbers are also far less than the average numbers of pupils for grades 10 and 12 mentioned above. In comparison with the ratio of 2 pupils to 1 book, 21.00 books translate into a pupil-text book ratio of 14:1.

As for physics text books, the study revealed that the Physics text books were the least available and least adequate books. An average number of 12.36 Physics 10 books was the largest number of physics books available. However, working against the ratio of 2 pupils to 1 book, 12.36 books translates into an alarming high pupil-text book ratio of 23:1.

The government recognises that poor investment in education has led to high pupil-text book ratio of 1:1.3 at basic school and 7: 1 at high school level and so it aspires to improve the pupil-text book ratio to 1:1 at basic school and 3:1 at high school levels (GRZ, 2006). However, the ratios reported by the Government of the Republic of Zambia (2006) are far much lower than the ones reported in this research and they cover science materials in combination with other subject disciplines indicating that the provision of teaching and learning materials in high schools, especially in science subjects is not getting any better. In fact, the ratios revealed in this study are mere averages. They are actually higher in some schools creating a situation which is not conducive for the teaching of science. As Schramn (1977) points out, text books are one basic channel for communicating scientific ideas and concepts in the classroom for the purpose of bringing about effective teaching and learning. If they are not available or adequate, the only source of information for the pupils will be the teacher and this will deprive them of the opportunity to study what they learn in class on their own. Consequently, this negatively affects the way they understand the science concepts they learn. Abimbade (1997) also added that text books help students to discover scientific ideas and consolidate on the concepts they learn on their own.

However, the current standard pupil-text book ratio of 2:1, in Zambian high schools, is difficult to attain because of the low economic performance in the country. Therefore, the Ministry of Education should just work towards achieving a pupil-text book ratio of 3:1 as suggested in the Vision 2030 document.

5.4 **Adequacy and state of physical infrastructure for teaching science**

Furthermore, the findings of the study also established that 13 (52%) schools, all of which were second generation schools, did not have laboratories. Second generation schools are high schools which were set up after upgrading existing basic schools whereas first generation schools are those which were built with all the facilities that go with a high school. The percentage reported in this study is far much higher than the percentages reported by Garritz and Talanquer (1999) in a World Bank study in Mexico. This implies that though lack of laboratories in high schools is a global occurrence, the problem is worse in countries like Zambia. The standard number of science laboratories which every high school must have is four (4). This translates into a laboratory space of 4 x $102m^2$. A laboratory serves as a workroom specially made for teaching and learning science. Baird (1990) also observed that laboratory learning environment warrants a radical shift from teacher-directed learning to purposeful inquiry that is more student-directed. Hofstein and Lunetta (2003) also pointed out that the laboratory offers unique opportunity for the students to relate science concepts with theories discussed in the classroom and in text books with observations of phenomena and systems. Laboratory work is also an important medium for enhancing attitudes, stimulating interest and enjoyment, and motivating students to learn science (Hofstein and Lunetta, 2003).

Therefore, it is a sad state of affairs to discover that some high schools operated without laboratories. Plans to improve the quality of science laboratories were made 20 years ago because MoE (1992) pointed out that priority in resource allocation, in secondary schools should be given to the rehabilitation of science laboratories and specialist rooms. However, the findings of this study indicated that no such measures have been taken. In other words, the Zambian government's recognition of science education as an important academic discipline which can contribute to economic development has not been matched with adequate resource allocation to science subjects. One measure that can be taken to mitigate this challenge is that, though some schools had commenced constructing laboratories using school grants, the government should move in and build science laboratories in all the high schools that need these facilities.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 **Overview**

This chapter presents the conclusion and recommendations drawn from the findings of the study. The study was conducted to investigate the provision of science teaching and learning materials in the high schools of Northern Province. The study, therefore, aimed at filling the knowledge gap by finding out the availability and adequacy of science teaching and learning materials in the high schools, the implications of absence of these materials and the measures which can be taken to mitigate the situation of non-availability and inadequacy of these materials.

6.2 **Conclusion**

The findings of the study revealed that some key science teaching and learning materials were not available in the high schools of Northern Province. Even those which were available were not adequate. These materials included apparatus, equipment, reagents and text books. This was shown by the high pupil-apparatus and pupil-book ratios. For instance the pupil-apparatus ratio for the most abundant apparatus was 14:1. For the most abundant text books, the pupil-text book ratios were 23:1, 14:1 and 7.2:1 for physics, chemistry and biology books respectively. Furthermore, most schools, all of which were second generation schools had no science laboratories and were instead using classrooms for lessons and other science activities. In addition to that the findings revealed that the decentralisation in the procurement of teaching and learning materials had not improved the provision of science materials in the high schools. It was also discovered from the findings that there was over-enrolment of pupils in all the classes in all the schools. All these findings pointed to the fact that the quality of the science the pupils were learning was low and hence, they were not being given a firm foundation to enable them take up future careers as scientists as well as to pursue further studies in science.

In order to cope with the challenges mentioned above, the study revealed that the schools were cutting down on enrolments and organising school-based in-service activities on science materials production. Teachers were also improvising science apparatus and equipment where possible. On the other hand, it was established that teachers were not doing much in terms of improvisation. This is evidenced by the fact that some of the science resources, such as animal cage and botanical gardens, which were not available, should have been constructed by the teachers at school.

The study also revealed that schools did not have school science policy such as a consistent programme of procuring science materials to replace those that are broken down. Furthermore, it was discovered that the National Science Centre did not produce adequate materials to meet the needs of all the schools and hence schools were purchasing the science materials from private suppliers. Furthermore, the book publishing industry was not doing enough in terms of publishing approved and recommended science books to meet the schools' demands. In addition to the above, it was discovered that there was need to encourage practical work as it had a role to play in science teaching. The findings of the study also indicated that the participants strongly felt that the science head of department or any science teacher should be involved every time science materials are being procured.

6.3 **Recommendations**

Basing on the findings above, the following recommendations were made:

1. The government should increase funding to the high schools by way of increasing per pupil capita so that more of the funds can be spent on the procurement of science teaching and learning materials.

2. The government should move in quickly and invest in educational infrastructure so that new science laboratories can be built and the old ones refurbished and re-quipped stocked with consumables, in schools where this is necessary. There is also need for the expansion of the existing classroom space. This will reduce the current over-enrolment levels, in schools, and also raise the quality of science education offered in high schools because education indicators such as pupil-text book and pupil-apparatus ratios will improve.

3. Furthermore, the government should encourage local publishing of approved and recommended science books by streamlining the functions of such units as the Zambia Educational Publishing House (ZEPH) and the National Science Centre (NSC) and also by encouraging collaboration between the Book Publishers Association of Zambia (BPAZ) and the Book Sellers Association of Zambia (BSAZ). Book levy can also be introduced by the government in various forms of

tax. This will improve the availability of science books on the local market which school can purchase.

4. The government should also encourage public private partnership (PPP) for science education because the private sector is the chief beneficiary from science and technology education.
5. The Ministry of Education must formulate a science education policy to guide them in the provision of teaching and learning materials for science subjects.
6. The Ministry of Education (MoE) should also set a standard class size for high schools which will allow for increased access to education but one which will not compromise on the quality of science being taught in schools.
7. Schools should make use of parents and teachers associations (PTA) funds to hold school-based in-service activities in science materials production. This will in effect stimulate a sense of improvisation in the teachers.
8. Schools should ensure that they formulate school science policies.

6. 4 **Suggestions for further research**

The following was identified as an area of possible future research:

An investigation of the impact of low provision of teaching and learning materials in science subjects on the performance of high school pupils in school certificate science examinations: A Case of Northern Province

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APPPENDIX A: **QUANTITIES OF SELECTED SCIENCE TEACHING AND LEARNING RESOURCES**

Teaching resource	N	Minimum	Maximum	Mean
Microscopes	25	0	10	1.60
Gas cylinders	25	0	6	.56
Beam balances	25	0	6	2.44
Spring balances	25	2	20	5.72
Bunsen burners	25	0	24	2.68
Laboratory thermometers	25	0	40	10.76
Clinical thermometers	25	0	4	.48
Circuit boards	25	0	13	3.88
Ammeters	25	1	15	5.12
Voltmeters	25	0	13	4.92
Voltameters	25	0	0	.00
Insect/mammal cages	25	0	0	.00
Human skeleton models	25	0	4	1.84
Human eye models	25	0	5	1.48
Human ear models	25	0	5	1.40
Magnifying lenses	25	7	130	61.60
Botanical gardens	25	0	0	.00
Thermos flasks	25	0	4	1.20
Calorimeters	25	0	10	.96
Torque rulers	25	0	30	2.60
Optical mirrors	25	0	100	30.12
Burettes	25	0	50	13.36
Pipettes	25	0	51	12.04
pH indicator booklets	25	0	3	.76
Round-bottomed flasks	25	0	20	8.56
Flat-bottomed flasks	25	1	11	5.48
Conical flasks	25	2	100	26.64
Delivery tubes	25	0	2	.40
Clamps and stands	25	2	50	13.20
Eureka cans	25	0	8	1.76
Laboratories	25	0	5	1.56

<u>Key</u>

N = number of schools
Minimum = minimum number of pupils per class per grade
Maximum = maximum number of pupils per class per grade
Mean = average class size per grade per school

APPENDIX B: **QUESTIONNAIRE FOR SCIENCE HEADS OF DEPARTMENT**

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

DEPARTMENT OF EDUCATIONAL ADMINISTRATION AND POLICY STUDIES

Dear respondent,

REF: PROVISION OF SCIENCE TEACHING LEARNING MATERIALS IN HIGH SCHOOLS OF NORTHERN PROVINCE

I am a Post-Graduate student in the Master of Education in Education Administration, and am conducting a research on the above subject. Kindly spare a few minutes to answer this questionnaire. The information you are going to provide will be purely for research and will be used as such. **You are advised not to write your name on the questionnaire.** Your cooperation will be appreciated.

Siwale Able

Part 1: Personal Information

1. Name of School ____

Answer the following questions by marking the part which applies to you with a tick [√]

2. Sex: Male [ ] Female [ ]
3. Highest professional qualification attained

(a) Bachelor of Science (Education) [ ]

(b) Bachelor of Education (Secondary) [ ]

(c) Advanced Diploma (ZAMSTEP)

(d) Secondary Teachers' Diploma (Science) [ ]

(e) Other qualification (Specify) ______________________________________

4. What subject(s) are you currently teaching?

(a) Biology [ ]

(b) Chemistry [ ]

(c) Physics [ ]

(d) Biology and Chemistry [ ]

(e) Biology and Physics [ ]

(f) Chemistry and Physics [ ]

(g) Biology, Chemistry and Physics

5. How many years have you been teaching in High School?

(a) 2 years and above [ ]

(b) 2 - 3 years [ ]

(c) 4 - 5 years [ ]

(d) 6 – 10 years [ ]

(e) 11 years and above [ ]

Part 2: Information about teaching materials

6. Kindly rate the adequacy of science teaching and learning materials in your school.

(a) Adequate [ ] (b) Fairly adequate [ ] (c) Inadequate [ ]

7. How often do you engage pupils in practical work in your subject(s)?

(a) Often [ ] (b) Rarely [ ] (c) Not at all [ ]

8. Is lack of apparatus an impediment in carrying out practical work in your science lessons?

(i) Yes [ ] (ii) No [ ]

9. How would you describe the pupil-text book ratios in your science teaching subject?

(i) Good [ ] (ii) Fair [ ] (iii) Not good [ ]

10. Is the number of pupils for every science apparatus/equipment such as beam balance, microscope, pipette, etc satisfactory to you?

(a) Yes [ ] (b) No [ ]

11. Does the number of pupils in a class occupying a laboratory, at a time, affect the way you conduct practical work?

(i) Yes [ ] (ii) No [ ]

Note: If your answer to (6) above is **No**, go to question 13.

12. Briefly explain how the number of pupils affect the way you conduct practical work.

13. Do you think practical work plays a significant role in assisting the pupils to understand science concepts more meaningfully?

(a) Yes [ ] (b) No [ ]

14. Does your school have a consistent programme for the procurement of science teaching and learning materials to replace those that are used up as well as the ones that are breaking down?

(i) Yes [ ] (ii) No [ ] (iii) Not sure

15. With the advent of decentralisation in the procurement of teaching and learning materials, state the year when your school last purchased science teaching and learning materials? **(*Exclude materials meant for practical examinations*)**

16. In your view, has the decentralisation of procurement of teaching and learning materials improved the adequacy of science teaching and learning materials in your school?

(i) Yes [ ] (ii) No [ ] (iii) Not sure [ ]

17. Who is in charge of procuring science teaching and learning materials in your school?

(a) The Head teacher [ ] (b) The Head of Department [ ] (c) The procurement officer [ ]

(d) Others (Specify) ____________________

18. Are you satisfied with the system of procurement you have indicated in (12) above?

(a) Yes [ ] (b) No [ ] (iii) Not sure

Note: If your answer to (7) above is **yes**, go to question 20.

19. Who would you suggest to be in charge of procurement of science teaching and learning materials?

    ____

20. Where does your school purchase most of the science apparatus, equipment and reagents?

(a) Private suppliers [ ] (b) National Science Centre [ ]

(c) Others (Specify) ____

21. Are there science teaching and learning materials that are still being centrally procured for you at the Ministry of Education Headquarters?

(i) Yes [ ] (ii) No [ ] (iii) Not sure [ ]

Note: If your answer to (11) above is **No**, go to question 23.

22. Name some of these materials that are procured for you by the Ministry of Education Headquarters in the spaces below.

    ____

    ____

    ____

23. Briefly explain the constraints which you face in the teaching of science and the measures you have taken to cope with these challenges.

    ____

    ____

    ____

    ____

    ____

24. Make suggestions about the ways in which schools can improve the provision of science teaching and learning materials under the current decentralization policy.

Thank you for your time.

APPENDIX C: **QUESTIONNAIRE FOR DEPUTY HEAD TEACHERS**

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

DEPARTMENT OF EDUCATIONAL ADMINISTRATION AND POLICY STUDIES

Dear respondent,

REF: PROVISION OF SCIENCE TEACHING LEARNING MATERIALS IN HIGH SCHOOLS OF NORTHERN PROVINCE

I am a Post-Graduate student in the Master of Education in Education Administration, and am conducting a research on the above subject. Kindly spare a few minutes to answer this questionnaire. The information you are going to provide will be purely for research and will be used as such. **You are advised not to write your name on the questionnaire.** Your cooperation will be appreciated.

Siwale Able

Part 1: Personal Information

25. Name of School ____

Answer the following questions by marking the part which applies to you with a tick [√]

26. Sex: Male [ ] Female [ ]

27. Highest professional qualification attained

(f) Bachelor of Science (Education) [ ]

(g) Bachelor of Education (Secondary) [ ]

(h) Advanced Diploma (ZAMSTEP)

(i) Secondary Teachers' Diploma (Science) [ ]

(j) Other qualification (Specify) ____

Part 2: Information about teaching materials

28. Kindly rate the adequacy of science teaching and learning materials in your school.

(b) Adequate [ ] (b) Fairly adequate [ ] (c) Inadequate [ ]

29. Do you know about the existence of the National Science Centre?

(ii) Yes [ ] (ii) No [ ]

30. In your view, what is the mandate of the National Science Centre as far as provision of science teaching and learning materials is concerned?

____

____

31. In your view what factors contribute to inadequacy in the science teaching and learning materials in high schools in your province?

____

____

32. Have you ever included science materials production in any of school-based INSET?

(i) Yes [ ] (ii) No [ ]

33. How would you describe the effectiveness of the decentralisation of procurement of educational materials?

(i) Very effective [ ] (ii) Fairly effective [ ] (iii) Not effective [ ]

34. Do you think the book publishing industry, in Zambia, is doing enough to meet the book needs of the schools?

(ii) Yes [ ] (ii) No [ ] (iii) Not sure [ ]

35. Make suggestions about the ways in which the government and schools can improve the provision of science teaching and learning materials under the current decentralization policy.

Government:

____

____

____

Schools:

____

____

____

Thank you for your time.

APPENDIX D: **OBSERVATION SCHEDULE FOR CHEMISTRY TEXT BOOKS**

S/N	Title	Quantity	Condition (Good/Fair/Bad)
1	Chemistry 10 Pupils' book		
2	Chemistry 11 Pupils' book		
3	Chemistry 12 Pupils' book		
4	GCSE Chemistry		
5	Certificate Chemistry		
6	O' Level Practical Chemistry		
7	Chemistry Made Clear		
8	Beginning Science-Chemistry		
9	Coordinated Science-Chemistry		
10	Balanced Science 1		
11	Balanced Science 2		
12	Science in Zimbabwe		

APPENDIX E: **OBSERVATION SCHEDULE FOR BIOLOGY TEXT BOOKS**

S/N	Title	Quantity	Condition (Good/Fair/Bad)
1	Biology 10 Pupils' book		
2	Biology 11 Pupils' book		
3	Biology 12 Pupil's book		
4	GCSE Biology		
5	Biology		
6	Biology-A Modern Introduction		
7	Beginning Science-Biology		
8	Coordinated Science-Biology		
9	Biology for Life		
10	The Living World		
11	Balanced Science 1		
12	Balanced Science 2		

APPENDIX F: **OBSERVATION SCHEDULE FOR PHYSICS TEXT BOOKS**

S/N	Title	Quantity	Condition (Bad/ Fair/Good)
1	Physics 10 Pupils' book		
2	Physics 11 Pupils' book		
3	Physics 12 Pupils' book		
4	Physics for Life		
5	Essentials of Physics		
6	GCSE Physics 4th Ed.		
7	Principles of Physics		
8	Explaining Physics		
9	O' Level Physics 5th Edition		
10	Coordinated Science- Physics		
11	Balanced Science 1		
12	Balanced Science 2		
13	Beginning Science- Physics		
14	Senior Physics 8		
15	Senior Physics 9		
16	Senior Physics 10		

APPENDIX G: **OBSERAVTION SCHEDULE FOR SCIENCE APPARATUS/EQUIPMENT**

Apparatus/Resource	Quantity	Condition(Good/Fair/Bad)
Microscope		
Gas cylinder		
Beam balance		
Spring balance		
Bunsen burner		
Laboratory thermometer		
Clinical thermometer		
Scapular		
Circuit board		
Ammeter		
Voltmeter		
Voltameter		
Insect/mammal cage		
Biological model		
Human skeleton		
Human eye		
Human ear		
Magnifying lens		
Botanical garden		
Thermos flask		
Calorimeter		
Torque ruler		
Optical mirror		
Burette		
Pipette		
PH indicator		
Round-bottomed flask		
Flat-bottomed		
Conical flask		
Delivery tube		
Clamp and stand		
Eureka can		
Laboratory room		

APPENDIX H: **OBSERVATION SCHEDULE FOR CAPACITY OF LABORATORY SPACE**

Grade	Number of Classes	Size of largest class	Size of smallest class	Average	Total Number of pupils
10					
11					
12					

APPENDIX I: **APPROVED AND RECOMMENDED CHEMISTRY BOOKS FOR HIGH SCHOOLS**

S/N	Title	Year of Publication	Author	Place	Publisher
1	Chemistry 10 Pupils' Book	1994	Chirwa, C. et al	Lusaka	Macmillan (Z)
2	Chemistry 11 Pupils' Book	1994	Swazi, H. et al	Lusaka	Macmillan (Z)
3	Chemistry 12 Pupils' Book	1994	Swazi, H. et al	Lusaka	Macmillan (Z)
4	GCSE Chemistry	1997	Earl, L and Wilford, D	London	John Murray
5	Certificate Chemistry	1998	Atkinson, K.	London	Macmillan
6	O' Level Practical Chemistry	2003	Odara, M.	Abuja	Salama
7	Chemistry Made Clear	2001	Gallagher, E and Ingram, P.	Oxford	OUP
8	Beginning Science-Chemistry	1997	Hart, R.	Oxford	OUP
9	Coordinated Science Chemistry	2001	Ingram, P.	Oxford	OUP
10	Balanced Science 1	1990	Jones, J. et al	Cambridge CUP	CUP
11	Balanced Science 2	1990	Jones, J. et al	Cambridge CUP	
12	Science in Zimbabwe	1987	Bethel, G.	Cambridge CUP	

Source: Curriculum Development Centre

APPENDIX J: **APPROVED AND RECOMMENDED PHYSICS BOOKS FOR HIGH SCHOOLS**

S/N	Title	Year of Publication	Author	Place	Publisher
1	Physics 10 Pupils' Book	1995	Chengo, A. et al	Lusaka	Macmillan (Z)
2	Physics 11 Pupils' Book	1995	Chengo, A. et al	Lusaka	Macmillan (Z)
3	Physics 12 Pupils' Book	1995	Chengo, A. et al	Lusaka	Macmillan (Z)
4	Physics for Life	1989	Warren, P.	Lusaka	Insaka Press
5	Essentials of Physics	1995	Willison, J.	Sydney	Macmillan
6	GCSE Physics 4th Ed.	2001	Duncan, T.	London	John M.
7	Principles of Physics	2001	Nelkon, M.	London	Longman
8	Explaining Physics	1987	Pople, S.	Oxford	OUP
9	O' Level Physics 5th Edition	1989	Abbort, A.F.	Oxford	OUP
10	Coordinated Science Physics	2001	Pople, S.	Oxford	OUP
11	Balanced Science 1	1990	Jones, J. et al	Cambridge CUP	
12	Balanced Science 2	1990	Jones, J. et al	Cambridge CUP	
13	Beginning Science-Physics	1997	Wellington, J.J.	Oxford	OUP
14	Senior Physics 8	1993	Peinaai, H.N.	New Delhi	Longman
15	Senior Physics 9	1993	Shirender, B.K.	New Delhi	Longman
16	Senior Physics 10	1993	Shirender, B.K.	New Delhi	Longman

Source: Curriculum Development Centre

APPENDIX K: **APPROVED AND RECOMMENDED BIOLOGY BOOKS FOR HIGH SCHOOLS**

S/N	Title	Year of Publication	Author	Place	Publisher
1	Biology 10 Pupils' Book	1995	Katete, T. et al	Lusaka	Macmillan (Z)
2	Biology 11 Pupils' Book	1995	Kateka, L. et al	Lusaka	Macmillan (Z)
3	Biology 12 Pupil's Book	1995	Mwale, R. et al	Lusaka	Macmillan (Z)
4	GCSE Biology	1995	Mackean, D.G.	London	John Murray
5	Biology	1995	Jones, G, and Jones, M.	London	John Murray
6	Biology- A Modern Introduction	1986	Beckett, M.B.	Oxford	OUP
7	Beginning Science- Biology	1997	Beckett, B.S.	Oxford	OUP
8	Coordinated Science Biology	1994	Beckett, B.S.	Oxford	OUP
9	Biology for Life	1986	Roberts, M.B.V.	Oxford	OUP
10	The Living World	1996	Roberts, M.B.V.	Oxford	OUP
11	Balanced Science 1	1990	Jones, J. et al	Cambridge	CUP
12	Balanced Science 2	1990	Jones, J. et al	Cambridge	CUP

Source: Curriculum Development Centre

APPENDIX L: **NATIONAL SCIENCE CENTRE MOBILE LABORATORY CONTENTS**

S/N	Description	Quantity
1	250ml Flat or Round bottomed flask	1
2	Distillation flask	1
3	Retort stand and clamp	1
4	Spirit burner	1
5	18mm test tube	1
6	15mm test tube	1
7	Test tube rack	1
8	100ml Glass beaker	1
9	250ml Glass beaker	1
10	100ml Measuring cylinder	1
11	Induction coil	1
12	Hand lens	2
13	Circuit board	1
14	Bi-metallic strip	1
15	Chalk duster	1
16	Filter funnel	1
17	Engine model	1
18	Tripod stand and wire gauze	1
19	Concave lens	1
20	Convex lens	1
21	Ordinary thermometer	1
22	Spring balance	1
23	Bunsen burner	1
24	Ammeter	1
25	Voltmeter	1
26	Liebig condenser	1
27	Bar magnet	1
28	Blue litmus paper	1 box
29	Red litmus paper	1 box
30	3Kg Gas cylinder	1
31	12 Volt motorbike battery	1
32	Siphoning pump	1
33	10l Plastic container	2
34	Plastic hand basin	1

Source: National Science Centre

APPENDIX M: **PERMISSION TO CONDUCT RESEARCH FROM THE HIGH SCHOOLS**

TS: 19991

The University of Zambia

DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Telephone: 290258/291777 P.O. Box 32379, Lusaka, Zambia

Fax: +260-1-29258 Your Ref:

E-mail drgs@unza.zm Our Ref:

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REPUBLIC OF ZAMBIA
MINISTRY OF EDUCATION
NORTHERN PROVINCE
29 NOV 2011
PROVINCIAL EDUCATION OFFICER
P.O. BOX 410175
KASAMA

① PESO
RMA
PEO.

14th September, 2011

The Provincial Education Officer

Kasama

RE: RESEARCH FOR MASTER'S DEGREE - Siwale Alle
(COMPUTER#: 530504804**)**

I write to introduce the above named Post-Graduate student who is currently on research. His/~~Her~~ study is on The Provision of Science Teaching and Learning materials in High Schools of Northern Province

Kindly assist him/~~her~~.

All Heads.
② Please give him all the support in his research.

PESO

Mall

P. M. Manchishi (Dr.)

For DIRECTOR(DRGS)

MINISTRY OF EDUCATION
NORTHERN PROVINCE
29 [illegible]
PRINC[illegible]
EDUCATION STANDARDS OFFICER
P.O. BOX [illegible]