2005

The status and quality of secondary science teaching and learning in Lagos State, Nigeria

Taiwo O. Ogunmade
Edith Cowan University

THE STATUS AND QUALITY OF SECONDARY SCIENCE TEACHING AND LEARNING IN LAGOS STATE, NIGERIA

BY

TAIWO OLUDARE OGUNMADE
BSc (Ed) Chemistry; MEd (Science Education)

Student ID No: 2035544

A thesis presented for the degree of Doctor of Philosophy

School of Education,

Faculty of Community Services,

Education and Social Science, Edith Cowan University,

Perth, Western Australia

OCTOBER 2005

EDITH COWAN UNIVERSITY

USE OF THIS THESIS

DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

(i) incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher learning;

(ii) contain any material previously published or written by another person except where due reference is made in the text; or

(iii) contain any defamatory material.

I also grant permission for the Library of Edith Cowan University to make duplicate copies of my thesis as required.

Signed______________________________ Date: ___________________
Taiwo Oludare Ogunmade

ABSTRACT

This study investigated and described the status and quality of secondary science teaching and learning in Lagos State, Nigeria. Quantitative and qualitative methods were used for gathering research data. Quantitative data were obtained from the surveys of 78 junior secondary science teachers and 500 junior secondary students from three Local Education Districts of Lagos State.

Qualitative data on the other hand, were gathered from analysis of national and state curriculum documents and from focus groups of science teachers, school principals, parent association representatives, education officers, teacher educators, representatives of the professional association for science teachers and representatives of examination bodies in Lagos State, Nigeria. Other key stakeholders including scientists in a government establishment and those working in industry were also interviewed.

Quantitative data were coded and analysed using the SPSS 13.0 statistical package to produce descriptive statistics. Qualitative data also were transcribed and categorized into emerging themes. Triangulation of data from various sources was used to reveal pictures of actual science teaching and learning and an ideal science for junior secondary schools in Lagos State, Nigeria.

Findings from this study indicate a gap between actual science teaching and learning and an ideal school science with regards to curriculum, pedagogy and learning, class sizes and resource allocation, teacher knowledge and skills, attitude and professional development, and community support.

Finally, realistic recommendations for closing the gap between actual and ideal science are suggested with possible actions for improving the quality of science teaching and learning for Lagos State, Nigeria.

ACKNOWLEDGEMENTS

First and foremost, I give special thanks and glory to the Almighty God for giving me the grace, wisdom and good health to complete this thesis. I am also indebted to my Principal supervisor, Professor Mark Hackling of Edith Cowan University and my Associate supervisor Professor Denis Goodrum of the University of Canberra for their constructive intellectual advice and uncompromising academic discussions in making this thesis a worthwhile undertaking.

I also acknowledge the kind assistance rendered to me by the following staff members of Edith Cowan University: Anita Kraffel, Paul HalfPenny, Emma Chessell-Keevers, Bill Noble, and Dr. Susan Hill. I would as well like to thank Dr Babalola (Babs) Adegbamigbe, Dr Ayinde Morris Benjamin and Mr Saidi Durojaiye Braimoh for their brotherly love, support and guidance and also my colleagues at Edith Cowan University, Perth.

My sincere appreciation to the families of Dr John Adegboye, Dr Wale Adesina and Mr and Mrs Omodunbi for their support and encouragement and also to members of Redeemed Christian Church of God (Jesus House, Perth, Western Australia) for their brotherly love.

I would like to acknowledge the cooperation and support rendered to me by Dr. C. O. Oke, Director of Planning, Research and Statistics in Lagos State Post Primary Teaching Service Commission (PP-TESCOM Headquarters) and the Directors of Oshodi/Isolo, Ojo and Alimosho Local Education Districts.

My special appreciation further goes to Mrs Adebayo, Messrs Ogunyemi, Ajisafe, Babalola, Whenanyon and Amore for their unflinching support and also to those principals, science teachers and other key stakeholders in science education in Lagos State who volunteered and participated in this study and for their numerous knowledge, experience and creativity, as without their support this thesis would not have been completed.

I am equally grateful to the Management of Adeniran Ogunsanya College of Education (AOCOED) Otto/Ijanikin, Lagos-Nigeria for granting me a study leave to pursue my doctoral degree.

My warmest appreciation to Olumide Owode, Edward Quaynor and Lady Evangelist Olaleye (Mrs) for their unflinching support and encouragement.

I wish to acknowledge also with grateful thanks, the Commonwealth Government of Australia for granting to me the prestigious International Postgraduate Research Scholarship (IPRS) and to the Management of Edith Cowan University for the International Stipends (ECUIS) for my living expenses during the study.

Finally, to my loving wife, Comfort for her continuing source of help and encouragement, her unalloyed love, support and understanding and to my children for their endurance day and night, always give me the confidence to work very hard while I was studying in Australia.

DEDICATION

This thesis is dedicated to my late parents: Mr and Mrs Johnson ' Tayo Ogunmade.
To my sons: Adebola Cornelius and Gbolahan Oluwole and my daughters: Feyisola Omonike, and Temilola Favour for their patience.

Also, to my twin-brother: Kehinde Olujare Ogunmade for his support and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Background to the Study

In recent times, there has been a growing public anxiety about the teaching and learning of science in Nigerian schools. Studies showed that large numbers of students seem to learn very little science at school, learning tends to be by rote and students find learning of science to be difficult (Eyibe, 1990; Jegede, 1992; Salau, 1996). The quality of science teaching and learning has also been questioned over time by parents, science educators, and the general public and even by the government (Adepoju, 1991; Ivowi, Okebukola, Oludotun & Akpan, 1992; Okebukola, 1997). Science teaching in Nigerian schools has been criticised because of the poor performance of Nigerian students in science subjects relative to their counterparts in other countries. This is evident from the Second International Science Study in which Nigerian students came last in primary science and second to last in secondary science among the participating countries of the world (STAN, 1992).

A number of factors have been identified to be responsible for these poor performances in science from the various studies conducted in Nigeria. These include the lack of motivation for most teachers, poor infrastructural facilities, inadequate textual materials, attitude of students to learning, lack of teaching skills and competence by science teachers, and lack of opportunities for professional development for science teachers (Braimoh & Okedeyi, 2001; Folaranmi, 2002; Okebukola, 1997; Olaleye, 2002; Olanrewaju, 1994).

Other studies mentioned that poor classroom organisation, lack of management techniques and poorly co-ordinated student activities also reduced the quality of science teaching and learning (Akale & Nwankwonta, 1996). Ivowi et al. (1992) also found the shortage of funds for equipment and materials for fruitful practical work; especially in view of large class size in most schools is a problem. Some other researchers also attribute the low percentage of students who pass examinations in science, to dissatisfaction with the syllabus, teachers' qualifications, workload, experience and disposition, general lack of teaching skills, and the ineffective style of delivery of subject matter (Adepoju, 1991; Salau, 1996).

Okebukola (1997) paints a gloomy description of science teaching in Nigerian schools when he asserts:

> The science class begins with a brief chat as an introduction. This is followed by the reading of the notes by the teacher to the students. At the end of the lesson, the left over notes on the topic is given to the class captain. In the class free time, the class captain copies the notes on the board or models the teacher by reading the notes for other students to copy (p. 4).

Research findings have further supported the concerns of Okebukola (1997) that teaching methods could result in poor state of learning and students' achievement in science (Adeyemi, 1990; Balogun, 1983; Odubunmi, 1986, 1998). A number of international researchers however provide evidence that teachers' content knowledge has an effect on both the content and the processes of instruction, thus influencing both what and how they teach (Haimes, 1996; Shulman, 1987; Treagust, 2002).

Over the years, science educators and researchers in science education have intensified their efforts to seek a clearer understanding of the issues involved in the declining performance of students in science. Studies indicate that research efforts have proposed various suggestions and recommendations for improving the quality of science teaching and learning in Nigerian classrooms (Ajewole, 1994; Busari, 1996; Igwebuike, 1996; Odubunmi, 1981; Okebukola, 1992; Olanrewaju, 1986). However, despite these various suggestions for improvement, the quality of science teaching and learning and students' achievement in secondary science continues to decline (Ikeobi, 1995; Ivowi, 1995). This is also evident in a recent report by the Shelter Right Initiative (Olubusuyi, 2003) that for eight consecutive years, between 1992 and 1999, Nigerian candidates trailed behind their counterparts from other countries in the West African region based on performance in science subjects conducted by the West African Examinations Council (WAEC).

The lukewarm attitude of society to science and the teaching profession, compared to other professions in the country, could be responsible for these lingering problems. Also, the non-involvement of all the key stakeholders in science education in Nigeria including teachers, students, school principals, education officers, teacher educators, curriculum planners, parent associations, professional bodies, scientists and educational leaders to gain their support in examining the actual situation of science teaching and learning could be a factor. There is therefore the need to involve key stakeholders to reveal a realistic ideal picture through which recommendations could be made in the context of science education in Nigeria. This in essence will help to arrest the decline in the quality of secondary science education.

The need to improve the quality of science teaching and learning for citizens so that they develop scientific literacy to cope with the demands of science and technology growth has been the yearning of every nation in this 21st century. Such efforts have been made by researchers in the United States of America (Darling-Hammond, 1997), Australia (Goodrum, Hackling & Rennie, 2001) and the United Kingdom (Millar & Osborne, 1998) by engaging the support of key stakeholders in science education. Recognising this, the need to involve key stakeholders in science education in making recommendations for improving the quality of science teaching and learning in Nigerian secondary schools as a means of helping citizens to become more scientifically literate, is a task that is widely acknowledged as important. This is the focus of this study.

Statement of the Problem

The current situation of science teaching and learning in Nigeria is a concern to all including government and the society at large. Research indicates that many students found science to be difficult, boring and not interesting to them (Salau, 1995, 1996). Large class sizes, inadequate funding, insufficient curriculum resources, poor teaching skills and lack of supports for teachers among other factors further limit the quality of science teaching and learning in Nigerian schools (Okebukola, 1997). To solve these lingering problems one needs to develop a realistic picture of what is currently happening in the teaching and learning of science in Nigerian schools and also to identify the factors that are limiting the quality of science education. Furthermore, one needs to develop a reasonable ideal picture for which the nation can strive towards within the existing resource limitations.

Rationale for the Study

From the range of evidence in the science education literature, it is very clear that science education in Nigeria is faced with numerous problems that need to be addressed so that the goal of equipping students to live effectively in our modern age of science and technology, as formulated in the Nigerian National Policy on Education (Federal Government of Nigeria) (FGN), 1981, 1998) will not become a daydream. It is, however, believed that if appropriate steps are not taken to address these lingering barriers to reform, the citizens will not be able to develop scientific literacy useful for coping in the modern scientific and technological world. Efforts at developing scientifically literate citizens by improving the quality of science teaching and learning in schools is a laudable reform that should preoccupy the mind of the policy makers and all the key stakeholders in science education in Nigeria.

It is imperative for the issues involved to be examined empirically in the context of science education in Nigeria. Gaining the support of the key stakeholders in exploring and revealing what is actually happening in science teaching and learning in our secondary schools and for them to formulate a realistic ideal picture of science teaching and learning through which recommendations for closing the gaps between the actual and ideal could be developed, is necessary to improve the quality of science education for Nigerian secondary students. This is the motivation for conducting this study.

Importantly, the research approach for this study was modelled on a recent study in Australia by Goodrum, et al. (2001) and compared two pictures of science teaching and learning in schools. These are the actual picture, which describes what is actually happening in schools and the ideal picture, which defines a realistic ideal quality teaching and learning in science in junior secondary schools in Lagos State, Nigeria. This study applies this established research approach to developing an education system in a developing country.

Significance of the Study

In an effort to improving the teaching of science in Nigerian secondary schools and make the learning of science more attractive to students, this study makes the following important contributions to knowledge and education.

Firstly, this study provides science educators, science curriculum planners and government with detailed information about the actual picture of science teaching, science learning, and educational practices in Nigerian schools, and realistic, cost effective ways of improving the situation. This in turn can help in planning and formulating further policies for science education in Nigeria.

Secondly, this study engages key stakeholders in science education in revealing the actual and ideal pictures and gaining their support for recommendations for closing the gap. This in essence informs them about the features of quality science education and gains their support for improving the recommendations of the study.

Thirdly, this study provides an opportunity to apply a research design developed in Australia to a developing nation in Africa, and to evaluate the effectiveness of that research design and compare findings between a developed and developing countries education system.

Purpose and Research Questions

The purpose of this study was to investigate and describe the status and quality of science teaching and learning in junior secondary schools in Lagos State, Nigeria with the intention of comparing an ideal picture of science teaching and learning with actual practices. More specifically, the study will address the following research questions:

1. What is a realistic ideal picture of teaching and learning of science in Nigerian secondary schools as perceived by teachers and other stakeholders?

2. What do science teachers, students and other stakeholders perceive as the nature of teaching and learning of science in Nigerian secondary schools at present?

3. What factors do teachers and other stakeholders perceive as militating against quality of teaching and learning of science in Nigerian Secondary schools?

4. How can these factors be addressed to improve the quality of teaching and learning of science in Nigerian secondary schools?

CHAPTER 2: LITERATURE REVIEW

Introduction

This Chapter presents a summary of national and international research literature, curriculum documents and reports that are relevant to this investigation of the status and quality of secondary science education in Lagos State, Nigeria. The Chapter begins with a review of the historical background of science education in Nigeria. This is followed by the purpose and goals for secondary science education. Within this section the nature and importance of scientific literacy is explored. The next section deals with the quality of teaching, learning and assessment practices in science education. Finally, the Chapter examines initial and continuing teacher education for science teachers.

Historical Background of Science Education in Nigeria

Before the advent of Western education in Nigeria, certain aspects of scientific knowledge were included in traditional forms of education (Abdullahi, 1984). The arrival of the British missionaries on the coast of Lagos in 1859 and subsequent establishment of churches and elementary schools in the town of Topo near Badagry in 1861 marked the beginning of western education in Nigeria. Abdullahi (1982) notes, the foundations for science teaching in Nigeria were laid between 1861 and 1897 when the rudiments of science were introduced in the timetable of some missionary primary schools and teacher training colleges. The teaching of science in Nigerian secondary schools, however, commenced after 1931 with the establishment of secondary schools. Bajah (1982) argues that the science curriculum in secondary schools at that time was nature study, which involved learning about the environment, plants, animals and non-living things. Consequently, the coverage and depth of science subjects taught in secondary schools were very low due to the scarcity of trained teachers and resources for science teaching (Abdullahi, 1984).

Very few students in secondary schools attempted science at external examinations conducted by Oxford and Cambridge Examination Boards before 1931, while most of those students who attempted it, failed (Abdullahi, 1984; Ogunleye, 1999). Of significance is that, at that time, many parents were uneducated traders, clergymen, carpenters, and fishermen and the few educated parents preferred sending their children abroad to study law, medicine and humanity courses rather than science and this consequently led to little progress being made in encouraging science education in Nigeria among the citizens.

The pressures from Nigerian nationals who had the opportunity to study abroad and the subsequent Education Ordinances (i.e. legislation on education) led the colonial government to establish post-secondary institutions and this marks the beginning of modern science teaching in Nigerian secondary schools. The first post-secondary institution, Yaba College (which was later upgraded in 1963 to be known as Yaba College of Technology) was established in 1932 and the first graduates from this college went to secondary schools to teach science and lay the foundation for the development of an appropriate curriculum in science for secondary students (Ogunleye, 1999).

A notable problem during this period was that the science curriculum was modelled on British syllabi, with content and activities in science that were beyond the experience of the Nigerian students and culturally inappropriate. Also, the science taught in secondary schools reflected the British requirements and aspirations rather than those of Nigeria (Taiwo, 1975). Abdullahi (1984) notes, the teaching and learning of science during the period was classical and emphasised rote learning of unrelated laws, definitions and concepts, and also teachers rarely conducted practical lessons in science for secondary students due to the lack of funds for laboratory facilities. These unfavourable conditions led to high failure and attrition rates in science subjects and a drift to arts subjects by most students because they perceived science to be very difficult to learn. Between 1932 and 1960 when Nigeria attained her independence from the British government, a number of educational reforms took place, including:

1. The introduction of the Higher School Certificate courses in some of the existing secondary schools in 1951 to afford students the opportunity to further study science with the emphasis being on laboratory work so as to meet the practical requirements of the science subjects.

2. The establishment of the West African Examination Council (W.A.E.C) in 1952 to conduct senior secondary examination in West African countries with its headquarters in

Accra, Ghana. Nigeria, Ghana, Sierra-Leone and Gambia were member nations. WAEC conducted its first senior secondary examination in 1955 and had a significant influence on science curricula.

3. The Science Teachers Association of Nigeria (S.T.A.N) was established in 1957 with the aim of promoting cooperation among science teachers in Nigeria with a view to raising the standard of science teaching in the country (STAN, 1973). It is worth noting that at the time of inauguration of STAN in 1957, less than 30 secondary schools throughout the country taught science (Bajah & Bello, 1996).

4. The Federal Colleges of Arts, Science and Technology at Ibadan in 1950; Zaria in 1952 and Enugu in 1954 were established with the aim of promoting the teaching of science.

It is equally important to recognise a number of international conferences in the early ‘60s drew the attention of developing countries, especially in sub-Saharan Africa, to the need for science and technology. Yoloye (1998) indicates three of the most significant international conferences on science education as the Rehovoth Conference of 1960, the Addis Ababa Conference of 1961 and the Tananarive Conference of 1962. The reports of these conferences raised national consciousness and awareness among Nigerians about education and led to the establishment of panels and commissions to examine educational priorities for Nigeria. Notable among the commissions was the Ashby Commission of 1960 which highlighted the poor quality of teachers, insufficient resources and poor quality of teaching of science in primary and secondary schools as factors that needed urgent attention at that time (Omolewa, 1977).

The abolition of Oxford and Cambridge examinations and the establishment of the West African Examination Council in 1952 to conduct secondary school examinations in Nigeria brought many changes into the science curriculum, and indigenized the content and scope of science teaching in Nigerian schools. It further led to the first science curriculum development project in Nigeria known as the Basic Science for Nigerian Secondary Schools (BSNSS) written by Nigerians and published in 1967 with a teachers’ guide. This project was jointly funded by the Ford Foundation of America and the Western Nigeria Regional Government and coordinated by the Comparative Education Study and Adaptation Centre

(CESAC) of the University of Lagos. This curriculum in General Science covered the first two years of secondary education in Nigeria and emphasized discovery teaching methods, and laboratory oriented activities. The philosophy of the project as reported by Ogunleye (1999) is “doing science the way the scientists do it, observing carefully, reporting honestly what is observed and being patient” (p. 106).

The issues of workforce planning, economic growth and social reforms among others led to the inauguration of the Nigerian National Conference in 1969 to develop a new direction for Nigerian education which later metamorphosed into the National Policy on Education in 1977 (Fafunwa, 1983). The policy which is popularly referred to as the 6-3-3-4 system of education and translated into six years of primary, three years of junior secondary, three years of senior secondary and four years of tertiary education was the outcome of the conference (Federal Government of Nigeria (FGN), 1981, 1998).

The National Policy on Education document was revised in 1981 and 1998 and has since being used in Nigerian schools until the present time. The document sets out clear educational objectives at all levels, which are related to the overall national objectives of building a free, democratic, egalitarian, strong, just and self reliant Nigerian society, full of opportunities for all citizens (FGN, 1998). The policy documents emphasized the importance of science and technology, with both State and Federal governments encouraging citizens to pursue science-related activities. The broad aims of secondary education in relation to science education as enunciated in the policy document include:

- to diversify the school curriculum to cater for differences in talents, opportunities and roles possessed by or open to students after their secondary school course;
- to equip students to live effectively in our modern age of science and technology; and
- to raise a generation of people who can think for themselves, respect the views and feelings of others, respect the dignity of labour and appreciate those values specified under our broad national aims, and live as good citizens (FGN,1998, p. 16).

Today in Nigeria, the junior secondary level of education is both pre-vocational and academic. It is compulsory and tuition free throughout all states of the Federation so that all citizens have access to basic education. The Junior Secondary Science Core Curriculum is in ‘integrated form’ based on the principle of the broad-field curriculum design (Federal Ministry of Education (FME), 1985). The curriculum emphasized integration of different science subjects which are relevant to the child’s need and experience with a purpose of stressing the fundamental unity of science and laying an adequate foundation for subsequent specialist studies in science education. The basic science subjects are taught in ‘integrated form’ referred to as ‘Integrated Science’ comprising biology, chemistry and physics topics to enable pupils to acquire further knowledge and develop scientific skills.

The senior secondary level is for those willing to have a complete six-year secondary education. It is comprehensive but has a core curriculum designed to broaden pupils’ knowledge and outlook. The core curriculum is the group of subjects, which every pupil must take in addition to his or her specialties (FGN, 1998). The subjects include:

1. English language
2. One Nigerian language
3. Mathematics
4. One of the following science subjects: Physics, Chemistry and Biology
5. One of Literature in English, History and Geography
6. Agricultural Science or a vocational subject.

The science content mandated in the national core curriculum for senior secondary school students is both preparatory and an interface with what is taught during the first year in the tertiary institutions. It is worth noting that at the senior secondary level Physics, Chemistry, and Biology are taught to students as if they will all be science students at the university (FME, 1982).

The Science Teachers Association of Nigeria (STAN) has over the years contributed towards science curriculum innovation and renewal and has been highly supportive of integrated science programs at the junior secondary level and has contributed to improving the teaching and learning of science at the senior secondary level by organizing seminars, workshops and conferences for science teachers and students.

Currently, the teaching and learning of science in Nigerian secondary schools is being limited by a number of factors. A national survey conducted by the Science Teachers Association of Nigeria (STAN, 1992) identified gross under funding, overloaded classrooms, shortages of qualified science teachers, and poor teaching strategies among other factors as contributory to students under achievement in science. Reports by Ivowi (1995) and Okebukola (1997) further confirmed that the problems still lingered in the schools. These reports are disheartening and concern teachers, science educators, curriculum planners and other key stakeholders including government.

Unlike at the inception of science education in Nigeria where science curriculum reflected British culture and requirements; today the science curriculum in Nigeria is based on indigenous cultures with emphasises on the use of indigenous or local materials and as well the language of the learners' environment in promoting the learning of science in schools (Olarewaju, 1991). Importantly, the culture of origin back-grounds, knowledge, and beliefs are crucial to science education (Shumba, 1999).

This section has reviewed the historical trends of science education in Nigeria. A disturbing scenario of science teaching and learning in Nigerian schools is reported and was found to have culminated from the British influence and historical background of science teaching in Nigeria. These lingering problems facing science teaching and learning in Nigeria still persist and have continued to affect the quality, growth and development of science education in Nigeria. These require the concerted effort of the government, science teachers and other key stakeholders to address the problems or else the nation may fail to meet the challenge of developing scientific literacy for all citizens in the 21st century.

Purpose and Goals for Secondary Science Education

This section presents the purpose and goals of science education and highlights the importance of scientific literacy. The section further examines the relationship between science and technology and the roles they play in the social and economic development of a nation.

Nigeria is located in West African sub-region and with a growing population of about 120 million people comprising of three major different ethnic groups: the Yoruba's from the south, Hausa's from the north and Igbo's from the east (Nigerian National Population Commission, 1998). Nigeria as a nation comprises of 36 states and education at all levels is the responsibilities of both the Federal and States governments. The level of poverty, environmental pollution and degradation in Nigeria has been ascribed to the level of ignorance and illiteracy among the citizenry. The level of environmental awareness among school leavers remains low (Balogun, 1987) and the current level of scientific illiteracy coupled with poor student achievement in science is of concern to governments, educational authorities and individuals (Akpan, 1996). The underlying problems have been traced to many factors including poor teacher preparation resulting in poor teaching skills among science teachers, and inability to determine a realistic and a well-articulated purpose and goals for secondary science education (Okebukola, 1997; STAN, 1992).

Researchers and science educators have over a decade presented several conflicting perspectives on the purpose and goals of science education (Bajah, 1998; Cobern, 1994; National Research Council, 1996; Oversby, 1998; UNESCO, 1994). Their views about the purpose and goals of science education include to:

1. develop creativity in learners;
2. improve scientific literacy and technological literacy of citizens;
3. prepare citizens for an active contribution towards their own culture; and,
4. inculcate the spirit of scientific thinking in learner.

According to Bell, Blair, Crawford and Lederman (2003) an adequate understanding of the nature of science and scientific inquiry is the main instructional purpose of science education. The Queensland School Curriculum Council (1999) notes, "science is part of the human quest for understanding and wisdom and reflects human wonder about the world. The study of science as a 'way of knowing,' and a 'way of doing' can help students reach deeper understandings of the world" (p. 1). Shamos (1995) claims, the knowledge of science is important in making crucial decisions on everyday issues and problems, and in the production of informed citizens who are capable of taking personal actions to find solutions to any identified issues and problems.

The American Association for the Advancement of Science (AAAS, 1989) argues that an understanding of science concepts and principles is crucial to developing scientific literacy and also for meaningful and productive careers in science and asserts thus, "more and more jobs today require people who have the ability to learn, reason, think, make decisions, and solve problems and as well engage in scientific discourse" (p. 13).

This assertion supports the goals for science education enumerated in the report of the National Science Education Standards (National Research Council, 1996) that the knowledge of science concepts and principles would help students to be able to:

- experience the richness and excitement of knowing about and understanding the natural world;
- use appropriate scientific processes and principles in making personal decisions;
- engage intelligently in public discourse and debate about matters of scientific and technological concern; and
- increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers (p. 13).

According to the National Science Education Standards (National Research Council) (NRC, 1996) scientifically literate persons are those who can think, ask questions, and provide logical and coherent answers to any situations and everyday experiences. Thus, a scientifically literate student develops higher order cognitive thinking to identify and evaluate ill-defined problems, to make informed decisions, and also to provide a variety of solutions to any particular problem (Craven & Penick, 2001; Hurd, 1993; Resnick, 1992). Therefore, understanding the nature of science and scientific inquiry to foster learners' ability to develop scientific literacy is a purpose and goals for science education.

The Meaning of Scientific Literacy

Currently, students' understanding of the nature of science and scientific inquiry is widely acknowledged as crucial for developing scientific literacy (AAAS, 1993; Lederman, 1999;

NRC, 1996). Goodrum, Hackling and Rennie (2001) note, science education helps citizens to understand their local environment and their health and well-being and to become scientifically literate. Scientific literacy for all the citizens therefore is acclaimed as the primary purpose and goals for science education (AAAS, 1989; Bybee, 1997; Goodrum, et al., 2001; Millar & Osborne, 1998).

Scientific literacy has been represented differently by science educators and researchers according to individual perspectives and so remained an elusive concept (Bybee, 1997; Hurd, 1998). Scientific literacy has been associated with scientific content knowledge, ways of thinking, and understandings of scientific facts, concepts and processes (Rascoe, Chun, Kemp, Jackson, Li, Oliver, & Tippins, 1999) or as part of an individual's intellectual ability or accomplishments in building socially informed, competent and responsible citizenship in a democratic society (Bybee,1997). An understanding of the meaning of scientific literacy is fundamental for improving the quality of science teaching and learning and for developing scientifically literate citizens.

The National Science Education Standards (NRC, 1996) define scientific literacy as "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (p. 22). The National Science Education Standards further assert:

> Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed (NRC, 1996, p. 22).

The OECD Programme for International Student Assessment (OECD, 1999) argues that scientific literacy is:

> …the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (p. 60).

Ryder (2001) describes scientific literacy as "an evolving combination of science-related attitudes, skill and knowledge that students need to develop inquiry, problem solving and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them" (p. 5). Hackling, Goodrum and Rennie. (2001) argued that scientific literacy encompasses more than just an understanding of the scientific processes and content, but is a high priority for all citizens, helping them:

- to be interested in, and understand the world around them,
- to engage in the discourses of and about science,
- to be skeptical and questioning of claims made by others about scientific matters,
- to be able to identify questions, investigate and draw evidence-based conclusions, and
- to make informed decisions about the environment and their own health and well-being (p. 7).

From these various definitions, it is clear that scientific literacy encompasses developing interest in science and its applications; the scientific processes of asking questions, investigating and drawing evidence-based conclusions; and, an understanding of science concepts, principles, theories, and processes, and the interrelationships between science, technology and society.

Scientific literacy can therefore be referred to as the ability of citizens to:

1. acquire scientific knowledge, principles and facts;
2. understand scientific concepts and processes;
3. identify scientific questions, investigate and draw evidence-based conclusions
4. engage in scientific discourse and make decisions about self and the natural world; and,
5. contribute to national economic growth and development.

Importance of Scientific Literacy

In recent times, scientific literacy has been recognised as a universal educational objective for all citizens in a world increasingly shaped by science and technology (AAAS, 1993; Bybee, 1997; Lederman, 1999; NRC, 1996). The address of the United Nations Educational, Scientific and Cultural Organisation's Director-General at the launching of Project 2000+: '*Scientific and Technological Literacy for all*' (UNESCO, 1993) clearly emphasizes the relevance of developing scientific literacy when he asserts:

> Efforts to achieve "Education for All" must therefore be closely linked to a worldwide drive to raise levels of scientific and technological literacy. In practice, this means ensuring sound numeracy, a grasp of the fundamental concepts and methods of science together with the development of elementary problem-solving skills and associated decision-making capabilities. All are required in a world in which political, economic, social and ethical considerations have become inextricably linked with the consequences of science and technology advance…….. in a world increasingly shaped by science and technology, scientific and technological literacy is a universal requirement, if people are not to be alienated in some degree from the society in which they live, they are not to be overwhelmed and demoralized by change, if they are to have the basic knowledge and understanding to make those multifarious political, environmental and ethical choices with which scientific discovery and its consequences are confronting us all… (p. 1).

The above assertion reflects the importance of scientific literacy and that literacy in science and technology is necessary for all citizens in resolving problems which make lives unsustainable in the modern age of science and technology.

Literature in science education and researchers (AAAS, 1993; Bell et al, 2003; Bianchini & Solomon, 2003; Bybee, 1997; National Research Council, 1996; Rascoe et al., 1999) claim that scientific literacy helps the citizens to:

1. have personal fulfillment and excitement;
2. improve and maintain national economic productivity;

3. develop the skills needed for resolving problems confronting the human race;
4. live interesting, responsible and productive lives;
5. evaluate the quality of scientific information;
6. make choices that arises everyday; and,
7. be involved and contribute to scientific and technological issues through public discourse and debate.

Basically, scientific literacy is a must for all citizens to contribute to the scientific and technological growth and development in the modern age of science and technology. Failure to improve the literacy of citizens in science and technology could be detrimental to social, political and economic growth and development of the nation.

Scientific and Technological Issues

Science and technology are increasingly impinging on the modern world economy, and developing literacy in science and technology for the citizens is a priority of present day education reform (Shymansky & Kyle, 1990). Science and technology are crucial to improving the standard of living for the community by providing better health care, improved and more nutritious diets, manageable and more effective land use, provision of a regular supply of energy, and preservation of perishable goods among others (Ware, 1992). UNESCO (2000, 2002) argues that science and technology are necessary to provide paths to economic development and sustainability. Holborn (1992) cited by UNESCO (1993) reports that:

> Today there is the recognition that the man-made world around is based on technology. It is the technology that we see around us. The science is less visible. Yet to obtain a more technologically literate society, there is a need for people to receive a more relevant grounding in science. This grounding involves the technology surrounding them and the issues and conflicts that are related to the use of that technology in society (p. 5).

Researchers argue that understanding of the interactions and relationships between science, technology and society (S-T-S) issues in education is an integral part of contemporary and future science education (Bybee, 1987; Fensham, 1983; Solomon, 1988a). Bell et al. (2003) and Matthews (1994) argue that participation in school science encourages students to develop deeper understandings of scientific concepts, the processes of scientific inquiry, and the nature of science for coping with the technological world.

Jenkins (1992) notes, “if school science is to nourish the intellectual excitement and adventure that science undoubtedly offers, it must do so in a context that acknowledges that pupils are growing up in a world that has at its disposal nuclear, chemical and biological weapons and which seems increasingly threatened by new technologies that not only bring great benefits but also problems and may seem to diminish, rather than enhance, individual freedom and choice” (p. 232).

The above assertion acknowledges the fact that an understanding of science and technology through school science is essential for students to understand and cope with the demands of the modern world. According to Goodrum et al. (2001), school curriculum often delineates science from technology and so students find science not interesting and not related to their lives. Layton, Jenkins and Donnelly (1994) argue that science and technology are relevant to scientific literacy and as such, should be bracketed. Jenkins (1992) further notes that science teaching need not concentrate on scientific features, laws and principles but to be taught within the context of technology.

Science and technology issues therefore need to involve teaching science concepts through technology so that science is developed through interesting contexts (Osborne & Collins, 2000; Shamos, 1995). Also Science-Technology-Society (S-T-S) issues should be included in the school science curriculum so that learners develop scientific and technological literacy (Bybee, 1997; Rascoe et al., 1999; Solomon, 1988b). Essentially, engaging students in problem-solving activities could be achieved through inclusion of Science-Technology-Society issues in the school science curriculum (Yager, 1993). These points suggest that there is a need to integrate into school science curricula in Nigeria, issues that involve science, technology and societal (S-T-S) concerns so that citizens develop scientific and technological literacy to live as good citizens and for them to cope with modern day scientific and technological advancement.

Research into Quality Teaching and Learning of Science

This section examines the characteristics of quality teaching and learning of science in schools with emphasis on teachers' content knowledge and the knowledge of teaching pedagogy. This follows with a section on constructivist approaches to teaching and learning. The section further looks into the role of science teachers in quality teaching and learning. This continues with a section on the inquiry approach to science teaching and learning. The next section reviews assessment practices and the purposes of assessment in teaching and learning of science. A further section highlights the classroom implications of quality teaching and its impact on students' achievement in science. The final section examines the factors that inhibit quality of science teaching and learning in schools**.**

Defining Quality

According to the Australian Concise Oxford Dictionary (Moore, 1997), the term 'quality' refers to the nature or appearance of something. In its modern usage it means to indicate a high (being a relative term) degree, character or nature attributed to a person, thing, process or event. Quality has been described in different ways, although, often in an intuitive manner (Reeves, 2002). Aminu (1995) refers to quality of education as "the principal measure of the effectiveness of education and the most vulnerable attribute that suffers when anything goes wrong with the system" (p. 13). Literatures describe quality as "the degree of excellence at an acceptable cost" (Broh, 1982, p. 3); "achieving or reaching for the highest standard" (Tuchman, 1980, p. 38); and the maintenance of academic standards (Cooper, 2002). Based on these different descriptions of the term 'quality' any definitions of quality depend upon which values that are given priority (Reeves, 2002). Basically, quality is a "fitness for purpose" (Higher Education Council, 1992, p. 6). Quality therefore is an elusive concept that takes on different meanings in different settings; however, it is fundamental for effective teaching and learning and for meeting educational goals.

For the purpose of this study, quality could be referred to as a process whereby teaching and learning are continuously improved and maintained with a view to bringing about desirable educational goals in the school system.

Quality Teaching and Learning of Science

Quality teaching of science is crucial for developing scientifically literate citizens and improving the economic productivity for sustainable development (NCMST, 2000; UNESCO, 2000). Darling-Hammond (1999) notes, quality teaching is crucial in enhancing students' achievement and strengthening public confidence in schools. Other reports and researchers (AAAS, 1989; Darling-Hammond, 1999; Darling-Hammond & Ball, 1997; NCMST, 2000; National Research Council, 1997) emphasise that quality teaching helps students attain a deep conceptual understanding. Adegbamigbe (2002) defines quality teaching as a series of dynamic processes and activities of teachers' actions within the educational context with a view to enhancing quality of students' learning and promoting job satisfaction.

Polland and Tann (1993) argue that quality teaching involves teachers who are competent with adequate knowledge and skills needed for effective classroom management, pupil assessment, subject teaching, and those who engage in regular professional learning. Also Vant Hooft (2005) claims that quality teaching encompasses prior knowledge activation, hands-on learning, and continuous reflection.

The report of the National Commission on Mathematics and Science Teaching for the 21st century (NCMST, 2000) presents a vision of high quality teaching which are summarized as those wherein: teachers have an adequate knowledge of subject matter; encourage inquiry and hands-on approaches to learning for students; recognise individual students as learners and insist that students learn; have adequate skills of observation, information gathering, sorting, classifying, predicting, and testing; having the knowledge and skills of questioning and probing, and also reflect on their practices; build on learners' strengths rather than trying to stamp out their weaknesses; carefully and thoroughly align the curriculum with assessment practices, and high standards for student learning; have regular support and opportunities for professional learning, continuing education, and effective use of technology; teachers being recognised, valued and rewarded; and, teachers being evaluated based on performance and achievement of the students.

The National Commission on Teaching and America's future (NCTAF, 1997) also corroborates that high quality teaching involves teachers that: have better and sound knowledge of the subject matter content and pedagogical strategies; have adequate understanding of what the learners know and need to learn; create a challenging and supportive classroom learning environment; interact with students and colleagues; have opportunities for ongoing professional learning; and regular reflection on their teaching and students' learning.

Quality teaching basically, is a "process that helps teachers to focus on the educational improvement of learners through the integration of adequate knowledge of the curriculum content areas, functional pedagogic skills, critical reflective teaching, empathy and commitment to the educational process, and the acquisition of managerial competencies within and outside the school context" (OECD, 1994, p. 35).

From the above definition, it is clear that quality teaching fundamentally involves teachers' knowledge of content and pedagogical skills, knowledge of the curriculum and effective supervision and classroom management as well as reflection to improve the learning outcomes of the learners.

The National Science Education Standards (National Research Council, 1996) clearly presents a vision for quality teaching and learning of science that includes:

1. students learning of science is greatly determined by how they are taught by teachers;
2. teachers' perceptions of science as a discipline and as a school subject to be learned by the students greatly influenced their actions and its teachability;
3. students' understanding of science is achieved through their engagement and active construction and social processing of information; and
4. teachers' understanding of and relationship with their students have a great influence on their actions.

These assertions in the National Science Education Standards indicate a shift from the behaviourist approach to teaching where students remain passive recipients of teacher-generated knowledge followed by drill and practice, to constructivist approaches wherein students engage in constructing knowledge of science from their prior experience and the teacher acts as a facilitator, scaffolding students' learning (National Research Council, 1996).

Recent reports of the National Board for Professional Teaching Standards (NBPTS, 1999) in the United States and the Standards of Professional Practice for Accomplished Teaching in Australian Classrooms (ASTA & Monash University, 2002) indicate that quality science teachers must:

- have adequate knowledge and understanding of the learners, their individual differences, how they develop in their learning and how to make knowledge accessible to all learners by treating them equally.
- have both content and pedagogy knowledge, have a better understanding of how their students learn, the prior knowledge they bring to each subject and then use a variety of instructional materials and teaching strategies that can be of assistance to the students in their classroom.
- create an enriched learning environment, sustain students' interests through their active participation in classroom activities, and collaborate with other teachers to develop a variety of instructional techniques and to assess and motivate the students' progress in learning through regular feedback towards the realization of the schools' goals.
- engage in continuous professional learning, critically examine their teaching practices, and seek to expand and deepen their knowledge by adapting their teaching to new findings, ideas and theories and to encourage their students in lifelong learning.
- work collaboratively with other professionals on instructional policy, curriculum and staff development, relate with parents and the school community and must be knowledgeable and skilled about specialized school and community resources that can be engaged for their students' benefit.

Quality teachers of science therefore are knowledgeable about science, learning, and science teaching and they create an environment where students are regarded and treated as active learners (National Research Council, 1996). Quality teaching and learning in science thus involves teachers' knowledge of subject matter and teaching pedagogy (Ball & McDiarmid, 1990; Brophy, 1986; Darling-Hammond, 1997; Shulman, 1986). Shulman (1986) argues that quality teachers have adequate knowledge of the subject matter content and that of pedagogical skills, which is termed 'Pedagogical Content Knowledge'. Quality teachers therefore according to Shulman (1986) would possess:

1. Content knowledge, which is the teacher's content background in the subject they teach.
2. General pedagogical knowledge, which embraces the principles and strategies of classroom management and organisation.
3. Curriculum knowledge, which is the knowledge of curriculum materials and resources that are relevant for the teaching of a particular topic.
4. Pedagogical content knowledge, which is the combination of content and pedagogy.
5. Knowledge of the learners and their characteristics, which comprises the knowledge of students' developmental levels and prior knowledge, and how teachers motivate students' learning.
6. Knowledge of educational contexts, which encompasses teachers' understanding of school environment including the classroom and the knowledge of the school communities.
7. Knowledge of education ends, purpose and values and their philosophical and historical grounds; this knowledge helps teachers to put their own goals into a larger perspective.

Gess-Newsome (1999) however argues that quality teachers have content knowledge and attitudes, pedagogical knowledge and skills, knowledge of students, and knowledge of curriculum. Gess-Newsome (1999) describes *content knowledge and attitudes* as those comprising teachers' conceptual knowledge, knowledge of nature of science, knowledge of integration, and relevance, and teacher attitudes such as enthusiasm and a willingness to support and create time for effective science teaching. According to Gess-Newsome, teachers who show positive attitudes such as curiosity, using problem solving approaches when answering questions, relying on data, being sceptical of explanations while being open to new ideas, and respecting reason and honesty in science will encourage their students to modeling such similar attitudes.

Gess-Newsome refers to *pedagogical knowledge* and skill as the ability of the teacher to plan, implement and assess students' engagement in meaningful science teaching that is active, relevant, developmentally appropriate, and build on learners' prior knowledge through the use of activities that are inquiry-oriented, support the social construction of accurate science knowledge, and develop classroom community.

Furthermore, Gess-Newsome argues that *knowledge of students* encompasses both a general knowledge of student development and specific knowledge of the students in one's own classroom. This allows the teacher to capitalize on student interests and motivations to create a relevant science curriculum as well as knowledge of student misconceptions for commonly taught topics.

Finally, Gess-Newsome describes the *knowledge of curriculum* as that which allows a teacher to select, adapt, or create instructional materials to meet student needs and recognise how these materials combine to create a coordinated program of science across grade levels and across the curriculum

Shulman describes pedagogical content knowledge as the knowledge that enables practising teachers to make connections between their knowledge of pedagogy and their knowledge of content. In addition, Clermont, Krajcik and Borko (1993) argue that pedagogical content knowledge includes an understanding of students' experience, developmental age, social economic background, and the prior knowledge that students bring with them in learning of specific topics; knowledge of the materials to use and how to sequence those materials to help students acquire new concepts and skills; and the knowledge of what makes the learning of those topics easy or difficult to students and, how teacher applies the teaching skills in bringing about changes in students' learning through interaction and engagement.

Clermont and co-workers (1993) therefore describe pedagogical content knowledge as a "blend of content and pedagogy that provides teachers with an understanding of how particular subject-matter topic, problems, and issues are organized, represented, and adapted to the diverse interests and abilities of learners, and then presented for instruction" (Clermont et al., 1993, p. 21).

Wilson, Shulman, and Richert (1987) further argue that pedagogical content knowledge is not simply a repertoire of multiple representations of the subject matter alone, but a way of thinking called ‘pedagogical reasoning’. Pedagogical reasoning is described as a knowledge base used by teachers to transform subject-matter into teachable forms and to create opportunities for effective classroom interactions (Clermont et al., 1993; Wilson, et al., 1987) and this is achieved by teachers through motivation, creativity and reflective thinking (Berliner, 1986; Feiman-Nemser & Parker, 1990; Leinhardt, 1986; Shulman, 1986, 1987; Wilson, et al., 1987).

Darling-Hammond and Ball (1997) note that teachers’ knowledge about learners, teaching and learning and their knowledge of instructional approaches to actively engage students are essential for facilitating students’ learning and understanding. They assert:

> Teacher expertise… or what teachers know and can do…affects all the core tasks of teaching. … and what teachers understand, both about content and students, shapes how judiciously they select from texts and other materials and how effectively they present material in the class. The teachers’ skills in assessing their students’ progress depends also on how deeply they themselves know the content, and how well they can understand and interpret students’ talk and written work (p. 2).

Quality teaching in science, therefore, also involves science teachers’ knowledge of the diagnostic skills for analysing the work students are doing, identifying their weaknesses and stage of progress, and then devising the means of helping students make progress, and for those who are experiencing difficulties, collaborating with other teachers through participative inquiry to devise learning plans for these students (Elmore, 1995; Goodrum & Hackling, 2003).

For the purpose of this study, quality teaching in science could be described as involving the ability of a teacher to use his or her knowledge of subject matter, knowledge of curriculum and the students, knowledge of teaching materials and classroom administration and pedagogy to facilitate students’ learning outcomes in science.

Beliefs about Science Teaching and Learning

Studies in education have shown that teachers' beliefs about science, science teaching and students' learning have an important influence in science education reforms and in the implementation of science curriculum (Crawford, 2000; Fang, 1996; Johnson, 2004, Keys, 2005; National Research Council, 1996). Many educators affirm that teachers' beliefs are often translated into classroom instructional practice (Brownlee, Boulton-Lewis & Purdie, 2002; Johnson, 2004; Pajares, 1992; Zeichner & Liston, 1996). Research indicates that the foundation of teachers' beliefs emanate from their own personal value system and shaped and reinforced through personal value experience as a student, through formal teacher training, teaching experience and family up bringing (Watters & Ginns, 1995). Therefore it is expedient to consider teachers' beliefs in the reform process by providing professional learning opportunities to change teachers' beliefs so as to achieve effective implementation of curriculum and pedagogy in science (Keys, 2005).

Researchers claim that a better understanding of teachers' beliefs is crucial for shaping the curriculum, for providing guidance for educational leaders as to how to sustain effective change; for providing professional learning that will help teachers reconcile their initial beliefs with that of the intended curriculum (Feldman, 2000; Keys, 2005; van Driel, Beijaard, & Verloop, 2001). Importantly, teachers' epistemological beliefs have an influence on how teachers' implement science curriculum (Keys, 2005) and so understanding of teachers' background, experiences and beliefs are important for quality teaching and learning in science (Johnson, 2004) and for developing scientifically literate citizens.

A number of studies into teachers' attitudes and beliefs in science teaching and learning have identified teachers' epistemological beliefs to include core and peripheral beliefs (Brownlee, Boulton-Lewis & Purdie, 2002). **Core beliefs** are beliefs about knowing that reflect a person's beliefs about what knowledge is, how knowledge is gained, its degree of certainty, and the limits and criteria for determining knowledge (Brownlee et al., 2002). **Peripheral beliefs** on the other hand are beliefs that relate to individual learning, and these include learning strategies, motivation, influences on learning and conceptions of learning outcomes (Brownlee, et al., 2002; Marton, Watkins & Tang, 1995). Peripheral beliefs basically involve students’ conceptions of learning, students’ approaches to learning and students learning outcomes (Biggs, 1989; Entwistle, 1998).

Keys (2003, 2005) further categorized teachers’ beliefs into contextual or environmental beliefs, expressed beliefs and entrenched beliefs. Keys defines **contextual beliefs** as those beliefs wherein teachers perceive that their ability to carry out or implement a certain teaching approach, curriculum tasks or initiative are dependent on certain environmental factors such as the need for enough time for teaching, need for adequate curriculum resources and equipments, and opportunity for professional learning among others. **Entrenched beliefs** are those beliefs that determine their actions or practice; such beliefs include teacher having regular inquiry-based practical and activity work for students because they believe this improves students’ inquiry skills (Keys, 2003, 2005). Keys notes that entrenched beliefs are reinforced over time as a result of teacher’s experience which validates his or her beliefs. Expressed beliefs are sets of beliefs that teachers espouse, however, they are not enacted in practice because of their unwillingness to make changes or certain sacrifices (Keys, 2003, 2005).

Further, Keys (2005) classifies expressed beliefs into four subtypes. These include platonic expressed beliefs, organizational beliefs, associated beliefs, and translational beliefs. Keys (2005) defines **platonic expressed beliefs** as those beliefs that are idealist views in nature and so are not fully embraced by the individual teachers. Such beliefs involve views expressed by teachers verbally. A typical example is that “an accomplished teacher is someone who participates in ongoing professional learning or someone who engages the learners in a lot of hands-on inquiry practical and activity work”, but in actual fact, the teacher does not demonstrate the expressed views within his/her practice.

Keys (2005) describes **organisational beliefs** as those beliefs that are identified by teachers as being imposed upon them by the school administration or curriculum body to which teachers gives verbal supports so as to maintain harmony, but in actual fact, teachers only slightly modify their actual practice. A typical example of organizational beliefs is a standing order from the school administration and or curriculum organization that teachers conduct regular inquiry-based hands-on practical and activity work in science. The teachers may verbally support this view, but in actual practice, is not done at all or only tentatively carried out by teachers.

Associated beliefs are related to those beliefs that are imposed on the teachers by the curriculum body or professional organization but the teachers have little knowledge about issue or practice and so these beliefs are associated by teachers to other beliefs or common practices (Keys, 2005). For example, the imposition of formative assessment by the curriculum body or professional organization on science teachers, however the teachers, have difficulties in achieving the stated goals due to lack of adequate understanding of the concepts.

Importantly, teachers are faced with a diverse range of beliefs and influences that have a significant impact on their organization of classroom activities. Such influences according to Keys (2005) include external pressures to cover curriculum, to prepare students for examination, to meet the expectations of colleagues and immediate supervisors.

Changes in curriculum implementation or other reform initiatives therefore require changes in teachers' beliefs through effective professional learning experiences to promote changes in their practice (Johnson, 2004).

Constructivism in Science Teaching and Learning

Reforms in recent years in science teaching and learning have recognised constructivism as an influential approach for developing scientific literacy (Matthews, 1997; Richardson, 1997; Tytler, 2002). Constructivism is an epistemology, a theory of knowledge that views learning as a personal construction (Jonassen & Reeves, 1996; Newman, Griffin, & Cole, 1989). Constructivists claim that teachers cannot transfer intact knowledge from their heads to the learner and that knowledge is constructed by the learner (Jonassen, 1991). Von Glaserfeld (1984) notes, learners do not simply reflect on what they are told (i.e., objectivist perspective which assumes that knowledge resides outside the bodies of the learner and that learning is a process of mapping entities or concepts onto learners) but learners construct knowledge and understandings and find regularity about the world events and information, and this is an ongoing process which may not be completed.

Duffy and Cunningham (1996) argue that learning is NOT synonymous with instruction and that it involves an active process of constructing knowledge rather than acquiring knowledge while instruction is the process by which knowledge construction is supported rather than a process of knowledge transmission.

The Queensland School Curriculum Council (1999) indicates that effective learning occurs only when the learner develops, constructs and accommodates meaning in a context that builds on their prior knowledge. Tytler (2002) argues that to develop a new understanding there is a need for learners to be encouraged to extend their prior knowledge to a new situation and he asserts:

> If we believe that knowledge is highly contextual, and that the fundamental difficulty in developing new understandings is extending them to new situations, then we need to plan for students to be exposed to a range of situations in which a particular science insight can be used. This would imply, for instance, that one-off activities followed by discussion are ineffective. Students need to be explicitly helped in extending new ideas to different situations as part of the conceptual change process (p. 30).

Essentially, constructivism is a theory that helps teachers to understand how their students learn and this guide their teaching practice.

Constructivism as an approach for improving teaching and learning has been modelled in many science classroom activities (Baird & Northfield, 1995; BSCS, 1994; Bybee, 1997; Driver, 1989; Millar, Leach & Osborne, 2000; Moussiaux & Norman, 1997; Osborne & Freyberg, 1985; Scott, Dyson & Gater, 1987; Tobin, 1990). The three most influential constructivist models in science education are the generative learning model (Cosgrove & Osborne, 1985; Osborne & Wittrock, 1983), the interactive learning approaches (Biddulph & Osborne, 1984), and the 5Es instructional model (Bybee, 1997).

The generative model of learning (Cosgrove & Osborne, 1985; Osborne & Wittrock, 1983) describes how children learn and how to teach children. The model consists of four phases;

the preliminary, focus, challenge and application. The **preliminary** phase is characterised by the teacher determining the prior knowledge that students might bring into the learning environment that is relevant to the new topic. Researchers (Gardner, 1993; Goodrum et al. 2001; Osborne & Wittrock, 1983) claim that students' prior knowledge and experiences have a powerful influence on their new knowledge and understanding. The **focus** phase deals with the activity that students engage in that makes explicit the range of students existing beliefs related to the new concept. The **challenge** phase is characterized by students comparing the scientific explanation with their own ideas and those of other students through debate, challenge and testing each others' ideas and so on. The final phase is the **application** phase during which students determine whether the concept could be useful and applicable to a variety of situations.

The second model, interactive learning approach (Biddulph & Osborne, 1984) consists of five phases namely: preparation, exploratory activities, students' questions, students' investigation and reflection. The **preparation** phase is the first stage in which the teacher gains the previous knowledge and ideas that students have about the topic and then organises resources together with the students. The next phase, **exploratory activities** involves the teacher asking students questions and encourages discussion among the students in order to arouse their curiosity of the topic with a view to gain insight into what ideas or prior knowledge the students have about the topic. **Students' questions** phase is primarily concerned with asking and clarifying of questions by the students. The **students' investigations** phase deals with the teacher helping the students in planning and conducting investigations based on the questions chosen through experimentation, reading of articles or books, writing of letters asking for information or consulting with experts. The final phase is **reflection** during which students are helped by the teacher to record, evaluate and reflect on the results of the investigations and the strategies they employed. Also students are encouraged to ask more questions, share, discuss and evaluate their findings with other students.

The third model, that is, the 5Es instructional model (Bybee, 1997) consists of five phases; engage, explore, explain, elaborate and evaluate. The **Engage** phase is designed to promote interest and motivation with emphasis on activities to arouse curiosity, puzzle students and raise questions for further investigation. The **Explore** phase provides students with, usually similar, practical experiences in which students continue to raise questions, listen to the views of others and begin to investigate different phenomena. Also students are encouraged to express and share views while value judgments about views are suspended. The **Explain** phase provides students with the opportunity to explain their findings to others and their ideas are subjected to greater scrutiny. Teacher introduces relevant scientific explanations during this phase, and students should have developed greater understanding of the phenomena under investigation. The **elaborate** phase involves students applying their new understandings, developed during previous phases, to a range of contexts. The final phase, that is, **evaluation**, involves assessing students' understanding and students are also encouraged to reflect on and question the ideas, which they have developed.

Constructivist approaches to science teaching are analogous to the science that scientists do in that they are inquiry-based and offer science teachers the opportunity to fulfill the constructivist promise of improved teaching and learning (Hausfather, 2001; Lorsbach & Tobin, 1998; Tam, 1999). Hausfather (2001) notes that constructivist epistemology encourages teachers to make sense of what they see, think, and do in facilitating students' learning. Tobin and Dawson (1992) claim that in a constructivist classroom, teachers understand that the prior knowledge that students bring to the learning environment is crucial and will strive to scaffold learning so that it connects with that prior knowledge. Thus, constructivist teachers are facilitators of learning rather than transmitters of knowledge to the learner's head (Chaille & Britain, 1991). A major criticism of the constructivist approach is that it requires more time for exploring and negotiating understanding with students (Tytler, 2002).

Brooks and Brooks (1993) summarised by Vasquez (1998) explain that teachers' roles in a constructivist classroom include:

> encouraging and accepting students' autonomy and initiative; using raw data and primary sources, along with manipulative, interactive and physical materials; when they are framing task, using cognitive terminology such as classify, analyse, predict, and create; allowing student responses to drive lessons, shift instructional strategies and alter content; familiarizing themselves with students' understandings of concepts before sharing their own understanding of those concepts; encouraging students to engage in dialogue, both

> with the teacher and with one another; encouraging student inquiry by posing thoughtful, open-ended questions and asking students to question each other; seeking elaboration of students' initial responses; engaging students in experiences that pose contradictions to their initial hypothesis and then encouraging discussion; allowing time after posing questions; providing time for students to construct relationships and create metaphors; and nurturing students' natural curiosity (p. 8).

Yager (1991) also notes that in a constructivist classroom, students' ideas and questions are encouraged, accepted, and used for curriculum planning, cooperative learning, reflection, and analyses. Taylor, Dawson, and Fraser (1995) further argue that in a constructivist-learning environment:

- Students are given the opportunity to communicate their understandings with other students, to generate plausible explanations for phenomena, to test, evaluate and defend their explanations among their peers, and actively engage in the social construction of knowledge, all of which are reflections of the nature of science.
- Students are provided with frequent opportunity to identify their own learning goals, to share control of the learning environment, and to develop and employ assessment criteria within the learning environment.
- The environment of the classroom is conducive for inquiry. That spirit of inquiry includes the freedom for students to question the operation of their class.
- Students must have the opportunity to experience the tentativeness of scientific knowledge. That is, students must understand that scientific knowledge is theory-laden and socially and culturally constructed (p. 5).

Taylor et al. (1995) clearly indicate that learning is a social process and that new meanings are negotiated. For this reason many researchers now use the term social constructivism to emphasise the social dimension to learning.

A recent report by the Department of Education and Training, Victoria (Education Victoria, 2003) '*Science in Schools Research Project*' summarised by Tytler (2002) states that in effective science classrooms:

- students are encouraged to actively engage with ideas and evidence;
- students are challenged to develop meaningful understanding;
- science is linked with students' lives and interests;
- students' individual learning needs and preferences are catered for;
- assessment is embedded within the science learning strategies;
- the nature of science is represented in its different aspects;
- the classroom is linked with the broader community; and
- learning technologies are exploited for their learning potentials (p. 34).

In addition Tytler (2002) views constructivist learning as one wherein: learning outcomes depend on the learning environment and the knowledge of the learner; learning involves the construction of meaning; and construction of meaning is a continuous and active process.

Therefore constructivism is an approach in which teachers and learners engage in discourse and problem-solving activities with a view to generate and promote new information (Brooks & Brooks, 1993). Thus, for teachers to successfully implement constructivist-teaching approaches in their classroom, they need the support of professional development and new curriculum materials (Venville, Wallace & Louden, 1998).

Teachers' roles in quality science teaching and learning

Quality teaching is a backbone of any educational system for developing scientifically literate citizens. The National Policy on Education (FGN, 1998), notes, "no educational standard can rise above the quality of the teacher" (p. 38). The National Science Education Standards (National Research Council, 1996) also asserts "what students learn is greatly influenced by how they are taught" (p. 28). Therefore students cannot achieve high levels of performance in the absence of skilled, talented and dedicated professional teachers.

A national inquiry report into teacher education in Australia (Commonwealth of Australia, 1980) argues that quality teachers are responsive and sensitive to the distinctive educational needs of special communities and to the particular configuration of special education needs of each pupil.

Other research into roles of quality teachers in classroom activities and processes (OECD, 1994; Shulman, 1986) further indicate that quality teachers' demonstrate commitment; have subject specific content knowledge and knowing their craft; love children; set an example of moral conduct; manage group effectively; incorporate new technology in their teaching and students' learning; master multiple models of teaching and learning; adjust and improvise their practice; know their students as individuals; exchange ideas with other teachers; reflect on their practice; collaborate with other teachers in advancing the profession of teaching; and they also contribute to society at large.

Increasingly, the teacher's role involves being a mentor or guide, one who extends students' deep understandings, and also one who facilitates the acquisition of students' higher order thinking and creative problems solving skills (Abell & Pizzini, 1992).

Basically, accomplished teachers of science are constructors, facilitators, open-minded and critical independent professionals, active co-operators and collaborators, mediators between learners and what they need to know, providers of scaffolding for understanding, coaches, and creators of learning environments and also have a rich understanding of the subject(s) they teach and appreciate how knowledge in their subject relates to other disciplines in helping learners to acquire knowledge (Association of California School Administrator, 2000). Therefore, accomplished science teachers are those who engage students in higher cognitive skills, who promote information literacy, and nurture collaborative classroom practices among students.

An Inquiry Approach in Teaching and Learning of Science

An understanding of the nature of science and scientific inquiry is crucial to defining the characteristics of scientifically literate persons (AAAS, 1993; Darling-Hammond, 1997; Goodrum et al., 2001; NSTA, 1992; Queensland School Curriculum Council, 1999). The

National Science Education Standards (National Research Council, 1996) claims that an understanding of the nature of scientific inquiry is an important goal of science education. A similar report by the American Association for the Advancement of Science (AAA, 1989) points out that inquiry approaches in science enable teachers' to be creative and enrich students' abilities in understanding science concepts and processes.

Bell et al. (2003) and Germann, Haskins and Ausl, (1996) claim that developing scientific literacy for the citizens requires engaging learners in scientific inquiry for them to develop broad knowledge and understandings of the processes and nature of science. The National Science Education Standards (NRC, 1996) notes that learners investigate, generate, ask authentic questions and construct reasonable explanations for the questions formulated through an inquiry approach in science teaching and learning so that they understand the world around them and become scientifically literate. Also inquiry instruction in science enables learners to formulate their own questions, devise ways to answer them through data collection and analysis and then determine the reliability of the knowledge acquired (Edwards, 1997).

Lawson (1995) further indicate that through inquiry-oriented teaching teachers could help learners to build their interest in the materials and activities, and to encourage their thinking, questioning and discussion for a variety of investigatory paths which fits the lesson content and learners' intellectual level with everyday social application problems. Basically, scientific inquiry is central to science instruction (Welch, Klopfer, Aikenhead & Robinson, 1981).

Hestenes (1987) describes scientific inquiry as a way of thinking about natural phenomena and the use of questions and experiments in testing plausible hypothesis to arrive at a logical conclusion. The National Science Education Standards (NRC, 1996) refers to scientific inquiry as:

> … the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to activities of students in which they develop knowledge and understanding of

scientific ideas, as well as an understanding of how scientists study the natural world (p. 23).

Thus, scientific inquiry involves students "working scientifically" through investigating, understanding and communicating (Hackling & Fairbrother, 1996; Queensland School Curriculum Council, 1999).

Literature in science education describes three levels of inquiry-based teaching and learning. These include structured inquiry, guided inquiry and open inquiry (Colburn, 2000; Hackling & Fairbrother, 1996). Colburn describes **structured** inquiry as one that involves the teacher engaging students in problem-solving activities and provides them with the procedures and materials to discover and generalize on their own from data collected. Essentially, the approach prescribes what students are to observe and which data they are to collect. **Guided** inquiry on the other hand involves the teacher providing only the materials and problem to investigate while the students manipulate the materials and solve the problem on their own. **Open** inquiry is similar to guided inquiry with the addition that students also formulate their own problem to investigate. Open inquiry in many ways, is analogous to doing science and a typical example of student open inquiry being the science fair or science talent search projects (Hackling, 1998; Hackling & Fairbrother, 1996).

Over the years, research in science education has compared inquiry-based and traditional teaching and learning approaches in science (e.g. Chang & Mao, 1998; Kaiser, 1996; Lott, 1983; Shymansky, 1984). A typical example is that of Lott (1983). Lott conducted an analysis of 39 studies involving expository and inquiry-oriented approaches in science and found that teachers who encourage inquiry approaches in their teaching have students who perform better than those taught using traditional approaches when higher-level cognitive processes were emphasized, but performed equally well on low-level cognitive processes. Thus the inquiry-based approach helps to develop higher-level cognitive skills in learners and improves learning outcomes among students.

In Nigeria, the inquiry approach has been recognised as a crucial teaching strategy for improving students' learning of science (FME 1985; FGN, 1998). The National Policy on Education (FGN, 1998) affirmed that teaching of science in schools should be by guided-discovery and inquiry approaches. However, studies indicate that inquiry teaching and learning approaches are rarely practiced in Nigerian science classrooms because of the lack of resources for effective practical work, among other factors (Ajewole, 1994; Teibo, 1973).

Teibo (1973) notes, "many ….teachers hardly arrange any laboratory work for their pupils probably because preparation for laboratory work makes much demand on their time and energy……The rigid, laborious and descriptive nature of its teaching has discouraged many intelligent students from pursuing their study of this discipline" (p. 1).

Yager (1991) also affirms that "most teachers know that inquiry is something that real scientists do, something that reformers have championed throughout their professional lives. And yet it remains something elusive; something that is poorly defined, something so broad that all can truthfully say they are doing some of it" (p. 3).

Ogunbowale (2001) points out that the broad scope of the science curriculum and emphasis on quantity of content coverage are the major constraints on inquiry approaches in science teaching and learning in Nigerian schools. However, the literature suggests that when teachers teach less content, they teach it better by introducing ideas in a variety of ways and thus encourage students' learning (Rutherford & Ahlgren, 1990; Wenning, 1997).

For the purpose of this study therefore, scientific inquiry could be referred to as an approach in which teachers create an enabling environment for students' curiosity and engage them in scientific investigations to solve problems that satisfy their ideas about the natural world.

Purpose and Practices of Assessment in Science Teaching and Learning

Assessment is an integral and essential component of quality teaching and learning in science (Goodrum et al., 2001) and for enhancing the achievement of scientific literacy (National Research Council, 1996). Assessment to many is regarded as a way of grading and reporting students' performances to their parents (Goodrum et al., 2001; Ogunjobi, 2000). Cooper (1997) notes:

> Assessment is not just about grading and reporting; it refers to our continual diagnosis of student learning and development. Assessment is not about stopping teaching and testing students; it is a constant, ongoing, embedded practice as we instruct and facilitate learning; it is a daily occurrence in all classrooms (p. 7).

The Education Department of Northern Territory Australia (2003) describes assessment as the collection and interpretation of information and making judgement about students' learning outcomes. Goodrum et al. (2001) refer to assessment in science as the "collection and interpretation of information about learners' knowledge, understandings, skills and attitudes relating to the science outcomes" (p. 21).

Basically, assessment in science education serves a variety of purposes. These include to monitor national standards; to compare standards of students' achievement with those of other countries; to give information through which teachers, educational administrators and also politicians can be held accountable to the larger society; to sort and classify students for education and training and for career placement by employers; to determine the route a student takes through the differentiated curricula that are on offer in school (Black, 1993; Wiliam, 2000). Assessment can also serve the purpose of reporting on a student's educational achievement to their parents or guardians and to the student themselves; to support students' learning by identifying obstacles that limit future learning; and further to provide appropriate and reasonable feedback to learners so that they know what to do to improve (Goldstein, 1996; Helgeson, 1992; Kellough & Kellough, 1999); and also for accountability (Goodrum et al., 2001).

Wiliam (2000) and Wiliam and Black (1996) claim that assessment information can be used to serve four purposes, i.e., diagnostic, formative, summative and evaluative purposes.

Wiliam (2000) describes diagnostic assessment as those assessments that provide information about the difficulties that a student is experiencing, and formative assessment as those used to provide feedback to learners about how to go about improving. Wiliam also refers to summative assessment as those assessments used to certify student achievement or potential, and evaluative assessment as a kind of assessments that are designed to evaluate institutions and curricula, and which serve the purposes of accountability.

The effectiveness of formative assessment in improving learning outcomes is associated with the amount of feedback given to learners following the assessment (Sadler, 1989). Regular feedback given as part of formative assessment helps learners to become aware of any gaps that may exist between their desired goals and their current knowledge, understanding, or skill and guides them through actions necessary to attain the goal (Boston, 2002; Sadler, 1989). Assessment information in science can therefore be used to improve teaching practice and students' learning through appropriate feedback (Goodrum et al., 2001) and so regular formative assessment is crucial in improving the quality of teaching and learning of science.

Factors inhibiting Quality Science Teaching

Currently, achieving quality teaching and learning in science for developing scientifically literate citizens is a worldwide problem facing many nations (Darling-Hammond, 1997; Goodrum et al., 2001; Osborne & Millar, 1998). Several studies in science education over the past decades have made attempts to unravel the causes of low achievement in science among students (Ajewole, 1994; Darling-Hammond, 1997; Goodrum et al., 2001; Odubunmi, 1986; Ogunleye, 1999; Ogunniyi, 1988; Okebukola, 1997). Various studies in the last decade in Nigeria reveal that inadequate human and material resources, overloaded curriculum, large class size, lack of qualified and competent teachers, lack of textual materials, inadequate laboratory apparatus and equipment, poor approaches to teaching and poor students' attitude in science limit the quality of science education (Akale & Nwankwonta, 1996; Folaranmi, 2002; Jegede & Okebukola, 1991).

In the review of science education in Nigeria, Okebukola (1997) identifies the following five factors as inhibiting science education in the country:

- Student-related factors; such as poor attitude to work, apprehension that science is naturally difficult to learn, difficulty associated with learning science symbols and difficulty in learning the language of science.

- Teacher-related factors; such as poor preparation of science teachers, lack of motivation of many science teachers, inadequate knowledge of subject matter by teachers, and lack of skills/competence required for teaching.
- School-related factors; such as overcrowded classrooms, overloaded examination syllabus, lack/inadequate laboratory and workshops, poorly equipped library and lack of vital instructional materials such as textbooks, teacher's guide and audio-visuals.
- Home-related factors; such as imposition of science subjects by parents on children despite poor attitude to science especially at the secondary level, non-monitoring at home of students' progress in science and lack of provision in many homes for the educational needs of students in science; and
- Curriculum-related factors; such as overloaded syllabus and insufficient time allotted to teaching of science in schools (p. 3-4).

Other researchers and science educators (Ingle & Turner, 1981; Jegede, 1990; Jegede & Okebukola, 1991; Ogunniyi, 1988; Peacock, 1995) found the conflict between science and African traditions and the African worldview as an important factor in determining the achievement of African students. Jegede, Fraser and Okebukola (1994) and Ogunniyi (1988) also indicate a mismatch between science taught in schools and African culture and African worldview as important impediment to learning science among African students. Dzama and Osborne (1999) further see a gap between indigenous African cultural beliefs and the worldview that Western education seeks to develop among African students as a crucial factor of underachievement in science education among the African students (Dzama & Osborne, 1999).

The predominance of English language in African schools in preference to indigenous language in science instruction is a barrier to effective learning of science (Olarewaju, 1991). Olarewaju (1991) and Tugwangye (1979) believe that effective learning of science in African schools involves a learner having opportunity of studying science in a language that forms a very intimate part of his or her personality, and in which he or she learns to express his or her first thoughts and develops relationships with those upon whom his or her early life depends. As pointed out by Olarewaju (1991):

science learning is greatly enhanced when the curriculum is developed in the mother tongue and the mother tongue is also used as the medium of instruction………the learning of English language should not be made a clog in the wheel of progress in the learning of science in Nigeria. The child should be taught science in the language (mother tongue) he or she already knows…Any attempt to impose foreign language on the child in learning another subject content (particularly science) will very probably lead him into confusion" (p. 3).

Ogunniyi (1988) further corroborates that traditional worldview needs to be adequately accommodated as opposed to assimilation of Western science in Africa in achieving effective science teaching. Ogunniyi, Jegede, Ogawa, Yandila and Oladele (1995) found that irrespective of teachers' non-Western cultural background, their worldviews are distinct from the science they taught in schools. Thus an adequate understanding of traditional worldviews is crucial to science education in non-Western societies. This in essence requires an integration of indigenous thought and practice with the language of the environment in improving African students' performance in science (Olarewaju, 1991; Yakubu, 1994). As Brunner (1966) notes, teaching is vastly facilitated by the medium of instruction, which ends by being not only the medium of exchange but the instrument that learner can use in bringing order into the environment.

Literature in science education in developed countries of Australia and the United States of America indicate teacher quality is the most important factor inhibiting science learning in schools that needs to be addressed (Darling-Hammond; 1997; Darling-Hammond & Ball, 1997; Goodrum et al., 2001). In the United States, Darling-Hammond (1997) in '*Doing what matters most: Investing in quality teaching*' reveals that without a sustained commitment to teachers' learning and school redesign, achieving quality achievement will remain unfulfilled. Darling-Hammond asserts:

> …the nation lacks systems to attract and retain the kinds of teachers needed for high demand fields and locations. Rather than creating policies to address shortages, standards are too often waived or lowered to admit people without qualifications to teach. …. Many beginning teachers receive little or no

> mentoring; and teacher evaluation and reward systems are disconnected from nation's educational goals. Professional development investments are fairly paltry, and most districts offerings, limited to "hit and run" workshops… And teachers have little time to learn from one another. They rarely have opportunities to plan or collaborate with other teachers, to observe and study teaching, or to talk together about how to improve curriculum and meet the needs of students. In short, many…teachers enter the profession with inadequate preparation (p. 2).

A similar study in Australia by Goodrum et al. (2001), claim that large class size, limited resources, inadequate time for preparation, reflection and teachers collaborating with colleagues limit the quality of teaching science in secondary schools. It is worth noting that quality teaching and learning of science in schools cannot be achieved in a vacuum but requires adequate resources, improved teacher preparation, limited class sizes, ongoing professional development for science teachers and the recognition of the importance of science education in society among others.

Improving the quality of teaching and students' achievement in science depends on the quality of initial teacher education, mentoring and induction programmes provided for beginning teachers, opportunities for ongoing professional development provided for teachers, teaching resources in school and community support among other factors.

Initial Science Teacher Preparation

Literature in science education has continued to claim that teacher quality is the most important factor that inhibits the quality of science education (Darling-Hammond, 1997; Darling-Hammond & Ball, 1997) and that most teachers lack adequate background knowledge in the fields they are asked to teach or sufficient skills for the students they need to teach (NRC, 1996). Schoon (1996) notes, effective science teachers have the knowledge of the learner, subject matter content, teaching pedagogy, school and the school environment.

Bryan, Abell and Anderson (1996) claim that prospective science teachers have different beliefs and knowledge about teaching and learning before entering teacher education programs. Kanstoroom (1999) also argues that a large portion of today's teachers are unprepared for the challenges that await them in the classroom. Thus, today's teachers need higher levels of education, skills, and knowledge in teacher education programmes and improving the quality of the initial teacher education should be a priority.

Initial teacher education is the primary responsibility of the universities and colleges or faculties of education (Ogunmade & Oyeleke, 1994; Shroyer, Ramey-Gassert & Wright, 1995). Initial teacher preparation varies remarkably from one state or country to another. In the United States of America for example, the preparation of teachers varies from state to state and from institution to institution (Hofer, 2005), although there may be some similarities. The primary path to science teacher education in most States in the United States of America is a four-year college degree consisting of two years of general science courses and followed by admission to an education programme coursework and field experiences in the schools (Halasz, Santiago, Ekholm, Matthews & McKenzie, 2004). In the State of California however, teacher preparation takes as long as five-year credential programme since a prospective teacher must first earn a baccalaureate (i.e., undergraduate) degree in an academic field before completing the requirement for the teaching credential (Halasz, et al., 2004).

In Germany, prospective teachers spend seven years of intensive training and must first obtain a degree comprising academic majors in two disciplines and then commence two or three more years of an intensive teacher preparation, which includes pedagogical seminars with classroom observations and intensively supervised practice teaching (Halasz, et al., 2004). Prospective science teachers in France pursue a five-year program of undergraduate studies and teacher education leading to an intensively supervised year-long internship in schools (Brisard, 2002). In Australia, a prospective science teacher undergoes four-years of tertiary education including at least one year of full-time teacher education (National Board of Employment, Education and Training, 1990). In Western Australia, there are various routes to becoming a teacher either by completing a four-year programme for the award of Bachelor of Education or a tertiary degree (e.g. Bachelor of Science) and a one-year

Graduate Diploma of Education (National Board of Employment, Education and Training, 1990).

Shulman (1987) argues that teacher education programmes should comprise knowledge of subject matter (content knowledge), knowledge of teaching the subject (pedagogical knowledge) and the knowledge of the subject matter and its teachability (content-pedagogical knowledge). Anderson and Mitchener (1994) note that variation in teachers' prior scientific and pedagogical knowledge beliefs is as a result of lack of articulation and coordination between content knowledge and pedagogical knowledge during their initial teacher education programs. Yager and Penick (1990) also identify lack of coordination in the nature of methods courses, practicum experiences, and the role of placement of clinical experiences as the immediate problems facing science teacher education that need to be addressed for quality science education (Yager & Penick, 1990). Rosario and Ison (1991) therefore claim that quality teacher education programs should include field-experience in which preservice teachers would be mentored by a master teacher and should be able to observe exemplary teaching in progress.

Historical Background of Initial Teacher Education in Nigeria

Teacher education has been recognised as the bedrock for equipping teachers for national development (Afe, 2001). The Nigerian National Policy on Education (FGN, 1998) recognises the importance of teacher education when it states "teacher education will continue to be given a major emphasis in all our educational planning because no educational system can rise above the quality of its teachers" (p. 38). The goals of teacher education in Nigeria are to:

a. produce highly motivated, conscientious and efficient classroom teachers for all levels of the education system;
b. encourage further the spirit of enquiry and creativity in teachers;
c. help teachers to fit into social life of the community and the society at large and enhance their commitment to national goals;
d. provide teachers with the intellectual and professional background adequate for their assignment and make them adaptable to changing situation; and

e . enhance teachers' commitment to the teaching profession (FGN, 1998, p. 39)

Teacher education in Nigeria has a strong relationship and history with the introduction of Western education by the Christian missionaries in the second half of the 19th century (Afe, 1995; Okafor, 1988, Taiwo, 1980). The increasing demand for secondary and higher education by Nigerians during the colonial regime was associated with the need for more native teachers to replace the expatriates so that teaching and learning could be culturally based. This led to the establishment of first teacher training institution in Nigeria by the Church Missionary society (CMS) in 1833 located in the then Western Region of Abeokuta (now Ogun State). Arguments, however, arose among researchers as regards to the name of the first teacher education institution, the location and the year of establishment in Nigeria. Fafunwa (1974) in his book '*History of Western Education in Nigeria*' notes that CMS was the first missionaries to establish teacher training college in 1859. Adesina (1977) argues that the first teacher training college in Nigeria was Saint Andrews College, Oyo established by the CMS in 1876.

Ogunleye (1999) in his book '*Science Education in Nigeria'* claims that the first generation of teacher education institutes are Saint Andrews College, Oyo (1876), Hope Waddell Institute, Calabar (1861), Baptist Training College, Ogbomoso (1899) and the Wesleyan Training Institute (1905). Thus the history of teacher education in Nigeria is an unresolved issue. According to Afe (2001) the first generation of teacher education institutes were established by the Christian missionaries to produce teacher evangelists and were supported by the colonial government through grants-in-aid and the promulgation of education codes and ordinances to complement the efforts of the missionaries (Afe, 2001).

The Phelps-Stokes commission report of 1922 paved the way for the Memorandum on Education in 1925 for the reorganization of education and promoted the view that education should be adapted to the local environment including local tradition and social organisation. The 1925 memorandum guided Nigerian education policy and development till 1960 when Nigeria became independent (Fafunwa, 1990).

The 1947 constitution divided the country into three regional administrative units and decentralised educational administration as a regional service, and introduced the Universal

Free Education Schemes by the Western and Eastern Regional Governments in 1950s. This led to expansion of primary education in the Western and Eastern regions and emphasised the need to have sufficient qualified and trained professional teachers in schools (Nwagwu, 1987 reported in Afe, 2001).

Before the Ashby Report of 1960 came into operation, the *Grade One Teacher Certificate* was the highest level of professional teacher qualification awarded in Nigeria to teachers (Afe, 2001). The recommendations of the Ashby report in 1960 led to the emergent of Advanced Teachers' Colleges for awarding the two-year Nigeria Certificate of Education (NCE) for Grade One teachers who aspired to further their education and was later modified by government to three years. This modification led to expansion of teacher education programme with the main purpose of training well-qualified non-graduate teachers in Languages, Arts, Sciences, Social Sciences, and Technical and Vocational Studies for secondary, teacher training and technical colleges (Agheta, 1983; Afe, 1992). Afe (1989) claims that the five Advanced Teachers' Colleges were established at Lagos (1962), Ibadan (1962), Owerri (1963), Kano (1964) and Abraka (1968) and were funded and staffed by UNESCO. These Advanced Teachers' Colleges were renamed Colleges of Education in the early 1970s and during this period, there were only a few universities awarding degrees in education in Nigeria.

Currently in Nigeria, Colleges award the Nigeria Certificate of Education (NCE) and some even prepare students for the award of University degrees in science education (B.Ed) or B.Sc(Ed) and they also train degree holders (unqualified teachers) for the award of Postgraduate Diploma in Education (PGDE)

Preparation of Secondary Science Teachers in Nigeria

Teacher education is regarded as a tertiary education in Nigeria and it is the responsibility of Federal and the State Governments. Currently in Nigeria, Colleges of education, and Faculties and Institutes of Education in the universities, National Teachers Institutes, and Schools of Education in the Polytechnics award the Nigeria Certificate of Education (NCE) and degrees in science education with specializations in Integrated Science, Chemistry, Biology or Physics (Ogunmade & Oyeleke, 1994; Olaleye, 2002). The initial science teachers' preparation involves a three-year college certificate (NCE) or four-year university degree which consists of coursework both in education and science together with supervised teaching practice in the schools.

At the graduate level, preservice teachers (without teaching qualifications usually those with honours degrees in science) are gradually introduced to the teaching profession and courses in education together with intensive teaching practice in the schools for a period of one to two years depending on individual institutions leading to the award of a Post Graduate Diploma in Education (PGDE).

Another path for science teacher preparation in Nigeria is through part-time or sandwich programmes organised by the Colleges of Education and the universities for providing on-the-job training to teachers with lower qualifications so that they can upgrade their qualifications and also for adults who are seeking a change of career into teaching. These programmes are suitable for adults who could not afford attending the full time programme as a result of financial commitments and other reasons. These programmes usually last for a longer period of four-years for NCE and five-years for degrees. Classes are held in the evenings, weekend and during school vacations. It is important to indicate that graduates from these programmes and the full-time courses have significantly reduced the shortages of science teachers in Nigerian schools.

Preservice courses include science, general method, courses in education and supervised teaching practice. The college or university lecturers, school principals and the cooperating teachers are responsible for supervising practical teaching experience in local schools for a period of 18 weeks in the universities and 12 weeks in the Colleges of Education. Preservice teachers engage in observing, planning instruction, whole class teaching and tutoring, supervising student examinations, keeping school records and taking part in other school activities like staff meetings and extra curricular activities.

The Federal government through the Ministry of Education and its parastatals, including the National Universities Commissions (NUC), is charged with the responsibilities of ensuring the orderly development of university education including certification of teachers, to maintain standards and ensure adequate funding (Ogunleye, 1999). The National

Commission for Colleges of Education (NCCE) established in1989 is charged with co-ordination of all aspects of teacher education programmes falling outside the universities and polytechnics (Ogunleye, 1999).

The National Teacher Institute (NTI) established in 1978 is also charged with providing courses of instruction leading to the development, upgrading and certification of teachers as specified in the relevant syllabus and using distance learning techniques. These bodies set the admission and graduation requirements in collaboration with the Science Teachers Association of Nigeria through accreditation of teacher education programmes in Nigeria tertiary institutions.

Recruitment of Science Teachers

There has been an increasing concern worldwide, about the difficulties of supplying sufficient numbers of qualified science teachers. Failure to staff schools with enough qualified science teachers has been recognised as a major social problem that could retard the quest for developing scientific literacy (Darling-Hammond, 1997). A growing number of policy initiative and reforms in science education has targeted the issue of manpower planning (e.g. AAAS, 1993; NRC, 1996; NCTAF, 1997). Darling-Hammond and Ball (1997) argue that a large numbers of teachers are reaching retirement age and also poor salary, inadequate training and support, and dissatisfaction are encouraging younger teachers to leave the profession in pursuit of better jobs. For example, fifty per cent of Australian secondary science teachers indicated on a TIMSS questionnaire that they would change to another career if they had the opportunity (Lokan, Ford & Greenwood, 1997).

Educators and policy makers worldwide are addressing science teacher shortages by improving initial teacher education programmes and ongoing professional development for science teachers (Darling-Hammond, 1997; Darling-Hammond & Ball, 1997; Goodrum & Hackling, 2003; Goodrum et al., 2001; Shepard, 2000). Shepard (2000) lists the current efforts being made to address the problem of teacher shortages in the United States of America, and these include: providing adequate training for non-professional science teachers; developing a mentor program teaming veteran and inexperienced teachers; encouraging science teachers to engage in professional development during the school year; rewarding teachers with certification from National Board for Professional Teaching Standards (NBPTS) and organizing summer workshops to better prepare current science teachers.

In Nigeria, quality science teachers are seen as valuable assets for achieving quality education and for national growth and development (FGN, 1998). Therefore both the federal and state governments are responsible for the recruitment of candidates into initial science teacher education programmes. To qualify for admission into a three-year teacher education programme in a College of Education for the award National Certificate of Education (NCE), a prospective teacher would have to obtain three credit passes in science subjects including at least a pass in English Language in an examination conducted by the West African Examination Council (WAEC) or the National Examination Council (NECO) the major examination bodies recognised for conducting senior secondary examinations in Nigeria.

Alternatively, a prospective teacher would obtain five credits including English Language and at least three science subjects to qualify for admission into a four-year initial teacher education programme in a University for the award Bachelor of Science degree in education. After the prospective science teacher has met the minimum requirements for admission into initial teacher education programme, he or she would thereafter sit for a competitive examination of either University Matriculation Examination (UME) in four subjects including English Language and two science subjects and mathematics or the Polytechnics and College of Education matriculation examination (PCE) in three subjects including English Language and two science subjects in an examination conducted by the Joint Admission and Matriculation Board (JAMB) established in 1978 as a body recognised by law for conducting entrance examinations into all courses in Nigeria tertiary institutions.

Consequently, the selection and admission of preservice science teachers would be determined by the JAMB in agreement with the individual colleges of education and universities to determine the cut-off points into different courses offered by the institutions. Generally, lower cut-off points are assigned to courses in education by these institutions compared with other professional courses like Medicine, Pharmacy, Law, and Accounting and Banking so that more candidates are recruited into the teaching profession.

It is worth noting that sometimes individual institutions conduct interviews for successful candidates in the matriculation examinations with a view to determining their eligibility for the teaching profession.

The minimum teaching qualification for admission into the teaching profession in Nigeria is the three-year National Certificate of Education (NCE). Before 2002, graduating teachers did not need to be registered before being appointed to schools (Noah, 2005). The National Policy on Education provided for the establishment of the Teachers' Registration Council (TRC). The TRC has recently (2000) begun a demographical survey of teachers in the country. Noah (2005) notes, that the failure of the government to back the TRC with an enabling law until 1998 has robbed the TRC of the control and regulation of the teaching profession in Nigeria.

Recruitment of qualified science teachers is carried out through the various ministries of education, both Federal and State. The Teaching Service Commission (TESCOM) which is an appendage of the State Ministry of Education in various States is charged with the responsibility of recruiting secondary science teachers at the State level while the Federal Civil Service Commission recruits new teachers for the Federal Ministry of Education. Qualified applicants are short listed for a written test conducted by the TESCOM and Ministry of Education officials. Successful applicants are invited for interviews which are conducted by experienced teachers, school administrators, education officers and science educators. Thereafter, successful applicants obtain their job placement. Applicants who do not restrict themselves to any location are mostly favoured during interviews and they are considered for appointments in rural areas and special inducements are provided to those teachers to encourage them stay in their jobs (Howard, 1998).

Induction Programme for Science Teachers

Quality teachers have adequate and better understanding of the school environment, school rules and regulations, and of professional ethics (Darling-Hammond & Sclan, 1996). London (2003) notes that teaching, unlike other noble professions, is the only profession where beginning teachers are expected to be self-sufficient on the first day in the classroom. Darling-Hammond and Sclan (1996) further corroborate that beginning teachers are left on their own to ‘sink or swim’ and that they have very few opportunities for professional learning programmes and support from colleagues.

Surprisingly, most of the beginning teachers are generally overwhelmed with school work and extra duties during their first lessons of teaching (Dauchess, 2003). Thus, most of the beginning teachers are being confronted with situations that are quite different from what are typically discussed in their undergraduate education courses and so a large numbers of beginning teachers leave teaching profession in their first three years due to ineffective induction programme (Lester, 1997). Lester refers to the first three years of beginning teachers in teaching profession as the ‘transition period’ during which beginning teachers interact with other teaching and non-teaching staff, relate to the students in order to understand their learning styles, familiarize with the school community and simultaneously reflect on their methods or otherwise most drop out.

The report of the Education Department of North West Territories in Canada (2003) claims that the first year in teaching determines the success and retention of beginning teachers in the profession as they are influenced more by their first school setting than by preparation. Research has continually argued that induction is one essential way for developing, retaining and retraining beginning teachers (Darling-Hammond, 1994; Gold, 1996; London, 2003; Luft, Roehrig, & Patterson, 2003).

According to Dauchess (2003) and London (1995, 2003), induction programmes help beginning teachers to familiarise themselves with the school environment and with other teachers, librarians, counsellors, students, classroom management, class control, school resources and also for the realization of their personal and professional satisfaction.

The National Science Education Standards report (National Research Council, 1996) emphatically supports induction for beginning teacher when it asserts “all must be committed to ensuring that ….new teachers… are supported and integrated into the ongoing life of the school” (p. 13). Also, Weiss and Weiss (1999) argue that beginning teachers should be encouraged to collaborate with other colleagues in curriculum writing sessions, classroom management, assessment methods and reflections on their instructional strategies. The American Association for the Advancement of Science (AAAS, 1997) notes that beginning teachers who receive induction often respond quickly to classroom management and instruction and are enthusiastic about teaching.

Researchers (Feiman-Nemser, 1996; Gold, 1996; Little, 1990; London, 1995, 2003; Palmer, 1998; Weiss & Weiss, 1998) indicate that induction serves to help:

- improve new teachers' performances;
- promote beginning teachers' personal and professional well being;
- beginning teachers acquire the culture of the educational system;
- new teachers accelerate their success and effectiveness and to be self-confidence;
- beginning teachers heighten their job satisfaction and thereby enhance their commitment to students, school and the profession;
- increase beginning teachers' opportunity for building connections with the community; and
- link instructional theory in teacher education programmes with the practice of classroom teaching.

Essentially, effective induction programme involves a sound recruitment process; ongoing mentoring or coaching; and opportunity for professional development programmes (London, 2003). The American Federation of Teachers (AFT, 2001) also argues that effective induction would include assigning all beginning teachers to mentors for at least one year with a reduced teaching load and with regular review of new teachers' activities to ascertain how they are improving.

Ongoing Professional Learning for Science Teachers

Ongoing professional learning is essential for teachers to improve the quality of teaching and students' learning in science (NCMST, 2000). Professional learning has been regarded in many quarters as formal education activities, including attendance at seminars, conferences, in-service courses or on-the-job training and workshops. Other researchers, however, believe that professional learning can occur in other than ‘formal’ settings.

Braimoh and Okedeyi (2001) see professional learning as a process wherein teachers work under the supervision of experts to enhance their professional practice and increase their knowledge of the academic subjects they teach. Darling-Hammond and McLaughlin (1996) claim that professional learning is “deepening teachers’ understanding about the teaching/learning process and the students they teach which must begin with pre-service education and continue throughout a teacher’s career” (p. 203). Diaz-Maggioli (2003) refers to professional learning as an ongoing formal or informal learning experiences in which teachers engage voluntarily to learn how best to improve their teaching from pre-service teacher education to retirement to meet the learning needs of their students. Goodrum and Hackling (2003) thus define professional learning as the responsibility of qualified teachers to continually improve their teaching practice.

According to the report of the National Commission on Mathematics and Science Teaching for the 21st Century - *Before it’s too late* (NCMST, 2000), professional learning is described as “a planned, collaborative, educational process of continuous improvement for teachers that helps them deepen their knowledge of the subject(s) they are teaching; sharpen their teaching skills in the classroom; keep up with developments in their fields, and in education generally; generate and contribute new knowledge to the profession; and increase their ability to monitor students’ work, so they can provide constructive feedback to students and appropriately redirect their own teaching” (p. 18).

For the purpose of this study, professional learning is defined as an ongoing lifelong career planned acquisition of knowledge, skills and competence by qualified teachers to expand and fulfill their professional potentials and practice to improve the quality of education and to meet the needs and aspirations of the learners.

Many research reports argue that most science teachers lack opportunities for professional learning to gain deeper understanding of their students, to collaborate with colleagues and experts on how to improve curriculum delivery, and also to observe and study teaching in order to improve their teaching practice for developing the scientific literacy of their students (Darling-Hammond, 1997; Goodrum et al. 2001; Millar & Osborne, 1998). Also criticized are the various conventional forms of 'hit and run' lectures and workshops being organised in a form of professional development for teachers (Anderson & Kanuka, 1997; Cevero, 1988; Schon, 1987).

Quality professional learning has been described as that which involve teachers' professional self-disclosure, reflection, growth and that is focused on job-embedded responsibilities (Darling-Hammond, 1997; Diaz-Maggioli, 2003). Researchers (Anderson & Mitchener, 1994; Bryan, Abell & Anderson, 1996; Crowther, 1998; Griffin, 1982; Luft, Roehrig & Patterson, O' Brien, 1992; Sikula, 1996) argue that effective professional learning involves long-term professional training, mentoring for beginning teachers, self-reflection and collaboration with colleagues and experts on curriculum materials and policy, and on instruction and student learning, peer review, and coaching so that teachers' beliefs and practices are progressively refined.

The National Science Education Standards (NRC, 1996) claim that effective professional development would:

- Provide regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice.
- Provide opportunities for teachers to receive feedback about their teaching and to understand, analyze, and apply that feedback to improve their practice.
- Provide opportunities for teachers to learn and use various tools and techniques for self-reflection and collegial reflection, such as peer coaching, portfolios, and journals.
- Support the sharing of teacher expertise by preparing and using mentors, teacher advisers, coaches, lead teachers, and resource teachers to provide professional development opportunities.
- Provide opportunities to know and have access to existing research and experiential knowledge.
- Provide opportunities to learn and use the skills of research to generate new knowledge of science and the teaching and learning of science (p. 8).

Basically, effective professional learning for teachers has clear expectations; a result-oriented focus, effective supports, collaboration and good modeling (Crowther, 1998). Thus, good professional learning is a balance between systemic leadership and teacher contribution to improve practice and educational quality (Sparks & Loucks-Horsley, 1990)

Summary

The advent of science education in Nigeria was a result of the arrival of the missionaries in the coast of Lagos in 1859 and the establishment of churches and elementary schools in the town of Topo near Badagry in 1861. The science taught in school at that time reflected the British requirements rather than those of Nigeria and the curriculum was modelled on British syllabuses, with content and activities in science that were beyond the experience of the Nigerian students (Taiwo, 1975). The establishment of the first post secondary institution in the country, that is, Yaba College in 1932 and the reforms in science education between 1932 and 1960 led to the introduction of the Higher School Certificate courses and the establishment of Federal Colleges of Arts, Science and Technology with the aim of promoting the teaching of science in Nigerian schools. The most prominent problems at the time were poor quality of instructional materials and teaching.

Improving the quality of science teaching and learning in schools has been recognised as the bedrock for all the citizens to become scientifically literate to meet the current challenges of modern science and technology (AAAS, 1993; Goodrum et al., 2001; National Research Council, 1996). Outcomes of research in science teaching and learning over the years recognise that constructivist teaching approaches could help in improving science teaching and learning, and that science teaching should be inquiry and activity-based for effective learning (Bell et al., 2003; Germann, et al., 1996; Lorsbach & Tobin, 1998; Matthews, 1994; Moussiaux & Norman, 1997; Richardson, 1997). Literature also reveals that authentic assessment with appropriate feedback to the learners is crucial for quality of science teaching and learning (Goodrum et al., 2001; Helgeson, 1992; National Research Council, 1996).

Effective teachers of science possess pedagogical content knowledge that provides them with an understanding of how particular subject-matter topics, problems, and issues can be organised for effective teaching and learning to meet the needs of students with diverse interests and abilities (Clermont, et al., 1993; Darling-Hammond, 1997; Shulman, 1986; Wilson, et al., 1987).

Induction of new teachers and ongoing professional learning for experienced teachers is needed to enhance teachers' pedagogical content knowledge and enhance teachers' personal and professional well being and also to strengthen their commitment to students, school, the school community, colleagues and the profession (Gold, 1996; Little, 1990; Palmer, 1998; Weiss & Weiss, 1998).

In conclusion, this Chapter reviews the historical background of science education in Nigeria and considers the curriculum documents, national and international reports and science education research literature in regards to quality teaching and learning of science in schools. The review of literature identifies key theories, constructs and variables impacting on the quality and status of science education which are summarised as a conceptual framework diagram in Figure 2.1.

The conceptual framework outlines the relationships of teachers' professional learning opportunities on their knowledge and beliefs and how these influence the implementation of intended core curriculum in junior secondary science for student-centered inquiry teaching. Also, the contextual factors that are limiting the implemented science curriculum and act as barriers to students' learning for developing scientific literacy are presented.

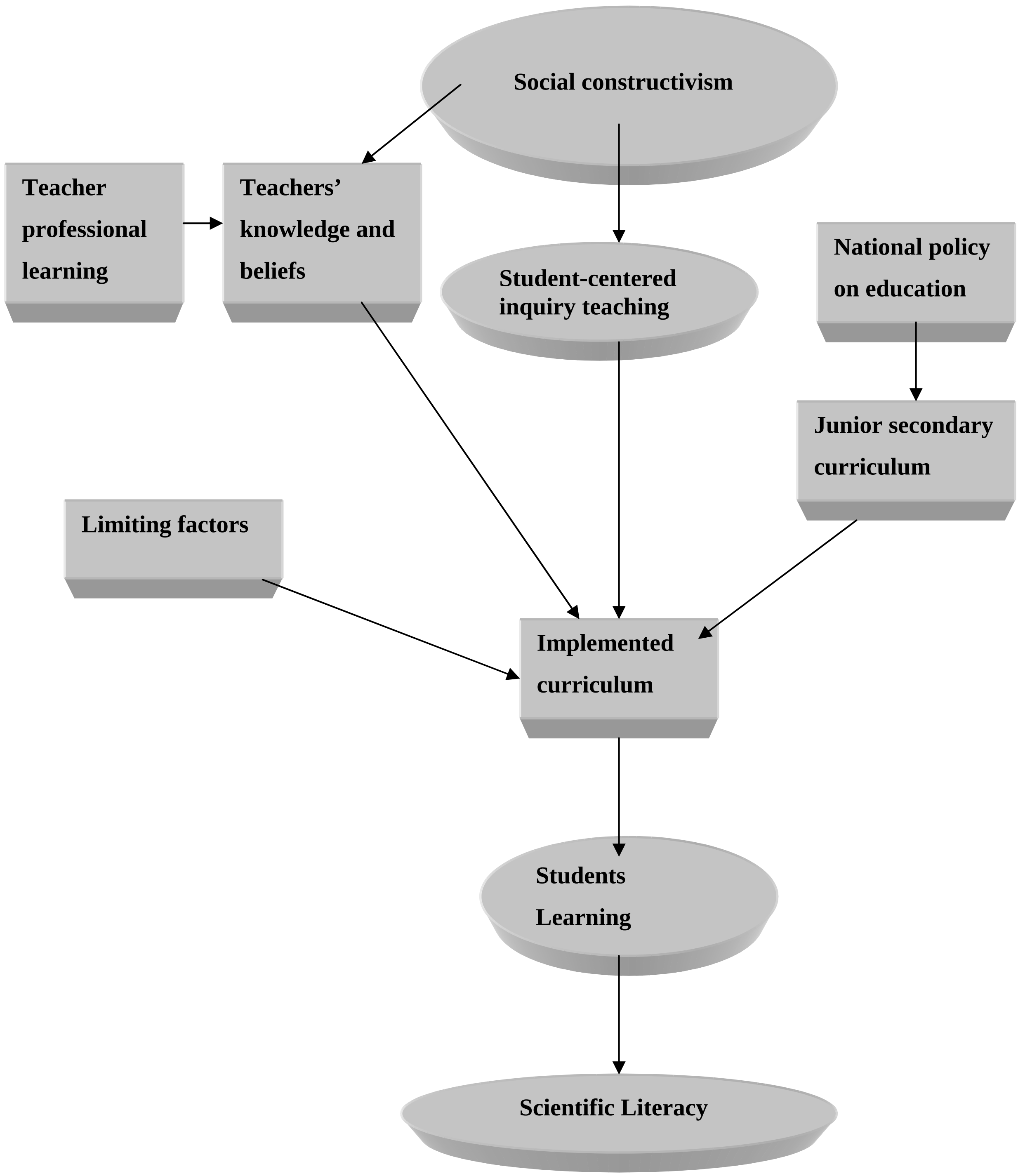

Figure 2.1: The Conceptual Framework

CHAPTER 3: METHODOLOGY

Introduction

This Chapter describes the research design methods and procedures that were used to investigate and describe the Status and Quality of Junior Secondary Science Teaching and Learning in Lagos State, Nigeria. The main research questions addressed to reveal the picture of actual science teaching and learning, and the picture of ideal science are:

1. What is a realistic ideal picture of teaching and learning of science in Nigerian secondary schools as perceived by teachers and other stakeholders?

2. What do science teachers, students and other stakeholders perceive as the nature of teaching and learning of science in Nigerian secondary schools at present?

3. What factors do teachers and other stakeholders perceive as militating against quality of teaching and learning of science in Nigerian Secondary schools?

4. How can these factors be addressed to improve the quality of teaching and learning of science in Nigerian secondary schools?

The research design for this study was modeled on a recent national study of science teaching and learning in Australia conducted by Goodrum, Hackling and Rennie (2001) that revealed two pictures of actual science teaching and learning and ideal science in Australian schools. The research design involved teacher and student survey questionnaires, focus group meetings of teachers and other key stakeholders in science education and interviews with scientists in government establishments and those working in industry so as to corroborate findings and make realistic recommendations for improving the quality of science education. The impact of this study in Australia is very great and this warrants modeling of the research approach for Lagos State, Nigeria so as to improve the quality of science education and for the realization of developing scientific literacy for citizens.

This Chapter comprises six sections. The first section deals with the research design which underpins the study and the rationale for adopting both quantitative and qualitative research methods. Section two focuses on the target population, the sample and sampling techniques. Sections three and four describe the research instruments and the procedures used for data collection. Section five outlines the data analysis procedures. Finally, a summary of the Chapter is presented in section six.

Research Design

This study was designed to describe the actual picture of secondary science teaching and learning to formulate a realistic ideal picture for science education in Lagos State, Nigeria. Data for the actual picture were generated through surveys of science teachers and students, focus group meetings with teachers and key stakeholders in science education, interviews with Ministry of Education curriculum officers and scientists, and by analysis of the national and state reports.

Data for the ideal picture of science teaching and learning were generated through analysis of the research literature, national and state curriculum documents and by survey of science teachers, focus group meetings and interviews with key stakeholders.

The purpose of collecting data related to actual and ideal pictures of teaching and learning of science in schools was to compare the ideal with the actual, and then to validly develop recommendations for closing the gap between the actual and ideal .

Importantly, the study involved both quantitative and qualitative approaches. The quantitative approach involves the use of questionnaires to survey both teachers and students. The teachers' survey helps to identify typical practice in curriculum delivery, teaching and assessment in secondary science, and factors limiting quality and acting as barriers to change. The students' survey further helped to gather students' views about their interest in science, their perceptions of the relevance of science, their own competence and work attitude to science.

The qualitative approach on the other hand involved focus group meetings with science teachers and other key stakeholders associated with science education in Lagos State, Nigeria. The focus groups were used to gather data that helped define quality in teaching and learning, describe current practices in science education.

Also, interviews were conducted with other stakeholders that have an influence on science education in Nigeria. These groups of people included a Senior Curriculum Officer in the Lagos State Post Primary Teaching Service Commission, a representative of Science Teachers Association of Nigeria (STAN), a Laboratory Technologist in a government establishment and a Chemical Analyst working in industry. The data from the interviews consist of information provided directly by the stakeholders about their experiences, knowledge and opinions about science teaching and learning in Lagos State schools.

A mixed method approach involving a combination of qualitative and quantitative data from different sources was used to corroborate findings in this study. Qualitative methods help to provide answers to questions by examining various social settings and individuals who inhabit the settings, allow the researchers to share in the understandings and perceptions of others, and to explore how people structure and give meaning to their daily lives (Berg, 1989). Giddens (1984) notes, qualitative methods help elucidate the frames of meaning of the actors and investigate the context of action**.** Miles and Huberman (1984) further argue that findings of qualitative methods have a quality of undeniability, because they help create concrete, vivid and meaningful flavour descriptions of incidents and events.

Patton (1990) and Thomas and Nelson (1996) also corroborate that using the focus group meetings and interviews can help researchers to gather information about several people’s views, perceptions and opinions in one session and for the participants to provide checks and balances on each other’s views, which can curb extreme views. Thus, qualitative methods is necessary for generalizing plausible alternative explanations, describing the program, constructing a narrative history, presenting data collection procedures, and summarizing (Campbell, 1974) and to help allow the researcher to have more continuous reflection on the research in progress, more interaction with the participants in the research, and more room for ongoing alteration as the research proceeds (Bouma, 2000).

Qualitative methods major setbacks include that they tend to produce large amounts of information that can only be focused after data collection, less focused at the outset that is, assume less in advance which variables are relevant, more open-ended, and are sensitive to context that are likely to be focused on in the intentions, explanations, and judgements of the participants, since it aims at providing the maximum opportunity for the researcher to learn from the subjects, or participants in the research (Bouma, 2000; Howe, 1985).

Quantitative methods essentially help to identify and assess the bounds of knowledgeability of the respondents and to assess the respondent's attitudes, values, beliefs or opinions (Berg, 1989; Bouma, 2000). House (1994) indicates that questionnaires in quantitative research give more precise, explicit, and predetermined measure and identification of relevant variables in advance. Lokan, Hollingsworth & Hackling (in press) further claim that questionnaires are economical and very simple to administer to sample large groups of respondents; give better potential to generalize findings because samples are larger; ensure efficient gathering of large quantities of baseline data; and also the responses gathered can usually be transformed easily by coding into data files that are ready for statistical analysis. However, questionnaires are very complex to construct and the success of using questionnaires depends on the honesty of the respondents (Bouma, 2000).

Despite the complex nature of the quantitative methods, they are more quickly accomplished, produce more reliable conclusions and help provide reportable findings involving percentages of variable occurrences (Berg, 1989). Therefore, quantitative methods are essential in educational research (Patton, 1980).

While quantitative and qualitative methods each gather valuable information on their own, findings from qualitative and quantitative methods are distinct and they complement one another in the content (Berg, 1998; Giddens, 1984). Basically, no single approach either qualitative or quantitative methods can be perfectly effective (Berg, 1998) and so each method can be improved significantly through triangulation of data from various sources (Erickson, 1986; Flick, 1992; Yin, 2003). This approach is relevant to this study to triangulate and corroborate findings from teachers, students and other stakeholders.

The diagrammatic framework (Figure 3.2) presents the various sources from which data were generated in this study.

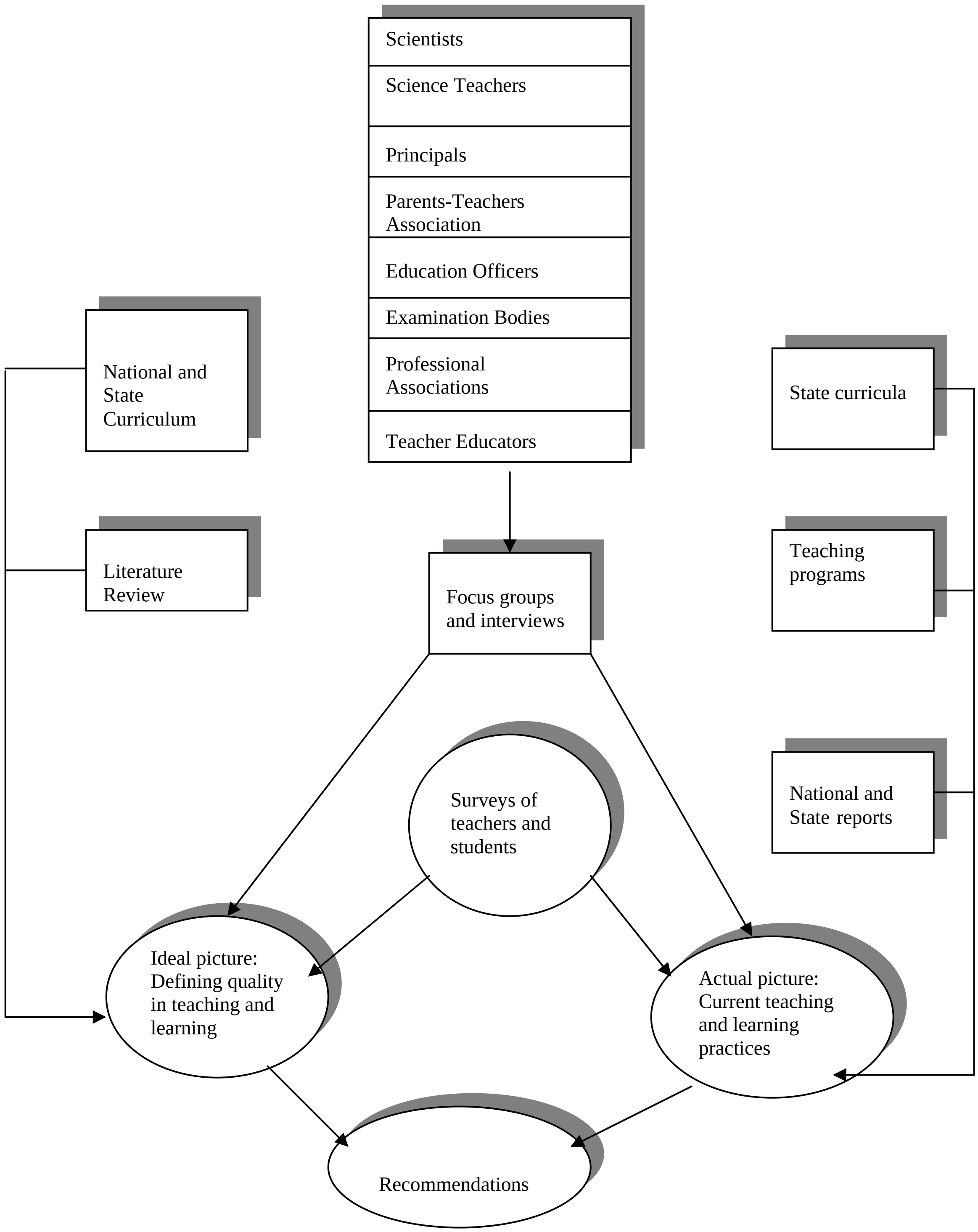

Figure 3.2: The framework for data collection

Population and Sample

This study was conducted in Lagos State, Nigeria. Lagos State is one of the 36 states in the Federal Republic of Nigeria with an estimated population of about 12 million people (Nigerian National Population Commission, 1998). Lagos State is divided into 20 Local Government Council areas for administrative purposes and each Local Council manages a Local Education District (LED) where in there is a Post Primary-Teaching Service Commission (PP-TESCOM) Zonal office. There are therefore, 20 Local Education Districts in Lagos State. The Lagos State Ministry of Education oversees educational matters in the state and controls the activities of the State's University, secondary, technical and primary schools. The 20 Post Primary Teaching Service Commission Zonal offices are an appendage of the State Ministry of Education. Each of the PP-TESCOM zonal offices oversees the activities of all the secondary schools within their locality on behalf of the State Ministry of Education. For the purpose of this study, the population comprised three of the 20 Local Education Districts in Lagos State. These include Alimosho, Ojo, and Oshodi-Isolo Local Education Districts.

The three Local Education Districts support 61 junior secondary schools (Alimosho 18, Ojo, 15 and Oshodi/Isolo-28) and all were involved in the study. It is worth noting that the secondary schools in these three LEDs are in close proximity to the investigator's base and were easily accessed. All 89 science teachers in the 61 junior secondary schools in the three LEDs were surveyed. Of the population of 89 science teachers, 78 returned questionnaires for analysis.

A random stratified sampling approach was used to select students from rural and urban schools for survey in each of the LEDs such that boys only, girls only and coeducational schools were represented. The selection procedure was such that for each LED, all boys only rural schools were placed in one list, all girls only rural schools in another list, and all coeducational rural schools in the third list. One school was selected at random from each list. The same was carried out for the all boys only urban schools, all girls only urban schools and all coeducational urban schools such that six secondary schools were selected from each LED and total of 18 secondary schools were selected from the three Local Education Districts for this study. One intact class was selected at random from boys only, girls only and coeducational schools until three rural and three urban JSS 1 (Junior Secondary School Year 1), JSS 2 and JSS 3 classes were involved in the study. A total of 980 students completed the student survey questionnaires. In Lagos State, there are 80% Coeducational: 10% Boys only: 10% Girls only. Seventy per cent of these schools are situated in urban locations and 30% in rural locations. Using these parameters, 500 questionnaires were randomly selected for analysis as indicated in Table 3.1 so that the sample was representative of the population of students in the three LEDs.

Table 3.1:

The sampling frame for the student survey

School type	School Location				Total
	Rural (30%)		Urban (70%)		
	Male	Female	Male	Female	
Coeducational	60	60	140	140	400 (80%)
Boys only	15	0	35	0	50 (10%)
Girls only	0	15	0	35	50 (10%)
Total	75	75	175	175	500

The focus group participants included science teachers, school principals, parents-teachers association (PTA) representatives, education officers, teacher educators, representatives of Science Teachers Association of Nigeria (STAN), and also representatives of examination bodies in Lagos State. Letter of invitation outlining the purpose of the study and consent form were sent to science teachers, school principals and other key stakeholders in science education in the three LEDs (see Appendices D and F). Only the participants who indicated their interest by completing and returning the consent form were selected to participate in the national and local focus group meetings as shown in Table 3.2 using purposive sampling methods so as to obtain a sample of participants who were informed and could provide a range of important perspectives to the research.

Table 3.2:

Sampling frame for the focus groups participants

Focus group	Ojo	Alimosho	Oshodi -Isolo	National
Science teachers	5	5	5	-
School principals	3	2	2	-
Representative of parent-teacher associations	2	2	2	-
Education officers	2	2	3	-
Representative of examination bodies	-	-	-	2
Representative of professional organisation for science teachers (STAN)	-	-	-	4
Teacher educators	-	-	-	6
Total	12	11	12	12

It is worth noting that the contribution of the key stakeholders is crucial to this study because of their roles in science education in Lagos State. Stakeholders include:

(i) The professional organization for science teachers (STAN) which helps to promote cooperation among science teachers in Nigeria with a view to raising the standard of science education in the country and is also involved in science curriculum innovation and renewal by translating national and educational objectives into curricula and teaching objectives.

(ii) The examination bodies (WAEC, NECO and State Examination Board) set public examination papers in science subjects and influence what is taught in schools, and as such, contribute to science curriculum development and to policy.

(iii) Science teachers help in planning a set of activities in which particular subject content is experienced by students, that is, teachers help to facilitate the implementation of the intended curriculum.

(iv) Teacher educators are responsible for producing highly motivated, conscientious and efficient classroom teachers for all levels of our education system and also provide teachers with the intellectual and professional background necessary for teaching science.

(v) Education officers are officials of the State Ministry of Education that are responsible for ensuring quality control in schools through regular inspection and continuous supervision of science instruction and other educational services. They also help in co-ordination of the activities of the Local Education Districts in order to improve and maintain science education standards at the local education level.

(vi) Parents-Teacher association representatives help to coordinate the activities of the parents and teachers through regular meetings and provide moral, social and financial supports in ensuring the growth and development of the school and the realization of educational goals for the local community.

(vii) School Principals set educational standards and goals, motivate and supervise staff including teachers, librarians, counsellors, coaches and others; develop academic programs, monitor students' educational progress, and, establish administrative policies and procedures for their schools.

Research Instruments

The main research instruments used for data collection in this study include teacher and student questionnaires, focus group meetings and interviews protocols.

Survey Questionnaires

The purpose of the survey questionnaire was to elicit information about the characteristics or opinions of the respondents (May, 2001). Two forms of survey questionnaire were used for data collection; a teacher survey and a student survey.

Both the teacher and student questionnaires were adapted from the studies conducted by Goodrum, et al. (2001), Goodrum and Hackling (2003) and TIMSS (1998) and were modified by the Researcher to suit the purpose of this study. In the development of the questionnaires, particular attention was given to ensure that questions are unambiguous, unbiased, unloaded, relevant, succinctly conceptualized as well as avoiding vagueness

(May, 2001). In particular, care was taken to ensure questions were appropriate for the culture and context of Nigeria.

Teacher survey

The teacher questionnaire comprised five sections. The first section elicited information on demographic data regarding the teacher's age, qualifications and years of teaching experience, area of teaching specialization, class size and school location. The second section focused on the teacher's views of characteristics of ideal (effective) science teaching and learning. Section three examined what is actually happening in the teaching and learning of science. Section four focused on the constraints to quality teaching and learning of science in schools. The final section sought the teacher's views of how they could be helped to close the gap between actual and ideal science teaching and learning.

Student survey

The purpose of the student survey was to investigate students' perceptions about science teaching and learning in secondary schools in Lagos State, Nigeria. The questionnaire comprised four sections. The first section asked for demographic data, including the student's school (boys/girls/coeducational), year/level and sex. Sections two and three elicited the students' views about what they see actually happening in science teaching and learning in his/her classroom. Section four asked students what they need to do, to be successful in science. The last part, section five contained open-ended questions in which students were asked to write answers describing how the study of science could be improved and the purpose of learning science.

Focus Groups

The purpose of the focus groups was to gather relevant data from the key stakeholders in science education to help define the nature of quality teaching and learning/ best practice in science education, and describe the current status and quality of science teaching and learning in Lagos State, Nigeria.

This study involved four focus group meetings, with three conducted at local level in each of the three Local Education Districts and the participants comprised science teachers, school principals, parents/teacher association representatives and education officers. The fourth, that is, the national focus group meeting was conducted for teacher educators, representatives of professional organization for science teachers (STAN) and the representatives of examination bodies in Lagos State, Nigeria. There were 11 to 12 participants in each of the focus group meetings as indicated in Table 3.2. The meetings addressed the following questions:

1. What would be the characteristics of an ideal quality teaching and learning of science in our secondary schools?
2. What do you see actually happening in our schools at the present time?
3. What are the factors that inhibit quality teaching and learning of science in our schools?
4. How can these factors be addressed so as to improve the quality of teaching and learning of science?

It is worth mentioning that during the national and local focus group meetings other issues of importance that are relevant to the purpose of this study were raised.

To achieve rich and constructive discussions during the focus group meting, participants were provided with the focus questions to afford them the opportunity to discuss them with their colleagues and to bring with them well constructed and broadly representative views before the commencement of the meetings. At each meeting, participants were provided with written materials on which they could record their views and were then divided into four small groups of two to three participants to examine each focus question for 15 to 20 minutes. Thereafter participants were brought together in a large group to discuss each of the four questions together with other issues that arose during the discussion. The whole group discussions were audio recorded by the Researcher. Each focus group meeting and the discussion lasted for about two hours.

Interviews

To gain a national perspective, interviews were also conducted with other key stakeholders in science education in Lagos State. These included a curriculum officer in the State Ministry of Education, a representative of STAN, a laboratory technologist working in a government establishment and a chemical analyst working in industry. They responded to a semi-structured interview that focused on the research questions. The main questions asked included:

(1) What would be the characteristics of an ideal (effective) quality teaching and learning of science in our secondary schools?

(2) How would you describe the teaching and learning of science at the present time in our secondary schools?

(3) What factors inhibit the quality of teaching and learning in our schools? Of these factors mentioned, which is more important?

(4) How do you think teachers can be helped to overcome these barriers?

Trustworthiness of the Instruments

An instrument is considered valid when there is confidence that it measures what it is intended to measure in a given situation (Punch, 1998). In determining the validity of the survey questionnaires, the Researcher presented the drafts to two experts in the field of science education to assess the questions for face and content validity. Based on their comments and suggestions the questionnaires were fine tuned to achieve the purpose of the study. Also the survey questionnaires were presented to the university ethics committee. Thereafter, survey questionnaires were pilot tested with science teachers and students from four junior secondary schools in a Local Education District in Lagos State that was not associated with this study. This was done in order to determine the clarity and relevance of the questions in eliciting information about the quality of secondary science teaching and learning in Lagos State. Based on their comments and feedback appropriate corrections were made with regards to an understanding the meaning of **ideal** teaching in the context of the study, and so the initial teacher questionnaire was revised to incorporate **'effective'** teaching.

Also section two of the student survey questionnaire that asked students to estimate the amount of time used for science teaching and learning activities in percentages was revised to include that the "total must be equal to 80 minutes". Thereafter the survey questionnaires were found suitable by the Researcher and were used to generate data for this research study. Pilot testing of the instruments reduced ambiguity of items and therefore enhanced their reliability (Day, 1979; Meriwether, 2001).

Procedure for Data Collection

Data collection for this research study involved six phases. These are enumerated as follows:

Phase 1- Seeking approval to access schools and requesting teachers' consent for their participation: A letter was sent to the Post Primary Teaching Service Commission (Headquarters) in Lagos State to inform them of the research and also to seek their consent and approval to nominate a contact person within the education department so that the study could be conducted in the State junior secondary schools (see Appendix C). Thereafter, a letter of introduction was obtained from the headquarters of the PP-TESCOM (see Appendix L) to the Zonal offices in the three Local education Districts for access to the schools involved in the study. Also, approval letters were obtained from the Zonal Directors (see Appendix K) for the Researcher to contact school principals, science teachers and other key stakeholders.

School principals, science teachers and other key stakeholders from each LED in Lagos State were approached by the Researcher to discuss the purpose of the study and to seek their consent for completing the questionnaires and also to participate in the focus group meetings and interviews. Participants who indicated interest in participating in the focus group meetings and interviews and returned consent forms were involved in the study.

Phase 2- Pilot testing of the research instruments: The teacher and student survey questionnaires were pilot tested with science teachers and students from four secondary schools in a Local Education District of Lagos State for both the content and construct validity. Also, interviews questions were pilot tested with a scientist working in industry to determine the level of understanding of the questions raised in the study. Based on the responses in the survey questionnaires and comments from the interviews appropriate corrections were made by the Researcher in agreement with my supervisors. Thereafter, the instruments were considered appropriate for the research study.

Phase 3- Distribution and administration of questionnaires: Teacher survey questionnaires were distributed to science teachers in the junior secondary schools in each of the LEDs that were involved in the study. Also, the student survey questionnaires were distributed to teachers at the sample schools. To ensure a high return rate of the questionnaires, the Researcher personally supervised the distribution and collection from teachers and students. Most of the teachers preferred completing the questionnaires from home and so some failed to return the questionnaires for analysis. The return rate was 88% for the teacher survey. A 100% return rate was achieved for the student survey, since the students were asked to respond to the questionnaires during class time. The administration of the student questionnaires was personally supervised by the Researcher.

Phase 4- Collection of curriculum documents from schools: In this phase, the Researcher obtained national, state and school curriculum documents from the Local Education Districts, school principals and teachers both from rural and urban secondary schools in the three LEDs. Curriculum documents obtained include: school diaries which record teachers' planning, schemes of work, records of students' performance, National Policy on Education document, National and State core curriculum in Integrated Science, science inventory records, continuous assessment records and students' performance record in order to obtain information about curriculum delivery, resources, time allocation, curriculum and pedagogy in science teaching and learning.

Phase 5- Focus group meetings: Four focus groups meetings were conducted by the Researcher; three local and one national meeting. The local focus group meeting for the Oshodi/Isolo LED was conducted on the 23rd March, 2004. This was followed by a national focus group meeting on the 24th March, 2004. The third focus meeting for Ojo LED took place on the 25th March, 2004. The final focus group meeting for Alimosho LED was conducted on the 24th June, 2004.

Phase 6- Interviews: The final phase of this research data collection involved interviews with a senior curriculum officer in Lagos State PP-TESCOM, a representative of STAN, a laboratory technologist in a government establishment and a chemical analyst working for industry. Consent forms and letters of invitation stating the purpose of the study were sent to nine individual key stakeholders in science education in Lagos State to seek for their consent to participate in the interviews. Interviews were conducted between 14th July to 5th August, 2004 with four participants who indicated their willingness to participate in the study and returned the consent forms. Interviews were audio recorded by the Researcher and lasted for about an hour.

Data Analysis

The research data collected were extensive and as such were analysed using both quantitative and qualitative methods. Patton (1990) notes, "the analysis of the empirical data aims to make sense of massive amounts of data, reduce the volume of information, identify significant patterns, and construct a framework for communicating the essence of what the data reveal" (p. 371-372).

Questionnaires

Data from the teacher and student questionnaires were analysed using descriptive statistical methods involving percentages, means, and standard deviations where appropriate. Responses to the open-ended questions were coded into categories and the frequency of teachers' and students' responses in each category was determined. Responses on the scale item were also coded in relation to the items so that the number and percentage that responded 'all the time', 'most of time', 'some time', 'not often' and 'never' were calculated using the SPSS 13.0 statistical package.

Focus groups and Interviews

The audio recordings from the focus group discussions and interviews were listened to several times by the Researcher and transcribed verbatim. Transcripts were analysed by reading through several times by the Researcher to identify emerging themes that are relevant to the study for interpretation and analysis. Data that occurred most frequently were emphasised in the reporting of findings.

Summary of Data Sources

In order to generate data to address each of the research questions for the study, various data sources were employed and these are presented in Table 3.3.

Table 3.3:

Data sources related to the research questions

Data sources	RQ1	RQ2	RQ3	RQ4
Teacher survey	√	√	√	√
Student survey		√		
Focus groups	√	√	√	√
Document analysis	√	√		
Interviews	√	√	√	√

Note: *RQ indicates the research question.*

Summary

The study was designed to investigate and describe the status and quality of secondary science teaching and learning in Lagos State, Nigeria with a view of generating data for actual and ideal pictures of teaching and learning of science in schools and to make recommendations for closing the gap between the actual and ideal. The research design was based on that developed by Goodrum, Hackling and Rennie (2001) for an Australian study.

Data for actual science teaching and learning were generated using teacher and student survey questionnaires, focus group meetings and interviews with teachers and other key stakeholders in science education in Lagos State, Nigeria and also by analysis of national and state curriculum documents. Data for an ideal picture of science teaching and learning were generated through the research literature, national and state curriculum documents and from data collected from the survey of science teachers, focus groups and interviews.

Data generated from the questionnaires were coded and analysed using descriptive statistics while data obtained from the focus groups and interviews were analysed qualitatively for emerging themes.

CHAPTER 4: TEACHER SURVEY RESULTS

Introduction

The role of teachers in achieving quality teaching and learning of science and the scientific literacy of students is of significant importance to science education. This Chapter therefore examines the results from the teachers' questionnaires, which were used to gather information regarding teachers' beliefs about the status and quality of science teaching and learning in Lagos State Secondary schools.

This Chapter is divided into 10 sections. The first section provides **demographic** information about the schools and teachers who participated in the study. The second section describes the teachers' beliefs about **the purpose for teaching science.** Teachers' beliefs about **the characteristics of ideal (effective) science teaching and learning** are examined in section three. **Teaching-learning and assessment strategies** are considered in sections five and six. Section seven examines the **resources for science teaching and learning.** Teachers' perceptions about the **factors inhibiting effective teaching and learning** of science are described in section eight while section nine provides teachers **views about improving teaching and learning** of science. The final section provides a **summary** of the Chapter.

Demographic Data

Lagos State comprises 20 Local Education Districts (LEDs). The three LEDs involved in this study support a total of 61 Junior Secondary Schools. The entire population of 89 science teachers was surveyed, and of these, 78 completed and returned questionnaires giving an 88% return rate. The distribution of teachers according to school type is presented in Table 4.1.

Table 4.1
Percentage of teachers from boys, girls and coeducational schools (n=78)

Category	N	Per cent
Boys only	7	9.0
Girls only	7	9.0
Coeducational	64	82.0
Total	78	100.0

Data in Table 4.1 reveal that the majority of science teachers were from coeducational schools (82%) with 9% each from boys only and girls only schools respectively. The sample of 78 science teachers comprised 29 males (37%) and 49 females (63%). The age distribution of teachers is summarised in Table 4.2.

Table 4.2
Percentage age distribution of teachers (n=78)

Category	N	Per cent
20 years and below	2	2.6
21-30 years	24	30.8
31-40 years	29	37.2
41-50 years	21	26.9
Above 50 years	2	2.6
Total	78	100

Almost 95% of the teachers were aged between 21 and 50 years, and only 5% were either below 21 years or over 50 years.

Finding 4.1

The majority of science teachers in the sample was female from coeducational schools with ages between 21 and 50 years.

The summary of teachers' teaching qualifications is presented in Table 4.3.

Table 4.3
Percentage of teachers with various science teaching qualifications (n=78)

Category	N	Per cent
HND/B.Sc	6	7.7
NCE	37	47.4
B.Ed/B.Sc(Ed)	30	38.5
HND/B.Sc +PGDE	4	5.1
NCE + B.Ed/B.Sc	1	1.3
Total	78	100

Note. *NCE–National Certificate of Education; HND-Higher National Diploma; PGDE-Postgraduate Diploma in Education*

The data in Table 4.3 indicate that almost all of the teachers (92%) had a preservice teacher education in science and education; however, 8% were trained only in science (HND/B.Sc). Almost half of the teachers (47%) had a three-year science and education training and 45% had four or more years of science and education training. The summary of teachers with higher degrees is presented in Table 4.4.

Table 4.4
Percentage of teachers with higher degrees (n=78)

Category	N	Per cent
None	70	89.7
M. Ed	5	6.4
M. Sc	3	3.8
PhD	0	0
Total	78	100

The majority of teachers had no higher degree in either science or education (90%). Only five teachers had a master degree in education and three had a master degree in science. The major subject areas of science teachers' qualifications are presented in Table 4.5.

Table 4.5
Major subject areas of science teachers (n=78)

Category	N	Per cent
Integrated Science	29	37.2
Chemistry	22	28.2
Biology	18	23.1
Physics	0	0
Agricultural Science	3	3.8
Mathematics	6	7.7
Total	78	100

Of the 78 science teachers, more than one-third majored in integrated science (37%), 23% in biological sciences, 28% in chemical sciences and no teacher had a major in physics. Other teachers majored in agricultural science (4%) and mathematics (8%). The summary of teachers' years of teaching experience is presented in Table 4.6

Table 4.6
Teachers' years of teaching experience (n=78)

Category	N	Per cent
5 years and below	29	37.2
6-10 years	20	25.6
11-15 years	17	21.8
16-20 years	10	12.8
Above 20 years	2	2.6
Total	78	100

Data in Table 4.6 indicate that nearly two-thirds of teachers (60%) had between 6-20 years of teaching experience. Thirty-seven per cent had less than six years teaching experience and only 3% had been teaching for more than 20 years.

Finding 4.2

All of the teachers in the sample had at least three years of higher education. Most teachers were trained in science or education and had teaching qualifications in integrated science, chemical sciences and biological sciences. Only a few teachers had master degrees in education or science. Almost two-thirds of teachers had 6-20 years teaching experience and more than one-third had less than six years of experience.

The sample of schools was drawn from urban and rural areas. Class sizes in urban and rural schools are summarised in Table 4.7.

Table 4.7
Class sizes in urban and rural schools (n=78)

Class size	Rural	Urban	Total
20-30	8	16	24
31-40	5	5	10
41-50	5	10	15
51-60	4	8	12
61-70	3	2	5
71-80	0	2	2
81-90	5	0	5
91-100	2	2	4
101-110	0	0	0
111-120	1	0	1
Total	33	45	78

The data in Table 4.7 indicate that the most common class sizes were between 20 and 60 students. Class sizes in rural schools ranged from 20 to 120 students with a modal class of 30 students and a mean of 53.5 students. In rural schools, the class sizes ranged from 20 to 100 students also with a modal class of 30 students and a mean of 45.8 students.

Finding 4.3

Class sizes ranged from 20 to 120 students. The mean class size in both rural and urban schools is almost 50 students per class with a modal class size of 30 students per class.

Beliefs about the Purpose for Teaching Science

The questionnaire asked science teachers about the main purpose for teaching science to junior secondary school students. Teachers' responses were grouped into categories and a summary of these data is presented in Table 4.8.

Table 4.8
Teachers' responses to the question: What do you see as the main purpose of teaching science to JSS students? (n=78).

Category	N	Per cent of respondents
Science knowledge, skills and attitude		
Encouraging students to develop an understanding of science principles and facts	33	42.3
Enabling students to develop skills and processes of science investigations	22	28.2
Enabling students to develop interest in science and foster a spirit of creativity and scientific inquiry	21	26.9
Further education and career aspiration		
Preparing students for senior secondary education	19	24.4
Preparing students for careers in science	16	20.5
Scientific literacy		
Helping students to apply science to understand their environment	18	23.1
Enabling students to apply science to understand their health	7	9.0

Note. *The total percentage is more than 100% since some teachers gave more than one response to the question.*

Data in Table 4.8 reveal that 71% of respondents believe that students are taught science to enable them to understand science principles and facts and to develop skills and processes of science investigation. More than one-quarter (27%) believe that science helps to develop students' interest and foster in them a spirit of creativity and scientific inquiry. Forty-four per cent indicated that the purpose of junior secondary science is to prepare students for senior secondary education or for a career in science. Also, 30% believe that science helps students apply science to understand the environment or their health.

Finding 4.4

Almost a quarter of the teachers believed that the main purpose for teaching science is to improve students' understanding of the environment and their health.

Beliefs about the Characteristics of Ideal (effective) Science Teaching

The questionnaire further asked science teachers about the characteristics of ideal (effective) science teaching. Teachers' responses were also grouped into categories and a summary of these data is presented in Table 4.9.

Table 4.9
Teachers' beliefs about the characteristics of ideal (effective) science teaching (n=78)

Category	N	Per cent of respondents
Pedagogy		
Students should do more of hands-on group activities	59	75.6
There should be regular interaction between learners and the teacher in the class	35	44.9
Resources		
The class size must be manageable with adequate material resources	39	50.0
There must be sufficient laboratories, textbooks and equipment and a conducive school environment	19	24.5
Teacher knowledge		
Teachers must have a sound knowledge of the subject matter	28	35.9
Teachers must have relevant skills and approaches to cater for students of different learning abilities	15	19.2
Teachers should be involved in ongoing professional development to improve their teaching	3	3.8
Support		
Teachers should feel supported by colleagues, school principals and local education authorities	3	3.8

Teachers should be recognized and valued by parents and the broader community for their contribution to education and scientific literacy of the citizens	2	2.6
Curriculum		
The curriculum must be relevant to the need of students and their environment	5	6.4

Note. *The total percentage is more than 100% since some teachers gave more than one response to the question.*

The data in Table 4.9 reveal that about three-quarters (76%) of respondents believe students should do more hands-on group activities and nearly half (45%) indicate there should be regular interaction between learners and the teacher. Fifty per cent indicate that the class size must be manageable with adequate material resources and one-quarter (25%) believe that there must be sufficient laboratories, textbooks and equipment and a school environment free from distractions so that it is conducive for learning. Also, more than one-third (36%) indicate teachers must have a sound knowledge of the subject matter and about one-fifth (19%) believe teachers must have relevant skills and approaches to cater for students of different learning abilities.

Finding 4.5

The majority of teachers believe that ideal/effective science teaching involves hands-on group activity and regular interaction between learners and the teacher made possible by manageable class sizes and adequate facilities and resources.

Finding 4.6

For effective science teaching, a number of conditions were suggested by the teachers including: good mastery of subject matter, relevant skills and approaches, regular engagement in ongoing professional learning and being supported by colleagues, schools principals and local education authorities and also being recognised and being valued by the parents and the broader community.

Teaching and Learning Strategies

The science teachers were asked for an estimate of time used for science teaching/learning activities in 80 minute lessons under ideal and actual circumstances. A summary of these data is presented in Table 4.10.

Table 4.10
Teachers' estimates of mean percentage time spent on various teaching-learning activities in 80 minute ideal and actual science lessons (n=78)

Category	Ideal science lesson		Actual science lesson	
	Mean per cent	S.D	Mean per cent	S.D
Teacher explaining /or demonstrating to whole class	26.6	11.3	29.5	11.6
Whole class discussion	18.2	9.6	14.9	7.0
Teacher giving notes to students	15.5	7.6	23.8	10.9
Students working individually including working from the text	17.6	7.6	15.8	8.6
Students doing practical and activity in small groups	22.1	8.5	16.0	8.8

In Lagos State, Junior Secondary Science students have typically 160 minutes of science instruction each week as two 40-minute lessons and one 80-minute lesson. Eighty-minute lessons provide opportunities for student practical work. The data in Table 4.10 reveal that in actual 80-minute lessons, on average, 68% of lesson time is devoted to teacher-centered activities (explanation, demonstration, whole-class discussion and giving notes) while only 32% of lesson time is devoted to student-centered activities (individual work, and small-group practical work). In ideal lessons, the teachers believe that the proportion of student-centered activity would be increased to 40%. In these 80-minute lessons designed for practical work, only 16% of class time is devoted to small-group practical work in actual lessons, and this would only be increased to 22% under ideal circumstances.

Finding 4.7

In actual 80-minute science lessons, teachers devote more than two-thirds of lesson time to teacher-centered activity and less than one-third to student-centered activity.

Finding 4.8

In an ideal science lesson, teachers would spend less class time giving notes to students and students would spend more time working independently of the teacher including working individually from the text and doing practical and activity work in small groups, than in actual science lessons.

Teachers were also asked to rate on a five point scale the frequency of their involvement in various teaching-learning activities associated with practical work in ideal and actual science lessons. The summary of teachers' ratings is presented in Table 4.11.

Table 4.11
Teachers' rating of the frequency of various teaching-learning activities associated with practical work in science lessons under ideal and actual circumstances (n=78)

	Ideal			Actual		
	AL+MT	ST	NO + NE	AL + MT	ST	NO + NE
Students do hands-on practical work every week	35.9	23.1	41.0	26.0	19.5	54.6
Students must carefully follow the teacher's instructions for experiments to reach the correct conclusions	98.8	1.3	0	89.8	9.0	1.3
Students plan their own experiments to investigate their own questions	27.2	52.6	19.2	28.6	31.2	40.3
Whole-class discussion occurs at the conclusion of activities to summarise the main ideas	69.2	16.7	14.1	56.4	23.1	20.5
There is not enough time after the experiment to discuss the main findings	19.3	32.1	48.7	18.0	32.1	50.0

Practical work is used to illustrate the concepts that have been introduced	64.1	25.6	10.3	51.2	25.6	23.0
Practical work is carried out by students before the theory is introduced	14.7	26.7	58.6	13.0	19.5	67.6

Note:*AL= All of the time; MT= Most of the time; ST= Some of the time NO= Not often ;NE= Never*

Data in Table 4.11 reveal that in actual science lessons, only 26% of the respondents believe that students do hands-on practical work every week all or most of the time and more than half (56%) agree that whole-class discussion occurs at the conclusion of activities to summarise the main ideas all or most of the time. Fifty-one per cent of the respondents believe that practical work is used to illustrate the concepts that have been introduced all or most of the time and 90% believe that students must carefully follow the teacher's instructions for experiments to reach correct conclusions all or most of the time.

Under ideal circumstances, only 36% of the respondents believe that students would do hands-on practical work every week all or most of the time and 99% indicate that students would carefully follow teacher's instructions for experiments to reach the correct conclusions all or most of the time. More than two-thirds (69%) believe there would be whole class discussions at the conclusion of activities to summarise the main ideas and almost two-thirds (64%) indicate there would be practical work to illustrate concepts that have been introduced all or most of the time.

Finding 4. 9

In actual science lesson, only 26% of the science teachers believe that students do hands-on practical work every week and 56% indicate that whole-class discussion occurs at the conclusion of activities to summarise the main ideas. Also, more than half the respondents believe that practical work is used to illustrate the concepts that have been introduced.

Finding 4.10

Under ideal circumstances, almost all of the teachers (99%) believe that students would carefully follow teacher instructions for experiments all or most of the time. A majority of respondents (64%) believe that practical work would be used to illustrate concepts that have been introduced and that students would be engaged in whole class discussion at the conclusion of activities to summaries the main ideas (69%) all or most of the time.

The questionnaire asked teachers' to indicate their beliefs about the ideal and actual conditions for teaching science. Table 4.12 provides a summary of teachers' responses.

Table 4.12
Teachers' rating of their agreement with the various statements about aspects of pedagogy, curriculum, teacher knowledge and community support under ideal and actual circumstances (n=78)

	Ideal			Actual		
	SA + A	A/D	D+SD	SA + A	A/D	D+SD
Pedagogy						
1.Discussion between students is discouraged so that we can cover more content	24.3	6.4	69.3	36.4	13.0	50.7
2.Students' existing knowledge is assessed to guide lesson planning	75.6	10.3	14.3	79.5	3.8	16.6
3.Students are encouraged to ask questions and express their own ideas	94.8	0	5.2	92.4	5.1	2.6
Curriculum						
4.The curriculum is focused on preparing students for life	82.3	3.8	13.9	83.4	10.3	6.4
5.The curriculum is focused on preparing students for study of science in the senior school	67.6	9.1	23.4	71.8	11.5	16.7
Teacher						
6.Teachers have a sound content knowledge	86.8	9.2	3.9	79.3	10.3	10.4

7.Teachers have the knowledge and skills required for teaching by inquiry	73.1	12.8	14.1	72.0	9.3	18.7
8.There is sufficient time to explore topics in depth	38.4	19.2	42.4	25.6	25.6	48.8
9.We cover a lot of content superficially to complete the scheme of work	55.9	13.0	31.2	61.6	11.5	26.9
Community support						
10.Teachers are supported by the school administration	58.5	20.8	20.8	47.4	21.8	30.7
11.Teachers have sufficient opportunity to attend seminars and workshops to improve their teaching	50.0	33.3	16.7	33.8	19.5	46.8
12.Teachers are recognised and valued by community	50.0	34.2	15.8	35.9	16.7	47.4

Note: SA= *Strongly agree; A= Agree; A/D= Agree / disagree; D= Disagree; SD=Strongly disagree*

In actual circumstance, almost all the respondents (92%) strongly agree or agree that students were encouraged to ask questions and express their own ideas. More than three-quarters strongly agree or agree that students' existing knowledge was assessed to guide lesson planning. A majority (83%) strongly agree or agree that the curriculum was focused on preparing students for life and almost three-quarters (72%) believe that the curriculum was focused on preparing students for study of science in the senior school. More than three-quarters (79.3%) strongly agree or agree that teachers must have a sound content knowledge and have the knowledge and skills required for teaching by inquiry (72%). Only 36% strongly agree or agree that teachers are recognised and valued by the community.

In ideal circumstances, teachers believe that there would be more student discussion (Item 1) and more time for exploring topics in depth (Item 8). They also agree that under ideal circumstances, there would be greater opportunities for teacher professional learning (Item

11) and teachers would have more support from the school administration and the community (Items 10 & 12) than under actual circumstances.

Finding 4.11

In actual science teaching a significant minority (36%) of teachers believe that discussion between students is discouraged in order to cover more content because teachers do not have sufficient time to explore topics in depth. A significant minority (30%) also agree that teachers are not supported by the school administration and (47%) have limited opportunity to attend seminars and workshops to improve their teaching and (47%) are not recognised and valued by the community.

Finding 4.12

In ideal circumstances, the respondents believe that teachers would have a sound content knowledge, more student discussion and sufficient time to explore topics in depth. They also believe teachers would be supported by the school administration and have sufficient opportunity to attend seminars and workshops to improve their teaching, and would be recognised and valued by community.

Assessment Strategies

The questionnaire asked teachers to rate the relative importance/weighting for assessment strategies used in science with emphasis on the learning outcomes, strategies and purpose for assessments in teaching and learning activities.

Table 4.13 presents a summary of teachers' ratings of the average percentage weighting for assessment of various learning outcomes.

Table 4.13

Average percentage weighting for assessment of various learning outcomes (n=78)

What do you assess?	Mean per cent	S.D
Understanding of science content	41.4	10.1
Science skills and processes	31.9	8.5
Science attitudes	26.9	8.4

On average, science teachers gave a higher assessment weighting for understanding of science content (41% weighting) than for skills and processes (32%) and for attitudes (27%). Table 4.14 presents teachers' average percentage weighting for various assessment strategies.

Table 4.14

Average percentage weighting for various assessment strategies (n=78)

How do you assess?	Mean per cent	S.D
Written tests and quizzes	44.9	14.3
Assignments/projects	19.3	7.0
Practical work	18.3	8.8
Practical tests	17.6	8.3

Data in Table 4.14 reveal that on average, science teachers gave a higher assessment weighting to written tests and quizzes (45%) than for assignments/projects (19%) and for practical work(18%) or practical tests (18%). Table 4.15 presents teachers' mean percentage weightings for various assessment purposes.

Table 4.15
Average percentage weighting for various assessment purposes (n=78)

Why do you assess?	Mean per cent	S.D
For grading and reporting	37.6	14.3
For student feedback on their learning	35.6	12.6
For identifying students' misunderstanding	26.7	10.9

Data in Table 4.15 reveal that on average, science teachers gave a higher weighting to assessment for grading and reporting (38%) and for student feedback (36%) than for identifying students' misunderstanding (27%).

Finding 4. 13

Written tests and quizzes are the most commonly used assessment strategy. Understanding of science content is given most weighting in assessment, and the most heavily weighted purposes for assessment is grading and reporting and for giving students feedback on their learning.

Resources

The questionnaire elicited information from teachers about the amount and condition of resources in their schools for teaching science. Table 4.16 reports data about the availability of laboratory assistants and textbooks.

Table 4.16
Resources for teaching science in schools (n=78)

Resources	Yes	No
We have a laboratory assistant	32.0	68.0
Most students have a textbook	34.6	65.4

Data in Table 4.16 reveal that more than two-thirds of the respondents reported there are no laboratory assistants in their schools (68%) and nearly two-thirds (65%) indicate that most students had no textbooks for learning science. The summary of teachers' estimates of amount of time spent on practical and activity work in schools with and without laboratory assistants is presented in Table 4.17.

Table 4.17

Teachers' estimates of average percentage time spent on practical and activity work in 80-minute actual science teaching-learning in schools with and without laboratory assistants (n=77)

Category	N	Mean per cent time	S.D
School with laboratory assistant	24	17.7	9.1
School without laboratory assistant	53	15.5	8.4

Data in Table 4.17 indicate that there was very little difference between schools with laboratory assistants and schools without laboratory assistants in terms of the amount of lesson time devoted to practical and activity work.

Teachers' were asked to rate the condition of resources and facilities for teaching science in their schools. The summary of teachers' responses is presented in Table 4.18.1.

Table 4.18.1

Teachers' rating of the resources for teaching science in schools (n=78)

Availability and condition of resources and facilities	Good	Satisfactory	Poor
Sufficient laboratory facilities	19.2	23.1	57.7
State of repair of laboratory facilities	6.5	27.3	66.2
Supply of chemical reagents	10.3	19.2	70.5
Amount of equipment for experiments	18.2	16.9	64.9
State of repair of laboratory equipment	15.4	20.5	64.1
Quality of the student textbook(s)	21.1	43.4	35.5

More than half of the respondents believe that schools had poor laboratory facilities (58%); poor state of repair of the school laboratory facilities (66%); inadequate supply of chemical reagents (71%); poor amount of equipment for experiments (65%); and, poor state of repair of laboratory equipment (64%). About two-thirds (65%) indicate the quality of textbooks for students' was good or satisfactory. Table 4.18.2 compares the amount and condition of resources in schools with and without laboratory assistants.

4.18.2
Teachers' rating of the amount and condition of resources and facilities for teaching science in schools with and without laboratory assistants (n=78

	School with laboratory assistant			School without laboratory Assistant		
	Good	Satisfactory	Poor	Good	Satisfactory	Poor
Amount of laboratory facilities	40.0	52.0	8.0	7.5	9.4	83.0
Amount of equipment for experiments	33.3	29.2	37.5	11.3	11.3	77.4
State of repair of laboratory equipment	20.0	48.0	32.0	11.3	9.4	79.2
State of repair of laboratory facilities	12.0	60.0	28.0	1.9	13.5	87.8
Supply of chemical reagents	20.0	40.0	40.0	7.5	5.7	87.8

Table 4.18.2 indicates that schools with laboratory assistants had good or satisfactory amounts of laboratory facilities (92% of teachers); equipment for experiments (63%); state of repair of laboratory equipment (68%); state of repair of laboratory facilities (72%); and, supply of chemical reagents (60%). Schools without laboratory assistants, however, had poor laboratory facilities (83% of teachers); equipment for experiments (77%); state of repair of laboratory equipment (79%); state of repair of facilities (88%); and, supply of chemical reagents (88%).

Finding 4.14

More than two-thirds of the schools did not have a laboratory assistant. The presence of a laboratory assistant was associated with only a small increase of teaching time allocated to practical work. Teachers from schools with laboratory assistants reported much higher levels of satisfaction with the availability and state of repair of equipment and facilities than teachers without laboratory assistants.

Finding 4.15

Almost two-thirds (65%) of the respondents rated the quality of student textbooks as either good or satisfactory, however, two-thirds of teachers believe that most students have no textbooks for science.

Factors Inhibiting Effective Teaching

The questionnaire asked science teachers to give any four factors that inhibit the teaching and learning of science in their schools in order of importance with the most important factor listed as first and the least important factor listed as fourth. The summary of rank of importance and the total weighted rank for each factor is presented in Table 4.19.

Table 4.19

Number of teachers mentioning factors inhibiting effective teaching, their rank of importance and the total weighted rank for each factor

Limiting factors	Number of teachers First(x4)	Second(x3)	Third(x2)	Fourth(x1)	Total[a] weighted rank
Resources					
Insufficient teaching resources including equipment, textbooks, specimens, charts	32	29	6	5	232
Lack of well equipped laboratory	19	8	1	1	103
Non-conducive classroom environment	8	4	6	5	61
Insufficient time for teaching science	3	7	3	11	50
Large class size	4	7	3	3	46
Lack of funds for school building and maintenance	2	5	4	2	33
Lack of laboratory support staff	0	0	2	0	4
Teachers					
Teachers' lack of subject matter knowledge	4	0	2	1	21
Inadequate teachers' motivation	1	1	4	3	18
Lack of professional development for teachers	1	0	2	4	12
Insufficient qualified and dedicated teachers	1	0	3	0	10
Support					
Lack of support from school administrators, parents and community	0	3	2	2	15
Poor remuneration and irregular payment of salary	1	0	3	3	13
Curriculum and pedagogy					
Overloaded science curriculum	2	0	1	0	10
Poor teaching skills and approaches	1	0	2	1	9

Student					
Poor students' attitude to science	5	9	19	3	78
Students' poor communication skills	0	1	2	0	7

Note: [a]*The total weighted rank was obtained by multiplying the number of teachers mentioning the factor with the weighting given for the ranks, and then summarising these weighted ranks.*

The six most important factors inhibiting effective teaching and learning of science mentioned by the respondents include insufficient teaching and learning resources, lack of well equipped laboratories, poor students' attitude to science, non-conducive classroom environment, insufficient time for teaching science and large class sizes. Teachers' lack of subject matter knowledge and inadequate motivation were also mentioned as factors that inhibit effective science teaching and learning.

Finding 4.16

The teachers indicated that the most important factors inhibiting effective teaching and learning of science in schools include insufficient teaching resources, lack of well equipped laboratories, poor students' attitude to science, non-conducive classroom environment, insufficient time for teaching science and large class sizes.

Improving Teaching and Learning

Finally, the questionnaire asked the science teachers to suggest various ways for improving the teaching and learning of science in schools. Table 4.20 provides a summary of the various suggestions given by teachers.

Table 4.20

Teachers' suggestions for improving teaching and learning of science (n=78)

Suggestions for improvement	N	Per cent of respondents
Resources		
Providing better or more equipment and facilities	61	78.2
Need for more curriculum resources	58	74.4
Need for regular supply of consumables e.g. reagents	41	52.6
Improved maintenance of classrooms	27	34.6
Need for better quality science textbooks for students and in school library	26	33.3
Providing more funds to build science laboratories and classrooms	19	24.4
Reducing the class size	10	12.8
Employing more qualified and dedicated science teachers	10	12.8
Need to reduce group size for practical work	5	6.4
Provision of qualified laboratory assistants in schools	2	2.6
Teachers		
Need for more professional learning programmes for science teachers	9	11.5
Motivating science teachers through incentives like science teaching allowance, housing and car loans etc.	8	10.3
Providing better remunerations and regular payment for teachers'	7	9.0
Need for teacher to develop skills for improvisation of equipments not available in schools	2	2.6
Need for teacher to teach subjects in his/her area of specialisation	1	1.3
Need for school administrators and principals to support teachers for acquiring higher degrees	1	1.3
Need for regular supervision of science teaching in schools	1	1.3
Encouraging teachers to show better attitude to work	1	1.3

Table 4.20: Continued

Suggestions for improvement	N	Per cent of respondents
Curriculum and pedagogy		
Need for more and better timing for science in the school timetable	21	26.9
Need for students to engage in hands-on activities in science	6	7.7
Reducing the science curriculum contents	4	5.1
Giving teachers free hand to operate the curriculum	3	3.8
Need to relate science to students' real life	2	2.6
Improving teacher-student relationships	1	1.3
Need for regular assessments and feedback for students	1	1.3
Support		
Encouraging students to develop interest and better attitudes in science	31	39.7
Need for better community supports for science teaching and teachers	6	7.7
Need for better parental concerns about education of their children and provision of textbooks for their children	5	6.4
Encouraging students to ask and answer questions in science class	2	2.6
Educating students better about the importance of science	1	1.3

The most common suggestions for improving science teaching and learning by the respondents include: providing more or better equipment and facilities (78%); better curriculum resources (74%); regular supply of consumables (53%); need for students to develop interest and better attitudes in science (40%); improved maintenance of classrooms (35%), additional funding for new laboratories and classrooms (33%), more and better timing for science in the school timetable (27%), employing more qualified and dedicated science teachers (13%) and more professional development programs for teachers (12%).

Finding 4.17

To improve the study of science, most respondents suggest there must be better or more equipment and facilities; better curriculum resources; regular supply of consumables, improved classroom maintenance and additional funds to build new laboratories. Also, mentioned is the need for students to develop interest and better attitudes in science, more and better timing for science in the school timetable, and more professional learning programs for teachers.

Summary of Findings

This Chapter has examined the demographic information about the schools and science teachers who participated in the study. The Chapter also reviewed science teachers' views about the purpose for teaching science to junior secondary students. The science teachers' views about the characteristics of ideal (effective) teaching and learning of science and their views about the actual teaching of science were further examined. The Chapter also looked into the various teaching-learning and assessment strategies used in science classrooms. In addition, teachers' responses on the amount and condition of resources and facilities for teaching science in schools were described. Finally, the Chapter examined the factors that inhibit effective teaching and learning of science and highlighted the various suggestions given by the science teachers for improving the quality of science teaching and learning. The main findings from this Chapter are as follow:

Finding 4.1: The majority of science teachers in the sample was female from coeducational schools with ages between 21 and 50 years.

Finding 4.2: All of the teachers in the sample had at least three years of higher education. Most teachers were trained in science or education and had teaching qualifications in integrated science, chemical sciences and biological sciences. Only a few teachers had master degrees in education or science. Almost two-thirds of teachers had 6-20 years teaching experience and more than one-third had less than six years of experience.

Finding 4.3: Class sizes ranged from 20 to 120 students. The mean class size in both rural and urban schools is almost 50 students per class with a modal class size of 30 students per class.

Finding 4.4: Almost a quarter of the teachers believed that the main purpose for teaching science is to improve students' understanding of the environment and their health.

Finding 4.5: The majority of teachers believe that ideal/effective science teaching involves hands-on group activity and regular interaction between learners and the teacher made possible by manageable class sizes and adequate facilities and resources.

Finding 4.6: For effective science teaching, a number of conditions were suggested by the teachers including: good mastery of subject matter, relevant skills and approaches, regular engagement in ongoing professional learning and being supported by colleagues, schools principals and local education authorities and also being recognised and being valued by the parents and the broader community.

Finding 4.7: In actual 80-minute science lessons, teachers devote more than two-thirds of lesson time to teacher-centered activity and less than one-third to student-centered activity.

Finding 4.8: In an ideal science lesson, teachers would spend less class time giving notes to students and students would spend more time working independently of the teacher including working individually from the text and doing practical and activity work in small groups, than in actual science lessons.

Finding 4.9: In actual science lesson, only 26% of the science teachers believe that students do hands-on practical work every week and 56% indicate that whole-class discussion occurs at the conclusion of activities to summarise the main ideas. Also, more than half the respondents believe that practical work is used to illustrate the concepts that have been introduced.

Finding 4.10: Under ideal circumstances, almost all of the teachers (99%) believe that students would carefully follow teacher instructions for experiments all or most of the time.

A majority of respondents (64%) believe that practical work would be used to illustrate concepts that have been introduced and that students would be engaged in whole class discussion at the conclusion of activities to summaries the main ideas (69%) all or most of the time.

Finding 4.11: In actual science teaching a significant minority (36%) of teachers believe that discussion between students is discouraged in order to cover more content because teachers do not have sufficient time to explore topics in depth. A significant minority (30%) also agree that teachers are not supported by the school administration and (47%) have limited opportunity to attend seminars and workshops to improve their teaching and (47%) are not recognised and valued by the community.

Finding 4.12: In ideal circumstances, the respondents believe that teachers would have a sound content knowledge, more student discussion and sufficient time to explore topics in depth. They also believe teachers would be supported by the school administration and have sufficient opportunity to attend seminars and workshops to improve their teaching, and would be recognised and valued by community.

Finding 4.13: Written tests and quizzes are the most commonly used assessment strategy. Understanding of science content is given most weighting in assessment, and the most heavily weighted purposes for assessment is grading and reporting and for giving students feedback on their learning.

Finding 4.14: More than two-thirds of the schools did not have a laboratory assistant. The presence of a laboratory assistant was associated with only a small increase of teaching time allocated to practical work. Teachers from schools with laboratory assistants reported much higher levels of satisfaction with the availability and state of repair of equipment and facilities than teachers without laboratory assistants.

Finding 4.15: Almost two-thirds (65%) of the respondents rated the quality of student textbooks as either good or satisfactory, however, two-thirds of teachers believe that most students have no textbooks for science.

Finding 4.16: The teachers indicated that the most important factors inhibiting effective teaching and learning of science in schools include insufficient teaching resources, lack of well equipped laboratories, poor students' attitude to science, non-conducive classroom environment, insufficient time for teaching science and large class sizes.

Finding 4.17: To improve the study of science, most respondents suggest there must be better or more equipment and facilities; better curriculum resources; regular supply of consumables, improved classroom maintenance and additional funds to build new laboratories. Also, mentioned is the need for students to develop interest and better attitudes in science, more and better timing for science in the school timetable, and more professional learning programs for teachers.

CHAPTER 5: STUDENT SURVEY RESULTS

Introduction

As key stakeholders in relation to the quality of secondary science education in Lagos State, data were gathered from 500 students by questionnaire. This Chapter reports data from the students' questionnaires and is divided into five sections. The first section presents **students' demographic data** with regards to the type of school attended, sex, age and the class levels. The second section examines **teaching-learning activities in science**. Students' views about the various **ways of improving the study of science** are presented in section three while section four considers students' views about the **importance of studying science**. The final section provides a **summary** of the Chapter.

Demographic Data

Of the 18 junior secondary schools from the three Local Education Districts used in this study in Lagos State, there are 80% coeducational, 10% boys only and 10% girls only schools. Seventy per cent of schools are located in urban and 30% in rural areas. A survey of junior secondary science students was carried out in the three Local Education Districts of Lagos State. About 980 junior secondary science students as intact class groups, (JSS1-JSS3) completed the student questionnaires. A sampling guide (see Table 5.1) involving stratified method was used to select 350 questionnaires from urban schools and 150 questionnaires from rural schools, and of these 400 was from co-educational, 50 from boys' only, and 50 from girls' only schools. The sample comprised 500 questionnaires with an equal number of questionnaires from JSS 1 (33.4%), JSS 2 (33.2%) and JSS 3 (33.4%) classes, and these were 50% males and 50% females for coding and analysis. The sample was therefore representative of the population. The mean ages of the respondents across class levels were 12.2 years for JSS1, 13.2 years for JSS2 and 14.31 years for JSS3.

Table 5.1
Percentage of students from boys, girls and coeducational schools according to school location, class level and sex (n=500)

School	Urban						Rural						Total
	JSS 1		JSS 2		JSS 3		JSS 1		JSS 2		JSS 3		
School Type	M	F	M	F	M	F	M	F	M	F	M	F	
Co-Educational	46	47	47	47	47	46	20	20	20	20	20	20	400
Boys only	12	0	11	0	12	0	5	0	5	0	5	0	50
Girls only	0	11	0	12	0	12	0	5	0	5	0	5	50
Totals	58	58	58	59	59	58	25	25	25	25	25	25	500
	350						150						

Note: JSS 1 = Junior Secondary School Year 1, M= male students and F= female students

Finding 5.1

The student sample comprised 80% from coeducational, 10% from boys only and 10% from girls' only schools with 250 males and 250 females from 70% urban and 30% rural secondary schools. There are equal numbers of students from JSS 1, JSS 2 and JSS 3. The sample is therefore representative of the population of JSS students in the three sampled LEDs of Lagos State.

Teaching-learning Activities

Students were asked to estimate the amount of time they spent on each of five categories of teaching-learning activity in a typical 80-minute lesson. Students also indicated how often they engaged in various teaching-learning activities in a typical 80-minute lesson, and what they need to do to be successful in science, on five-point agreement scale items. The summaries of their responses are presented in Tables 5.2.1 – 5.6.

Table 5.2.1
Students' estimates of average percentage of time allocated to various teaching-learning activities in a typical 80-minute lesson (n=500)

Category	Mean time (in per cent)	Standard deviation
Teacher explaining/or demonstrating to whole class	25.1	7.8
Whole class discussion	19.6	6.2
Note copying	23.1	7.4
Students working individually including working from the text	16.1	5.5
Students doing practical and activity in small groups	15.9	5.8

Table 5.2.1 reveals that almost half of the total time devoted to teaching and learning in 80-minute lessons is allocated to teacher explanations and demonstrations and note copying by the students. About 20% of the time is used to engage students in whole class discussion with the teacher while only 16% of the lesson time is used for students taking part in group practical activities. Table 5.2.2 summarises the amount of time spent estimated by teachers and students on different teaching-learning strategies.

Table 5.2.2.
Teachers' and students' estimates of the percentage of time spent on different teaching learning activities in a typical 80-minute lesson

Category	Amount of time spent on teaching-learning activities in per cent	
	Teachers (n=78)	Students (n=500)
Teacher explaining/or demonstrating to whole class	29.5	25.1
Whole class discussion	14.9	19.6
Teacher giving notes to students	13.8	23.1
Students working individually including working from text	15.8	16.0
Students doing practical and activity in small groups	16.0	15.9

Data in Table 5.2.2 show strong agreement between teachers' and students' estimates of the amount of time spent on teaching-learning activities. Teachers indicated that 30% of the 80-minute lesson time was spent on explanation and demonstration to the whole class and the students gave estimate of 25% of the lesson time. Teachers also indicated they spent 24% of the lesson time giving notes to students and this correlates with 23% of the lesson time estimated by students. In addition, teachers' estimates of 16% of the lesson time spent on students working individually including working from text agrees with students' estimates of 16% of the lesson time. Teachers' estimates that 16% of the lesson time was spent on students doing practical and activity in small groups further agrees with students' estimates of 16% of the lesson time spent on practical and activity work. However, there is a variation in the teachers' estimates which indicated that 15% of the lesson time was spent on whole-class discussion as against students' estimates of 20% of the lesson time.

The students' rating of the frequency in which various teaching-learning activities occur in science lessons is summarised in Table 5.3.

It should however be noted that neutral responses are not included in Tables 5.3 and 5.4 since there values are of a less significant contribution to research data when compare to the values given by the majority of respondents who indicated all of the time, most of the time, not often, and never and as well as those respondents who indicated strongly agree, agree, disagree and strongly disagree in their responses respectively.

Table 5.3
Students' rating of the frequency of various teaching-learning activities in science lessons

In my science class	N	Per cent of responses AL + MT	Per cent of responses NO+ NE
I listen to the teacher explaining ideas	487	86.2	3.7
I copy notes the teacher gives me	493	88.4	1.8
I read science textbooks and form my own notes	492	44.3	15.5
I watch the teacher do an experiment	494	71.1	12.2
I carry out science experiments	488	48.8	25.4

I follow instructions in practical work	497	77.0	7.4
We plan our own experiments	495	41.2	25.3
I work in groups with other students	489	46.0	19.4
I have class discussions with other students on various topics	495	44.2	12.5
I find science interesting to learn	494	74.9	7.3
I get excited about what we do in science	489	75.7	6.4
I am bored with the science we do in class	490	43.2	37.0
Science lessons deal with things I am concerned about	500	64.8	12.4
Science is not related to my life	496	37.1	45.0
I learn about scientists and what scientists do	490	60.2	15.1
I ask questions on what is not clear to me	494	62.1	6.1

Note: AL= All of the time; MT= Most of the time; NO= Not often; NE= Never

From the data in Table 5.3 students listen to the teacher explaining ideas all or most of the time (86%), copy notes all or most of the time (88%), watch the teacher do an experiment all or most of the time (71%), and all or most of the time they follow the teacher's instructions in practical work (77%). However, fewer students indicated that they read the textbook and made their own notes (44%), carry out practical experiment on their own all or most of the time (49%) and only 41% indicated they planned their own experiment all or most of the time. The frequency of group work (46%) and discussion with other students (44.2%) were also quite low. In addition, about two-thirds of students' believe that science deals with what they are concerned with (65%) but does not relate much to their life (37%). It could be inferred from these data that instruction is highly teacher-centered, students are passive listeners to teachers' instruction and there are limited opportunities for students to do hands-on activities.

Finding 5.2

Students' estimate that almost half of the total time devoted to teaching and learning in 80-minute lessons is allocated to teacher explanation/demonstration and note copying by the students while only 16% of the lesson is devoted to student group-based practical work**.**

Finding 5.3

Teacher-centered or teacher-directed activity predominates in lessons and there is less frequent independent student practical works or student discussion in science lessons.

The questionnaire asked students to rate four items about learning science on a five point agreement scale. Table 5.4 summarises the students' responses to these items.

Table 5.4

Percentage of students' responses to four items about learning science (n=500)

To do well in science, I need to be able to……	N	Per cent of respondents SA + A	Per cent of respondents D + SD
think and ask questions	497	96.4	0.8
understand and explain science ideas	498	84.6	5.2
remember lots of facts	499	84.6	7.6
apply science to understand things in my life	497	82.5	9.2

Note: SA= Strongly agree; A= Agree; D= Disagree; SD= Strongly disagree

Data in Table 5.4 indicate that the majority of students believe that for them to do well in science, they need to think and ask questions (96%), understand and explain science ideas (85%), remember lots of facts (85%) and apply science to understand things in their lives (83%). Thus, learning science involves more than just remembering facts; it requires a search for understanding and applying ideas to their own lives.

Finding 5.4

A large majority of the students (>80%) believe that to do well in science, they must be able to think and ask questions, understand and explain science ideas, remember lots of facts and apply science to understand the world around them.

Suggestions for Improving the Study of Science

In this section, students were asked to respond to various items about what need to be done to improve the study of science. Summaries of students' responses are presented in Tables 5.5.1 and 5.5.2.

Table 5.5.1

Percentage of students' responses to the question: How could the study of science be improved? (n=500)

The study of science can be improved when……	N	Per cent
Resources		
Resources for learning are available (laboratories, science facilities, equipment, access to textbooks)	264	52.8
There is a conducive school environment (not noisy, well ventilated, good lighting system, and not polluted)	18	3.6
There are specialist science schools	5	1.0
Computers are used to support teaching-learning	5	1.0
Students have their own materials to study at home (textbooks, writing materials, charts)	5	1.0
Teachers		
There are good teachers (qualified, competent and interested)	133	26.6
Teachers use good teaching approaches (from simple to complex, discuss new ideas and demonstrates)	15	3.0
Teachers are friendly and respond to students' problems	3	0.6
Curriculum and pedagogy		
Students do group work (assignments, practical and projects)	212	42.4
Students are engaged in learning (being attentive, reading notes, doing home work, carrying out own observation, asking and responding to questions)	167	33.4

Students learn more about the contributions of earlier scientists and watch science documentaries	12	2.4
Students engage in career talks, field trips, excursions, and science clubs	10	2.0
Science is related to the learner's environment using concrete examples	9	1.8
Tutorials and extra lessons are organised for students	2	0.4
More time is allotted to science teaching-learning	2	0.4
Community Support		
Society is educated more about the importance of science (orientation and awareness about science)	28	5.6

Note: Many students made more than one suggestion for improving the study of science. The 500 students made a total of 890 suggestions for improvement.

The four most common suggestions for improving science were: sufficient science facilities and equipment (53%); more student group work (42%); having qualified, competent and interested teachers (27%); and, students being actively engaged in learning (33%).

Finding 5.5

Science can be improved by providing sufficient science facilities and equipment; qualified, competent and interested teachers; engaging students in group work; and students being actively engaged in learning.

Suggestions for improving science teaching and learning mentioned by teachers and students are compared in Table 5.5.2.

Table 5.5.2:
Percentage of teachers and students mentioning various ways for improving science teaching and learning activities

Category	Suggestions for improving science in per cent	
	Teacher (n=78)	Student (n=500)
Resources		
Provision of resources and equipment	78.2	52.8
Improved maintenance of classroom	34.6	3.6
Teachers		
Employing more qualified and dedicated teachers	12.8	26.6
Curriculum and pedagogy		
Need for more and better timing for science in the school timetable	26.9	0.4
Need to engage students in hands-on activities	7.7	42.4

Data in Table 5.5.2 reveal that the most common suggestions by teachers for improving the teaching-learning of science include provision of resources and equipment (78%), improved maintenance of classroom (35%) and create more and better timing for science in the school timetable. However, 27% of the students suggested that more qualified and dedicated science teachers should be employed and that they need to engage in hands-on activities (42%).

Finding 5.6

Many science teachers believe that science teaching and learning can be improved by provision of resources and equipment, improved classroom maintenance and more or better timing for science in the school timetable. Students however, indicated that more qualified and dedicated science teachers should be employed and that they should engage more in hands-on activities.

Importance of Studying Science

To gain information about students' understanding of the importance of science, students were asked to explain the various ways in which the study of science will help them now or in the future. Students' responses were grouped into categories and the frequency of responses in each category are summarised in Table 5.6.

Table 5.6
Percentage of students giving various responses to the question: How will the study of science help you now or in the future? (n= 500)

The study of science can help now or in the future…..	N	Per cent
To understand the world around me	155	31.0
To build up my career	154	30.8
To be curious, creative and inquisitive	143	28.6
To understand my health	77	15.4
To gain respect for being good at science	24	4.8
To be a good citizen	26	5.2
To overcome superstitions	4	0.8

Note: *Many students indicated more than one way in which the study of science will help them now or in the future. The 500 students made 583 suggestions.*

Table 5.6 indicates that nearly one-third of students believe studying science will help to: understand the world around them including their environment; to build up their future careers; and enable them to be curious, creative and inquisitive. Only 15% mentioned that science would enable them to understand their health. Ten per cent of the students believe the study of science would enable them gain societal respect (5%) or to be a good citizen (5%) while only about one per cent indicated it would enable them overcome superstitions.

Finding 5.7

Only one-third of the students believe that studying science helps them understand the world, build up careers, and be curious, creative and inquisitive, and only 15% students believed that science helped them understand their health.

Summary of findings

The Chapter presents the analysis of students' responses to the questionnaires. The responses of 500 students who completed the survey were analysed and divided into five sections comprising students' demographic information, teaching-learning activities in science, improving the study of science, and the importance of science. The major findings of the analysis in this Chapter are as follows:

Finding 5.1: The student sample comprised 80% from coeducational, 10% from boys only and 10% from girls' only schools with 250 males and 250 females from 70% urban and 30% rural secondary schools. There are equal numbers of students from JSS 1, JSS 2 and JSS 3. The sample is therefore representative of the population of JSS students in the three sampled LEDs of Lagos State.

Finding 5.2: Students' estimate that almost half of the total time devoted to teaching and learning in 80-minute lessons is allocated to teacher explanation/demonstration and note copying by the students while only 16% of the lesson is devoted to student group-based practical work**.**

Finding 5.3: Teacher-centered or teacher-directed activity predominates in lessons and there is less frequent independent student practical works or student discussion in science lessons.

Finding 5.4: A large majority of the students (>80%) believe that to do well in science, they must be able to think and ask questions, understand and explain science ideas, remember lots of facts and apply science to understand the world around them.

Finding 5.5: Science can be improved by providing sufficient science facilities and equipment; qualified, competent and interested teachers; engaging students in group work; and students being actively engaged in learning.

Finding 5.6: Many science teachers believe that science teaching and learning can be improved by provision of resources and equipment, improved classroom maintenance and more or better timing for science in the school timetable. Students however, indicated that more qualified and dedicated science teachers should be employed and that they should engage more in hands-on activities.

Finding 5.7: Only one in three students believe that studying science helps them to understand the world, build up careers, and be curious, creative and inquisitive, and only 15% agree that science helps to understand one’s health.

CHAPTER 6: FOCUS GROUPS AND INTERVIEWS

Introduction

The involvement of all key stakeholders in science education in Nigeria, in making appropriate recommendations for improving the quality of teaching and learning of science in schools is crucial for reform of science education and for developing scientifically literate citizens.

This Chapter therefore considers the views of the key stakeholders in science education within Lagos State, Nigeria. Science teachers, school principals, education officers, representatives of parent/teacher associations, teacher educators, members of professional association for science teachers, and representatives of examination bodies participated in the focus group meetings. In addition, interviews were also held with a senior curriculum officer, a chemical analyst, a laboratory technologist and a former chairman of the Science Teachers Association of Nigeria.

The Chapter is divided into five sections based on the questions used in the focus group meetings and interviews. Section one focuses on **the characteristics of ideal science teaching and learning** and section two describes **what actually is happening in science teaching and learning** in Junior Secondary Schools. The **factors inhibiting the quality of science teaching and learning** are examined in section three and section four describes **suggestions for improving the quality of science teaching and learning**. The last section presents a **summary of the findings** from the focus group meetings and interviews.

Participants

Focus Groups

To obtain relevant qualitative data for this study, four focus group meetings were organised by the Researcher in Lagos State, Nigeria between the 23rd March and 25th May, 2004. One focus group meeting was conducted in each of the three Local Education Districts for science teachers, principals of secondary schools, education officers and representatives of the parent/teacher association, and one national focus group meeting for other key stakeholders including teacher educators, representatives of examination bodies and members of the professional organisation for science teachers.

Interviews

So that the study would have a national perspective, interviews were conducted with four other key stakeholders in science education including a senior science curriculum officer from the Lagos State Post Primary Teaching Service Commission, a former chairman of the Science Teachers Association of Nigeria in Lagos State, a laboratory scientist in a government establishment and a chemical analyst working in industry. These interviews were conducted between 14th July and 5th August, 2004.

Results

As the participants in the focus group discussions and the interviews were asked the same questions, their responses are considered together. The views of participants across groups have been synthesized into themes which are reported in relation to the questions.

Question 1: What would be the characteristics of an ideal quality teaching and learning of science in our secondary schools?

Consistent views were expressed by participants with regards to the characteristics of ideal science teaching and learning. The main themes arising from the discussions included: funding, resources, facilities and class size; curriculum and pedagogy; teacher knowledge, skills, attitude and professional learning; and, community support. The summaries of comments made by participants that reflect their understandings of a quality teaching and learning of science are described under these themes.

Theme 1.1: Funding, resources, facilities and class size

The participants argued that under ideal circumstances there would be continuous and adequate funding by government for building more classrooms, laboratories and libraries, for maintenance of schools, and in procuring the necessary curriculum resources including equipment and materials such as chemicals, reagents and modern textbooks. They also indicated that class sizes would be manageable and classrooms would be well-ventilated, devoid of noise and distractions with enough seats for all students so as to encourage learning.

“The government should fund teaching and learning of science (Curriculum officer, interview, 28/07/04)”.

“The learners should learn in a laboratory that is well equipped, the materials should be enough………, (Parent, Ojo focus group, 25/03/04)”.

“There should be availability of teaching and learning resources, not just only the physical laboratories, but it should be well equipped and the materials must not be obsolete. (Teacher educator, National focus group, 24/03/04).

Modern and quality textbooks should be made available for …teacher and students for them to have a broad knowledge and for the teacher to have up-to-date information in their fields of teaching (Principal, Ojo focus group, 25/03/04).

“The classrooms should be well ventilated…. there should be enough seats for the students to seat comfortably. The population of students offering science subjects should not outnumber the capacities of the teacher, that is, need for manageable class size… and the number of the students should not outnumber the equipment that is available in the school (Parent, Ojo focus group, 25/03/04)”.

“The learning environment should motivate the learner to learn and….schools should be situated in a conducive learning environment devoid of distraction and noise (Examination officer, National focus group, 24/03/04)”.

Finding 6.1.1

An ideal science is adequately funded by government so that schools would be provided with well-ventilated classrooms devoid of noise and distractions with enough seats for students, well-equipped laboratories with materials and equipment, sufficient curriculum resources including chemicals, reagents and quality textbooks that are not obsolete, and would have manageable class sizes.

Theme 1.2: Curriculum, pedagogy and learning

Under ideal circumstances the curriculum provides learning experiences needed for developing science learning outcomes through effective interaction and activity-oriented instructional strategies. The participants' responses about curriculum focused on an inquiry approach to learning and the role of practical work in science. They also emphasised that effective pedagogy should involve practical and activity work, excursions for students, classroom interaction including discussion and questioning to enhance active engagement of students in learning.

"Science curriculum should be inquiry-based (Science teacher, Oshodi/Isolo, focus group**,** 23/03/04)".

"Science curriculum should be activity-oriented…….where students are made to involve in practical work. Students should be allowed to interact together …. discuss together ……so that things they discover themselves can be discussed and as to how then they are involved in inquiry process (Laboratory technologist, interview, 05/08/04)".

"Science curriculum should create the interest of the learner in the learning process (STAN representative, 14/07/04)".

"…students should be allowed to touch……..to demonstrate and to carry out practical of what they are taught theoretically ….students learn more when they manipulate things themselves. Thus………..teachers should give students opportunities to talk, ask questions and manipulate things in the classroom (Education officer, Ojo focus group, 24/03/04**)**".

"Students should go out for excursions to places of interest in order for them to observe things in their natural environment or habitat and the ways of producing things in the laboratories or industries (Principal, Alimosho focus group, 24\03\04)".

Finding 6.1.2

An ideal science curriculum is inquiry-based and activity-oriented so that science pedagogy would involve practical and activity work, excursions for students, classroom interaction including discussion and questioning to actively engage students in learning.

Theme 1.3: Teacher knowledge and skills, attitude, and professional learning

Under ideal circumstances teachers would have a rich knowledge of subject matter and pedagogical skills for achieving the purpose and goals for secondary science education. Also, an accomplished science teacher would have good professional attitudes and be continuously involved in professional learning activities. The participants emphasised that, ideally, science teachers would be well-qualified, knowledgeable and resourceful. They also indicated that science teachers would be ready and willing to teach and to be regularly involved in research and professional learning programmes in order to update their knowledge.

"Teacher must be well qualified………to teach science (Parent, Alimosho focus group, 24/07/04)".

"The teacher has to be seasoned or knowledgeable in his or her area of specialisation (Chemical analyst, interview, 20/07/04)".

"The teacher must be resourceful to relate the classroom activities to the world situation………… in order to teach his or her subject successfully (Teacher educator, National focus group, 24/03/04)".

"Teacher should be ready and willing to teach (Examination officer, National focus group, 24/03/04)".

"Teachers should ……involve in research programmes (Laboratory technologist, 5/08/04)".

"Teachers should …….. attend seminars, conferences and workshops …. to update their knowledge (Parent, Ojo focus group, 25/03/04)".

Finding 6.1.3
Ideal science requires that teachers are well qualified, have rich subject matter knowledge and good pedagogical skills and are resourceful to relate the classroom activities to the local environment. Science teachers would also be readily available and willing to teach, regularly attending seminars, workshops and conferences, and involved in research activities to update their knowledge.

Theme 1.4: Community support

The participants indicated that under ideal circumstances, science teachers would be encouraged, recognised and valued by members of the community, and that they would not be overlaboured.

"Incentives should be given to teachers …to encourage them from time to time because their job is more laborious (Parent, Ojo focus group, 25/03/04)".

"Teachers must be recognised and valued by members of the society (Teacher educator, National focus group, 24/03/04)".

"Science teachers should not be overlaboured or overloaded with work (Principal, Ojo focus group, 25/03/04)".

Finding 6.1.4
Under ideal circumstances science teachers would be encouraged with incentives such as improved salaries and allowances, they would be recognised and valued by the community, and would not be overloaded with work.

Question 2: What do you see actually happening in the teaching and learning of science in our secondary schools at the present time?

Participants' responses about actual science teaching were organised into themes. The themes that emerged were the same as those for ideal science teaching and learning: funding, resources, facilities and class size; curriculum and pedagogy; teacher knowledge, skills, attitude and professional learning; and, community support.

Theme 2.1: Funding, resources, facilities and class size

In actual science teaching and learning, schools lack proper funding for building new classrooms and laboratories, for adequate classroom maintenance and for providing resources and facilities. The participants indicated that the government provides inadequate funds for schools. Schools lack well-equipped laboratories and well-stocked libraries, have insufficient resources including chemicals, reagents, equipment and textbooks, and there is a general lack of maintenance of school facilities. They further remarked that students learn under harsh condition with a noisy environment and without enough seats for students, and that the class sizes are very large thereby making the teaching of science difficult and tedious for the teachers.

"Poverty or lack of funds has made it impossible for secondary schools to run and perform their expected roles (STAN representative**,** Interview, 14/07/04)".

"….. secondary school lack well-equipped laboratories and resources (Chemical analyst, Interview, 20/07/04)".

"……..most of the chemicals we have in the laboratories are expired (Science teacher**,** Oshodi/Isolo focus group, 23/03/04)".

"Our laboratories are nothing to write home on…….. lack of maintenance culture has destroyed all those equipment in the laboratories (STAN representative, Interview, 14/07/04)".

“Majority of student do not have textbooks……………….. Most of these schools do not have libraries and where they have one, the textbooks in the libraries are either obsolete or outdated (Examination officer, National focus group, 24/03/04**)”.**

“The class size is so large that the amount of resources for teaching could not meet up with the demand of the large number of students. The class size is such that ……. the number of students to a teacher is about 100 (Laboratory technologist, Interview, 05/08/04)”.

“Today in most secondary schools in Lagos State, the class size is so large. Teachers find the teaching of science boring due to the large number of students per class (Principal, Ojo focus group, 25/03/04)”.

“…the learning environment in most of our schools is so bad that students learn under harsh condition ….. which are noisy (Science teacher, Alimosho focus group, 24/06/04)”.

Finding 6.2.1

Schools are not properly funded by the government and lack enough classrooms, well-equipped laboratories, well-stocked libraries and resources including chemicals, reagents, equipment and quality textbooks. There is a general lack of maintenance of the school facilities. The classroom environment is not conducive for learning as they are noisy and there are not enough seats for students. Class sizes are large and teachers find the teaching of science very tedious.

Theme 2.2: Curriculum, pedagogy and learning

In actual science teaching and learning, theoretical aspects are emphasised and students are engaged in a few hands-on activities thereby making science teacher-centered and too difficult for students. The participants remarked that the science curriculum is overloaded with content, students learn in abstract, the approach is didactic and theoretical, and students do few hands-on practical activities.

“The science curriculum in use in our secondary schools today is overloaded with contents….teacher rarely covers the entire curriculum content for the students before their final examination (Science teacher, Alimosho focus group, 24/06/2004)”.

“Today, in most of our secondary schools, much emphasis is…..on theory. Students are not practically exposed to the rudiments of science (Laboratory technologist, Interview, 05\08\04)”.

“The teaching of science in our school is a theoretical thing; the practical aspect of it is lacking (Parent, Oshodi/Isolo focus group, 23/03/04)”.

“Students are not practically exposed to the rudiments of science (Laboratory technologist, Interview, 05/08/04)”.

“…….most of the students cannot actually identify for instance, some of the reagents use in the course of science practical and also cannot identify some of the equipments that are commonly found in science laboratories (Curriculum Officer, Interview, 28/07/04)”.

Finding 6.2.2

Science curriculum content is being overloaded with content, science teaching and learning is didactic and theoretical, and students rarely engage in hands-on practical and activity work.

Theme 2.3: Teacher knowledge and skills, attitude, and professional learning

In actual science teaching and learning, schools do not have enough qualified, dedicated and knowledgeable science teachers. Also, science teachers have a limited range of pedagogical skills due to limited opportunities for participation in professional learning activities. The participants explained that most teachers do not have enough background knowledge in the science they teach; do not show enough enthusiasm in science and this has a detrimental effect on students’ interest in science.

"Science teachers are not enough in our schools (Chemical analyst, Interview, 20/07/04)".

"Most of the science teachers do not have the knowledge and skills of drawing in biology (Examination Officer, National focus group, 24/03/04)".

"Today, not all the teachers are qualified ………some of those teaching science in our schools do not have enough background knowledge in science subjects in which they are teaching. In some cases, National Certificate in Education holders in Biology/Chemistry are teaching Physics aspects of integrated science to students. So, one can not expect much from such a teacher (Teacher educator, National focus group, 24/03/04)".

"Some of the teachers do not show enough enthusiasm in the teaching of science (Parent, Ojo focus group, 25/03/04)".

"……teachers are not being totally committed to teaching science may be due to poor motivation (Chemical analyst, Interview, 20/07/04)".

"Today, a lot of teachers are not so equally dedicated to their profession (Examination Officer, National focus group, 24/03/04)".

"……there is generally lack of in-service training in the system. ……many do not know what they need to do any longer because they are not making science lively to the learner and the learners are becoming very boring (Principal, Ojo focus group, 24/06/04)".
"Students …… show no more positive attitude to science in school any longer (Laboratory technologist, Interview, 05/08/04)".

Finding 6.2.3

Schools do not have enough qualified, knowledgeable, skilled and dedicated science teachers. Most of the science teachers do not have the basic knowledge of physics/chemistry or biology aspect of the integrated science they teach. Teachers lack opportunities for professional learning and do not show enough enthusiasm in science, and this affects students' interest in science.

Theme 2.4: Community support

In actual science teaching and learning, schools are not being supported by the community and science teachers are not being valued and recognised. Also, science teachers are not motivated with improved and regular payment of salaries and allowances and students too, are not being encouraged to do science in schools. The participants emphasised that teachers' morale is low because they are not valued and recognised by the community.

"The value system about education in our society is wrong due to the way the society speaks about education in general and science education in particular. More positive attitude is shown to courses like courses like accounting, Pharmacy, medicine, law … than to education (Principal, Ojo focus group, 25/03/04)".

"Today nobody wants to become science teachers and teacher in general because teachers are not being motivated. …….. their morale is low or rather killed and this is transferred to the students and thus students too lose interest in science (Parent, Oshodi/Isolo focus group, 23/03/03)".

"Today …. in our society, teachers are seen as the unfortunate ones and thus go the slogan "*House for rent! Please teachers need not apply*"…. The societies in which we are do not encourage people to take to teaching as a profession. …… The way the society looks at the teacher is a creation of the government because of the way and manner teachers are treated by the government due to lack of motivation, non-regular payment of salaries and allowances including science teaching allowance (Principal, Oshodi/Isolo focus group, 23/03/03)".

Finding 6.2.4

Teachers' morale is low because they are not adequately motivated and encouraged through improved and prompt payment of salaries, allowances and other incentives by government, and, they are not valued and recognised by the community.

Question 3: What do you think are the factors that inhibit the teaching and learning of science in our secondary schools?

Participants' views about the factors inhibiting the teaching and learning of science in Junior Secondary Schools in Lagos State were identified and organised into a similar themes. These included: funding, resources, facilities and class size constraint; curriculum and pedagogy constraints; teacher knowledge, skills, attitude and professional learning constraints; and, community support constraints.

Theme 3.1: Funding, resources, facilities and class size

There is inadequate funding for schools and these have an adverse effect in that there are not sufficient resources for the large number of students. The participants mentioned that science education is poorly funded by government; schools lack enough classrooms, well-equipped laboratories and reagents, libraries, insufficient curriculum resources including textbooks, class sizes are large, and many schools do not have a laboratory assistant.

"Poor funding of science education due to wrong placement of priority by the government is a factor (Principal, Alimosho focus group, 24/06/04)".

"……. there are not enough classrooms to accommodate the students for the science (Chemical analyst, Interview, 20/07/04)".

"…most of our secondary schools do lack infrastructures like laboratories……there are no equipment, no materials to work with, there are no reagents and chemicals for students….. we do not have enough laboratory staffs like technicians, laboratory assistants and laboratory attendants who would be assisting the science teachers (Laboratory technologists, Interview, 05/08/04)".

"The schools lack functional libraries and quality science textbooks for teacher and students (STAN representatives, National focus group, 24/03/04)".

"The number of students that offer (study) science this day is very large (Science teacher, Ojo focus group, 25/04/03)".

Finding 6.3.1

Most of the schools are poorly funded by government and do not have enough classrooms, and many classrooms do not have enough seats for all the students. They lack well-equipped laboratories with chemicals and reagents and the libraries are without modern quality textbooks. Also, the class sizes are large and most schools do not have laboratory assistants thereby making science teaching difficult and tedious for teachers and so students are less involved in hands-on practical activities. Thus resources limitations impact on the implemented curriculum in ways that limit opportunities for learning

Theme 3.2: Curriculum, pedagogy and learning

Ineffective teaching and assessment strategies have a negative impact on students' interest in science and these factors constitute major hindrances to the quality of science education in schools. The participants emphasised that science the curriculum is overloaded with content; science is taught in abstract; there is insufficient time for science learning and lack of effective assessment and follow-up. They further stated that students lack mathematical background, discipline, interest and communication skills in science because they found the language of instruction in science, that is, English, difficult to comprehend and un-relate to the first language spoken mostly at home.

"Most students do not understand the language of instruction in science (Science teacher, Ojo focus group, 25/03/04)".

"……students lack mathematical background to do well in science in school. …..Also, most of the students lack communication skills to understand the language of instruction and the language used by the textbook authors..... There is lack of discipline and interest on the part of the students (Science teacher, Oshodi/Isolo focus group, 23/03/04)".

"The science curriculum is overloaded with little amount of class time allocated to science teaching in the school timetable to cover the curriculum content (STAN representative, National focus group, 24/03/04)".

"….most of the teaching is in abstract (Parent, Ojo focus group, 25/03/04)".

"….there is a lack of effective testing and follow-up (Curriculum Officer, Interview, 28/07/04)".

"The interest of the student needs to be considered. …students lack interest in science (Education Officer, Oshodi/Isolo focus group, 23/03/04)".

"Teachers are overloaded with the number of periods they teach per week. In some cases, science teachers teach about 24 to 30 periods a week while on the other hand they combine science ….. with mathematics teaching which makes the work so overloaded for the teachers (Examination Officer, focus group, 24/03/04)".

"In our society, a lot of superstitious meanings are attached to the teaching and learning of science in schools (Science teacher, Oshodi/Isolo focus group, 23/03/04)".

Finding 6.3.2

The science curriculum is overloaded with content, science is taught in abstract, there is no enough time for science learning in the school timetable and there is no effective assessment and follow-up thereby making science learning teacher-centered and didactic. Also, students are more oriented toward traditional beliefs, and lack mathematical background knowledge, discipline, interest and communication skills because there is a conflict between the language of instruction in science and the first language spoken most of the time at home which limits their learning.

Theme 3.3: Teacher knowledge and skills, attitude, and professional learning

Most schools do not have sufficient human resources and qualified and dedicated science teachers. Also, teachers are not adequately committed to teaching and to support students' learning because they have limited opportunities for participation in professional learning activities and thereby they have limited skills for teaching science. The participants indicated that schools lack enough qualified science teachers, and science teachers' lack in-service training, effective pedagogical knowledge and teaching skills.

"The number of teachers available to teach science subjects in schools is so short compared with the number of students. ……., there are inadequate numbers of science teachers in our secondary schools (Teacher educator, National focus group, 24/03/04)".

"Most of the teachers are not current; they are outdated in the teaching of science. There is lack of in-service training. …… the teachers are not qualified and those that are qualified are not current about the trends in science teaching (Parent, Alimosho focus group, 24/06/04)".

"…..in science, it is like teachers themselves do not employ appropriate teaching methods. ….teachers ……are lacking in knowledge of how to improvise (Laboratory technologist, Interview, 05/08/04)".

Finding 6.3.3

Schools lack enough qualified science teachers with knowledge of effective pedagogy and teaching skills. Also, science teachers lack sufficient opportunities for in-service training to improve their teaching, thereby making them not competent enough to regularly engage their students in practical and activity work.

Theme 3.4: Community support

Science teachers are not adequately supported and are poorly remunerated by the government. Teaching and teachers are not valued by the community and so teachers are not so dedicated to their profession. The participants remarked that science learning in schools is not valued and recognised by the community and teachers are paid lower salaries and allowances compared to their colleagues in other professions. This is made worse by the fact that salary payments are not made on a regular basis; payments are often delayed.

"…there is lack of motivation on the part of government for the science teachers (Science teacher, Oshodi/Isolo focus group, 23/03/04)".

Teachers …….are poorly paid…. compared to other cadre of professionals (Parent, Alimosho focus group, 24/06/04)".

"…..teachers are looked upon as the less privileged in the society and so they are not given up to optimum (Chemical analyst, Interview, 20/07/04)".

Finding 6.3.4

Learning of science and science teachers are not valued and recognised by the community. Consequently, science teachers are not given salaries and allowances that are commensurate with their responsibilities and that of other professionals. Teachers are therefore not dedicated to their profession and look elsewhere for jobs that will be more rewarding.

Question 4: How can these factors be addressed to improve the quality of teaching and learning of science in Nigerian secondary schools?

This section presents the main suggestions of the participants for improving the quality of teaching and learning of science in Junior Secondary Schools in Lagos State. The participants gave general suggestions for improving science teaching and learning (e.g. improve funding); however, very few specific mechanisms were suggested for making these improvements.

Theme 4.1: Funding, resources, facilities and class size

Effective teaching and learning of science requires adequate funding to build more new classrooms and laboratories and also to provide facilities and equipment including curriculum resources such as textbooks and consumables for the teachers to engage students in practical and activity work. The participants remarked that government should provide enough funds to schools and science education in particular for more classrooms, laboratories, libraries and curriculum resources including equipment, facilities and textbooks, and that there should be manageable class sizes.

"……government should provide enough funds to build more classrooms and laboratories and provide equipment and resources for the teaching and learning of science (Laboratory Technologist, Interview, 05/08/04)".

"More funds should be allocated to education in general and science education in particular to procure the needed materials and equipment for teaching and learning in our secondary schools (STAN representative, National focus group, 24/03/04)".

"The government needs to build more classrooms, laboratories and libraries for the students. Also … needs to provide quality science textbooks for teachers and students (Curriculum Officer, Interview, 28/07/04)".

"It is the shortages of classrooms that led to a class size of 100 or more students per class…..when the government builds more classrooms, we are going to have a reduced number of students in the classroom ….in ratio 40:1(Curriculum Officer, Interview, 28/07/04)".

"There is a need for the provision of libraries stocked with science textbooks in the school (STAN representative, National focus group, 24/03/04)".

"There is a need to reduce the teacher/student ratio to the minimum such that the teacher will have enough time for preparation and evaluation of instruction (Examination Officer, National focus group, 24/03/04)".

Finding 6.4.1

There should be an increased allocation of funds for education by government to build new classrooms and laboratories so that class sizes can be reduced. There should also be sufficient funds to equip the laboratories with chemicals and reagents, for regular maintenance of laboratories and equipment, and to provide quality textbooks for the library.

Theme 4.2: Curriculum, pedagogy and learning

To improve the teaching and learning of science, the curriculum content should be reduced and more time should be allocated for science learning in the school timetable so as to provide opportunities for teachers to engage students in hands-on practical and activity work together with appropriate classroom interactions such as discussing, questioning, and excursions for students. The participants emphasised that the science curriculum should be changed so that it is inquiry-based and student-centered rather than being didactic and teacher-centered.

"…..the curriculum delivery in school should be inquiry in nature (Parent, Oshodi/Isolo focus group, 23/03/04)".

"Science teaching and learning should be student-centered ... allowing students to be actively engaged in their own learning through activity based instruction … to interact and manipulate the learning materials most of the time (Parent, Alimosho focus group, 24/06/04)".

"There is need for teachers to modify curriculum based on popular demands…. more time, say about 4 periods (160minutes) should be created for practical and 2 periods (80 minutes) for theory per week, that is, there should be more room for less talk and more practice on the part of the teacher and the students (Education Officer, Ojo focus group, 25/03/04)".

"…... the interest of the students should be made to come first as to the offering (choosing) of science as subject in schools, that is, students should not be coerced to offer (choose) science by either teachers or their parents (Education officer, Ojo focus group, 25/03/04)".

Finding 6.4.2

There should be a reduction in the science curriculum content and more time allocated for science per week in the school timetable to provide opportunities for inquiry-oriented student practical work.

Theme 4.3: Teacher knowledge and skills, attitude, and professional learning

To improve the quality of science, there should be adequate number of qualified, dedicated and knowledgeable science teachers in all schools. The participants emphasised that there is a need for improved teacher preparation through adequate and regular assessment and internship for practicing science teachers. Science teachers should be encouraged and supported to participate in seminars, conferences, workshops with a view to improve their teaching skills and for them to have a broad knowledge of how students learn science. They also indicated that science teachers should be familiar with contemporary trends and strategies in science teaching and learning by constantly reading through the current journals in science education.

"More qualified science teachers need to be employed (Examination Officer, National focus group, 24/03/04)".

"Practising teachers need to be scrutinized adequately well during their training to make sure that they are up to the task of teaching at the end of their programme. Thus, there is need for student-teacher reassessment during their training (Examination Officer, National focus group, 24/03/04)".

"….teachers need to …..engaging themselves in attending conferences, workshops, seminars and collaboratively share knowledge with other science teachers on issues relating to teaching and learning science in our secondary schools (Principal, Alimosho focus group, 20/06/04)".

"…teachers should be encouraged to go for internship, seminars, workshops and conferences. …..teachers should be encouraged to read through journals, current journals; this will expose new ideas and contexts about science teaching (Laboratory Technologist, Interview, 05/08/04)".

Finding 6.4.3

There should be a regular assessment and a one-year internship in a local secondary school for pre-service science teachers to ensure they are dedicated and competent for teaching. Also, more qualified science teachers should be employed by government in all schools and they should be supported to regularly participate in professional learning activities in order to improve their teaching of science.

Theme 4.4: Community support

To enhance the quality of science teaching and learning, science teaching and science teachers should be valued and recognised by the community. The government should improve teachers' salaries and allowances and provide science teachers with other incentives like car loans, housing loans and scholarships with a view to enhance their status, and to encourage them to be dedicated in improve their teaching of science. The participants remarked that teachers' salary and allowances should be comparable with other equivalent professions.

"The salary structure for teacher should be same if not more than that of other cadres of government workers in order to attract more people to teaching (Science teacher, Oshodi/Isolo focus group, 23/03/04)".

"Teachers salaries should be paid regularly as at when due just as other cadres of workers is paid. Also, science teaching allowance should be paid to all science teachers in other to motivate them to work and conduct practical lesson with their students (Parent, Oshodi/Isolo focus group, 23/03/04)".

"Parents need to cooperate with the teachers and provide supports where necessary to the school in procuring the needed materials in the science laboratories through the Parent/Teacher Association (PTA) (Education Officer, Alimosho focus group, 24/06/04)".

"There is a need for … effective coordination, monitoring and evaluation of science activities in the State Secondary Schools (Parent, Alimosho focus group, 24/06/04)".

"….the society needs to be educated about the importance and benefits of science to national growth and development (Teacher educator, National focus group, 24/03/04)".

"Efforts should be made to encourage industries around who employ scientists to contribute to funding of education and science education in particular. ….. be it in form of engaging science students in an industrial practical attachment, sponsoring of science quizzes and competitions, donation of science textbooks and equipments and building of physical classrooms and laboratories in schools (Education Officer, Ojo focus group, 25/03/04)".

Finding 6.4.4

Teachers' salary and allowances should be improved so that they are commensurate to other cadres of government workers and professionals. Also, teachers salaries and allowances should regularly be paid and they should be supported, valued and recognised by government and the community through appropriate incentives including housing loans, car loans, furniture allowance, science practical allowance and scholarships for further education with a view to improve their status and encourage them to improve their teaching and also to encourage other professionals into science teaching.

Summary

This Chapter has looked into the participants' views which include teachers and other key stakeholders in science education about the status and quality of science teaching and learning in Lagos State, Nigeria. Specifically, the Chapter has examined the participants' views about the characteristics of an ideal science teaching and learning in schools. Also highlighted in the Chapter are the present situation of science education and the inhibiting factors in Lagos State Secondary schools. Finally, the Chapter presented the participants' views and suggestions for improving the teaching and learning of science in junior secondary schools in Lagos State, Nigeria. The findings summarising the main themes emanating from the participants' arguments and comments are summarised in the tables below.

Theme 1: Funding, resources, facilities and class size

Ideal	Actual	Constraints	Overcoming constraints
An ideal science education programme is adequately funded by government so that schools would be provided with well-ventilated classrooms devoid of noise and distractions, well-equipped laboratories with materials and equipment, sufficient curriculum resources including chemicals, reagents and quality textbooks that are not obsolete, and have a manageable class size with enough seats for students.	Schools are not properly funded by the government and lack enough classrooms, well-equipped laboratories, well-stocked libraries and resources including chemicals, reagents, equipment and quality textbooks. There is a general lack of maintenance of the school facilities. The classroom environment is not conducive for learning, characterised with noise and not enough seats for students, large class sizes, and teachers find the teaching of science very difficult and tedious.	Most of the schools are poorly funded by government and do not have enough classrooms, and many classrooms do not have enough seats for all the students. They lack well-equipped laboratories with chemicals and reagents and the libraries are without modern quality textbooks. Also, the class sizes are large and most schools do not have laboratory assistants thereby making science teaching difficult and tedious for teachers and so students are less involved in hands-on practical activities.	There should be more allocation of funds for education by government to build new classrooms and laboratories so that class sizes can be reduced. There should also be sufficient funds to equip the laboratories with chemicals and reagents, for regular maintenance of laboratories and equipment, and to provide quality textbooks for the library.

Theme 2: Curriculum, pedagogy and learning

Ideal	Actual	Constraints	Overcoming constraints
An ideal science education programme curriculum is inquiry-based and activity-oriented so that science pedagogy would involve practical and activity work, excursions for students, classroom interaction including discussion and questioning to actively engage students in learning.	Science teaching and learning is didactic and theoretical , and students rarely engage in hands-on practical and activity work.	The science curriculum is overloaded with content, science is taught in abstract, there is no enough time for science learning in the school timetable and there is no effective assessment and follow-up thereby making science learning to be teacher-centered and didactic. Also, students are more oriented toward traditional beliefs, and lack mathematical background knowledge, discipline, interest and communication skills because there is a conflict between the language of instruction in science and the first language spoken most of the time at home which limits their learning.	There should be a reduction in the science curriculum content and more time allocated for science per week in the school timetable to provide opportunities for student practical work.

Theme 3: Teachers' knowledge and skills, attitude, and professional learning

Ideal	Actual	Constraints	Overcoming constraints
An ideal science education programme requires teachers being well qualified, have rich subject matter knowledge and good pedagogical skills and are being resourceful to relate the classroom activities to the local environment so that science teachers should be readily available and willing to teach, regularly attending seminars, workshops and conferences, and involved in research activities to update their knowledge.	Schools do not have enough qualified, knowledgeable, skilled and dedicated science teachers. Teachers lack opportunities for professional learning and do not show enough enthusiasm in science, and this affect students' interest in science.	Schools lack enough qualified science teachers with knowledge of effective pedagogy and teaching skills. Also, science teachers' have not enough opportunities for in-service training to improve their teaching, thereby making them not competent enough to regularly engage their students in practical and activity work.	There should be a regular assessment and a one-year internship in a local secondary school for pre-service science teachers to ensure they are dedicated and competent for teaching. Also, more qualified science teachers should be employed by government in all schools and they should be supported to regularly participate in professional learning activities in science.

Theme 4: Community support

Ideal	Actual	Constraints	Overcoming constraints
An ideal science education programme would involve teachers who are being encouraged with incentives, being recognised and valued by the community, and not being overloaded with work.	Teachers' morale is low because they are not adequately motivated and encouraged through improved and prompt payment of salaries, allowances and other incentives by government, and, they are not valued and recognised by the society.	Learning of science and science teachers are not valued and recognised by the community. Consequently, science teachers are not given salaries and allowances that are commensurate with their responsibilities and that of other professionals. Teachers are therefore not dedicated to their profession and look elsewhere for jobs that will be more rewarding.	Teachers' salary and allowances should be improved so that they are commensurate to other cadres of government workers and professionals. Also, teachers salaries and allowances should regularly be paid and they should be supported, valued and recognised by government and the community through appropriate incentives including housing loans, car loans, furniture allowance, science practical allowance and scholarships for further education with a view to improve their status and encourage them to improve their teaching and also to encourage other professionals into science teaching.

CHAPTER SEVEN: DOCUMENT ANALYSIS

Introduction

Analysis of curriculum documents forms an important phase in this research study as they describe the intended curriculum which can be compared with the actual implemented curriculum. During the data collection period, the Researcher obtained various science curriculum documents from school principals, science teachers and also from the officials of the Lagos State Post Primary Teaching Service Commission in the three Local Education Districts. Specifically, this Chapter reviews the various national and state curriculum documents for Integrated Science in Lagos State, Nigeria, including the National Policy on Education; National Core Curriculum in Integrated Science, integrated science scheme of work, science laboratory inventory record and the school timetable among others.

National Policy on Education and National Core Curriculum Documents in Integrated Science

The Nigerian National Policy on Education (FGN, 1998) has as its broad aims for secondary education, to prepare learners for useful living within the society and for higher education. The national policy's aims and objectives of secondary education are: to provide learners with the opportunities for education of a higher quality; to equip students to live effectively in the modern age of science and technology; to raise a generation of people who can think for themselves, respect the views and feelings of others, respect the dignity of labour, and appreciate those values specified under our broad national aims; and to live as good citizens (FGN, 1998, p. 16).

Finding 7.1

The purpose of secondary education in Nigeria is to prepare students for useful living within society and for higher studies.

The National Core Curriculum for Junior Secondary Schools in Integrated Science emphasises teaching the pupils "what science is and how a scientist works" (FME, 1985, p. 3) based on the developmental level, educational background and the learner's physical environment so that learner would develop interest in science and also would be involved and develop themselves through inquiry processes.

It is envisaged in the national core curriculum, that learners who are taught Integrated Science would acquire the skills necessary for scientific inquiry, of "observing carefully and thoroughly; reporting completely and accurately what is observed; organising information acquired; generalising on the basis of acquired information; predicting as a result of the generalisations; designing experiments (including controls where necessary) to check predictions; using models to explain phenomena where appropriate; continuing the process of inquiry when new data do not conform to prediction" (FME, 1985, p. 3).

In summary, the core curriculum in science emphasises inquiry-discovery approaches to teaching and learning of science so that learners have a grasp of the "concept of the fundamental unity of science; gains the commonality of approach to problems of a scientific nature; is helped to gain an understanding of the role and function of science in everyday life, and the world in which he/she lives" (FME, 1985, p. 3).

In Nigerian junior secondary schools, science is taught as 'Integrated Science' comprising biology, chemistry and physics. In practice, the Integrated Science core curriculum is divided into three years of JSS1-JSS3. Teachers are expected to teach and cover six main topics: you as a living thing; you and your home; living components of the environment; non-living components of the environment; saving your energy; and controlling the environment (FME, 1985) over three years with three school terms per year. The core curriculum topics are further divided into sub-topics, each with a scheme of work covering 9-12 weeks for each school term (FME, 1985).

The main sub-topics that teacher must teach under biology include; characteristics of living things; characteristics of animals; human beings as intelligent animals; know your body; feeding; health of the family; classification of matter; grouping of organisms; activities of living things; environmental sanitation; sewage; disease vectors; and preventive medicine including clean water and immunization; movement; excretory system; respiratory system; circulatory system; digestive system; growth and development; ecology; maintaining balance in the environment; and pollutants in the environment; food storage; sense organs;

reproductive system; health; continuity of the family; care of the child; our disappearing forests; and controlling the weather (FME, 1985).

The chemistry sub-topics are observing samples of non-living things; classification of non-living components; measurements; states of matter; air and water; physical and chemical changes; elements, compounds and mixtures; further investigation of air and water; hydrogen; rusting; energy and measurement; chemical symbols, formulae and equations; atomic structure, metals and non-metals; activity series; and acids, bases and salts.

Also, physics sub-topics include: humans and space; science-related occupations; tools (machines) for work and force; energy and appliances in the home; forms of energy; force; simple machines and maintenance of machines; energy conversion and transfer; energy and work; kinetic theory; and humans in space. Although the curriculum is entitled Integrated Science, it should be noted that each of biology, chemistry and physics topics are to be taught separately with equal time allocations.

Further analysis of the Integrated Science syllabus for Lagos State junior secondary schools reveals inclusion of personal hygiene and health issues topics like puberty, masturbation ovulation and the menstrual cycle, myths and facts about sexual intercourse, preventing teenage pregnancy, effects of drugs and self-medication during pregnancy, breastfeeding and its advantages, disease vectors, care of the child and importance of immunization and prevention against diseases, and also myths and facts about HIV/AIDS (Lagos State Ministry of Education, 2003).

Analysis of a typical school timetable reveals that two 40-minute lessons and one 80-minute lesson; totaling 160 minutes per week are allocated for science. It is believed that the 80-minute lessons would provide opportunities for teachers to do practical work with students. It could be inferred from the various topics outlined in the core curriculum that the subject matter contents to be covered by teachers are very extensive, however, the Integrated Science core curriculum gives guidelines to teachers about the various activities to be performed with the expectations that when adhered to strictly, they would be able to implement the science curriculum as intended.

Importantly, the amount of time allocated for science instruction is inadequate since students need more time for practical work to gain first and experiences of natural phenomena and teachers require more time to prepare for teaching science.

Finding 7.2

The intended core curriculum documents for junior secondary Integrated Science in Nigeria encompasses a number of issues relating to learners' environment and health and well being and also emphasises inquiry-discovery approach with extensive subject matter content; however, there is only 160 minutes per week allocated for science which is insufficient to cover all the required content using practical work and an inquiry approach.

Other Curriculum Documents

Other curriculum documents, namely Integrated Science scheme of work; school attendance register; students' excursion record; school science timetable; school register of work; continuous assessment record; cumulative master marks record; the laboratory inventory record; and diaries of work provide science teachers with resources to support their teaching and assessment practices including lesson plans for achieving quality science education (FGN, 1998; FME, 1985; Lagos State Ministry of Education, 2003). For example, the scheme of work for Integrated Science is divided into three terms of 11-13 sub-topics per term. In most cases, week one is used for revision of the previous term's work and weeks 2-10 are for actual teaching and learning activities. Weeks 11-13 are used for revision of the term's work and for the end of term examination.

The laboratory inventory record for Integrated Science from a typical school indicates the amount of materials, equipment, chemicals and consumables available in the school for practical experiments. In most cases, the materials available are very limited for the large class sizes. For example, only 100g of salts like sodium carbonate are provided and materials such as microscopes are limited to only 10 instruments. Many important materials and reagents such as pH meters and calorimeters are not available in schools.

Finding 7.3

The schemes of work for the Integrated Science curriculum in Lagos State junior secondary schools comprise 11 to 13 sub-topics to be taught per term. This requires for sufficient facilities and equipments including chemicals and reagents and to be supported with a class of 30 students for teaching by inquiry.

Summary

This Chapter has presented the analysis of the curriculum documents that guide science teaching in junior secondary schools. The Nigerian National Policy on Education and the National Core Curriculum for Integrated Science documents were examined to identify the aims for secondary education and for science education. Other relevant curriculum documents were used to identify the schemes of work and curriculum content used in implementing teaching and learning of science for the purpose of achieving the intended goals of science education in schools as highlighted in the national policy on education and the national core curriculum documents. The main findings derived from this Chapter that describe the nature of the intended science curriculum are the following:

Finding 7.1: The purpose of secondary education in Nigeria is to prepare students for useful living within society and for higher studies.

Finding 7.2: The intended core curriculum documents for junior secondary Integrated Science in Nigeria encompasses a number of issues relating to learners' environment and health and well being and also emphasises inquiry-discovery approach with extensive subject matter content; however, there is only 160 minutes per week allocated for science which is insufficient to cover all the required content using practical work and an inquiry approach.

Finding 7.3: The schemes of work for the Integrated Science curriculum in Lagos State junior secondary schools comprise 11 to 13 sub-topics to be taught per term. This requires for sufficient facilities and equipments including chemicals and reagents and to be supported with a class of 30 students for teaching by inquiry.

CHAPTER 8: DISCUSSION

Introduction

The primary purpose of this study was to investigate the status and quality of junior secondary science teaching and learning in Lagos State, Nigeria. Specifically, the study develops two pictures; one of ideal science teaching and learning and the other of actual practices. By comparing the actual and ideal pictures, recommendations can be developed for improving science education in Lagos State.

Data about **ideal** science teaching were generated from the review of national and international literature, surveys of science teachers and students, focus group meetings with science teachers and other key stakeholders in science education, and also from interviews with other members of the science education community including scientists in government establishments and those working in industry. Stakeholder input ensured that the ideal picture was realistic and appropriate to the Nigerian context. Also, data about **actual** science teaching were generated from surveys of science teachers and students, focus group meetings of school principals, science teachers, other key stakeholders, interviews with members of science education community including scientists in government establishments and those working in industry, and from analysis of curriculum documents.

The research design (Figure 3.2) for this study was modeled on a national study of the status and quality of science teaching and learning conducted by Goodrum, Hackling and Rennie (2001) in Australia. The conceptual framework (Figure 2.1) and the research questions were used to guide the analysis of data generated from teachers, students, other key stakeholders and curriculum documents. Questionnaires were completed by 78 junior secondary science teachers from the Alimosho, Ojo and Oshodi/Isolo Local Education Districts, and also by 500 junior secondary school (JSS) students. The audio-recordings of the focus group meetings and the interviews were transcribed and read through several times by the Researcher in order to identify the emerging themes and patterns for coding (Krawthwohl, 1998).

Triangulation of data from these sources (Erickson, 1986; Flick, 1992; Yin, 2003) helped identify the main themes and corroborate findings to generate consensual pictures of ideal and actual science teaching and learning in junior secondary schools in Lagos State, Nigeria. Several general assertions are developed in this Chapter as a result of the triangulation of data from Chapters 4-7 by aggregation of findings developed from the data reported in these Chapters.

The Researcher identified six primary themes from the data which are used as a framework for making realistic recommendations for change which are reported in the final chapter of the thesis. The themes discussed in this Chapter include:

1. The science curriculum
2. Class sizes and resources in science
3. Community support
4. Beliefs about the purpose for secondary science education
5. Teaching-learning and assessment practices in science
6. Teacher education and professional learning

Theme 1: The Science Curriculum

A quality science curriculum is necessary for achieving quality science education and scientific literacy for all students. An analysis of the Nigerian National Policy on Education (FGN, 1998) and the Core Curriculum documents in Integrated Science (FME, 1985) reveals that the intended science curriculum contains extensive subject matter content relating to biology, chemistry and physics, and topics on environmental and health related issues which are important aspects of developing scientific literacy. The curriculum document in integrated science is subdivided into traditional discipline of biology, physics and chemistry so that learners would have basic background knowledge in these areas of science so that these could help them to perform well in their further studies in science at the senior secondary and higher education. Furthermore, equal time of between 9-12 weeks is designated to each of these subject areas. This is to allow teachers have enough time to prepare and teach so that individual subject areas topics would be covered before the learners' seat for the final examinations. The goals of the intended science curriculum focus on preparation of learners for useful living within the society and for higher education (Findings 7.1 & 7.2).

The teacher focus groups also confirmed that the implemented science curriculum is overloaded with content and that there is not sufficient time allocated to science in the school timetable for learners to engage in effective inquiry-centered laboratory activities (Findings 6.2.2 & 7.2). These findings are also supported by teacher questionnaire data that show that discussion between students is discouraged so that teachers could cover more lesson content for the purposes of preparing students for examinations, for the study of science in the senior secondary school, and for career aspirations in science (Table 4.12 & Finding 4.11).

The student questionnaire data gave further insight into the actual science curriculum in schools and reveal that science lessons are boring and students need to remember lots of facts for them to do well in science (Tables 5.3 & 5.4). This in essence involves memorization of science facts, theories and principles for the purpose of examination. More than one-third of the students believe that the science they learn in school is not related to their life because science is based on factual information rather than conceptual understanding arising from inquiry-oriented science set in the context of the learners' environment and health (Table 5.3 & Finding 4.4).

Under ideal circumstances, teacher questionnaire data suggests that the science curriculum would be relevant to the needs of students and their environment (Table 4.9); would develop students' skills and processes of science investigation; and would also enable students to develop interest in science and foster a spirit of creativity and scientific inquiry so that learners would develop meaningful understanding of the nature of science (Table 4.8). The teacher questionnaire data further argue that an ideal science curriculum would give teachers a free hand to operate the curriculum so that science can be related to students' real life and learners are engaged in regular hands-on activities in science (Table 4.20).

Teacher focus group data also suggested that ideal science would be inquiry-based and activity-oriented so that science pedagogy would involve practical and activity work and learners would engage in manipulating and investigating things for themselves and would also be involved in classroom interaction including discussion and questioning, and also field work excursions so as to relate science to learners' local environments (Finding 6.1.2). The analysis of the core curriculum document in Integrated Science indicates that the intended science curriculum would relate to the developmental level, educational background and learners' environment or the world of work (Finding 7.2).

Although, the national core curriculum in science does not specifically mention scientific literacy, however its statements are consistent with achieving scientific literacy for all students. This core curriculum in science includes issues of social and environmental concerns which are essential for developing scientifically literate students and emphasises inquiry-oriented and student-centered approaches to teaching and learning science. Consequently, this could help learners to develop better understandings of the nature of science and scientific inquiry (Findings 6.1.2 & 6.2.2).

The evidence from this study has shown that in actual science, the implemented curriculum is overloaded with subject matter content and focuses on transmission of content to be memorised for examination and for the study of science in the senior secondary school. Also, this study reveals that students do not find science taught in class related to their lives and students believe they have to remember lots of facts to do well in science, which is in contrast to an inquiry-oriented learning approach in science.

The findings from this study also corroborate the Australian report by Goodrum, et al. (2001) and the Nigerian report by Okebukola (1997) that the implemented science curriculum is overloaded with subject matter content. Basically, the science curriculum content in Nigeria is quite large, and it aims at meeting the objectives outlined in the National Policy on Education (FGN, 1998) to prepare learners for useful living within the society and for higher education.

The teacher survey data reveal that ideal science curriculum would contain issues that are relevant to the needs of the learner and their environment, would focus on developing students' skills and processes of science investigation and foster in learners a spirit of creativity and scientific inquiry so that learners would learn about the nature of science from their prior knowledge and develop an understanding from experience in a more constructivist manner. These findings are consistent with previous research (Akpan, 1996; Goodrum et al., 2001; McComas, 2002; Millar & Osborne, 1998; Nakagiri, 1992; Ogunbowale, 2001) that argues that the science curriculum should be relevant to the needs of students and their environment and that it would contain less subject matter content for in-depth learning of a smaller range of topics in order for the learners to develop positive attitudes and rational thinking processes for scientific literacy.

Bybee (1993) and Cuban (1992) argue that the science curriculum should focus on developing scientific inquiry so that learners would have a better understanding of the nature of science (Abd-El-Khalick & Boujauode, 1997) in a more constructivist manner (Tytler, 2002; von Glaserfeld, 1981, 1989) to understand the world around them and their health (AAAS, 1998; Goodrum et al., 2001, Millar & Osborne, 1998; National Research Council, 1996). Hofstein, Navon, Kipnis and Mamlok-Naaman (2005) also affirm "inquiry-centered laboratories have the potential to enhance students' meaningful learning, conceptual understanding, and their understanding of the nature of science" (p. 791).

The Nigerian science curriculum is overloaded in subject matter content and is geared towards preparation of learners for senior secondary education and careers in science. This impacts negatively on the teaching and learning of science and learners therefore found science boring and lack interest in the subject.

In Australia, the Australia Education Council (AEC, 1994) stated that the science curriculum should help to develop learners' ability to use the skills of scientific investigation; apply scientific knowledge and understanding of some of the key scientific theories, principles, concepts, models and ideas to explain and predict events in their day to day activities; helps learners to communicate scientific understanding to different audiences for a range of purposes; help learners to use scientific language to communicate effectively and to further their own understandings; help learners to apply and evaluate scientific knowledge and understanding in diverse ways and contexts to construct and modify their understanding of the natural world and technological world; and also to understand and appreciate the evolutionary nature of scientific knowledge and the nature of science, its history, its relationships with other human endeavours and its contribution to the larger society.

An ideal science curriculum, would therefore contain less subject matter content and should be inquiry-based and student-centered so that learners would have a better understanding of the nature of science and to engage in everyday social issues through extended scientific investigations that could result in developing and reinforcing their concepts and skills in relevant contexts thus developing scientifically literate citizens.

General Finding 8.1

In actual science, the curriculum is overloaded with subject matter content and focuses on transmission of content to be memorised for examinations and for senior secondary education. Under ideal circumstances, the science curriculum would focus on meeting the needs of the learners and emphasise in-depth learning of less subject matter content so that students would learn by inquiry and have a better understanding of the nature of science from their experience in a more constructivist manner.

Theme 2: Class Sizes and Resources in Science

Quality science teaching and learning requires that there are sufficient classrooms and laboratories, adequate curriculum resources, modern equipment and facilities and manageable class sizes. Teacher questionnaire data reveal that in actual science teaching and learning there are not enough science classrooms and laboratories, science classes are very large, science laboratories have inadequate facilities and equipment, and supplies of chemicals and reagents for experiments are quite low (Tables 4.7; 4.18.1 & Findings 4.3). In addition, more than two-thirds of the science teachers indicated that currently their schools lack laboratory assistants (Table 4.16 & Finding 4.14) and the condition of science facilities and equipment in their schools is very poor due to lack of maintenance because of the lack of laboratory assistants in schools (Table 4.18.2). Teacher questionnaire data reveal that the quality of student textbook(s) was quite satisfactory; however, about two-thirds of teachers indicate that most of their students do not have their own textbook(s) to study at home (Tables 4.16 & 4.18.1).

Teacher focus group data further corroborate the teacher questionnaire data and mention that many schools do not have enough classrooms, classrooms are not well ventilated and also that there are not enough seats for all students; they learn science under harsh conditions which are not conducive for effective learning (Finding 6.2.1).

Under ideal circumstances, teacher questionnaire data suggest that class sizes would be manageable so that teachers would employ a variety of teaching approaches and provide opportunities for teachers to recognize individual students as learners and give feedback to individuals and also to organize students into small groups for practical and activity work. Teachers also argue there would be adequate curriculum resources including textbooks, and sufficient equipment and adequate supplies of chemicals and reagents so that students would conduct their own experiments and engage in scientific investigations to generate or refine knowledge, find solutions to problems and pose more questions about issues that they are curious about in science (Table 4.9).

Teachers further believe that ideal science would be supported with additional funds to build more science laboratories and classrooms so that the class sizes would be reduced for effective teaching and also to provide schools with enough relevant teaching resources so that the teaching-learning environment is characterized by enjoyment, fulfillment and mutual respect between the teacher and students and for teacher to regularly engage learners in practical and activity work (Table 4.9 & Finding 4.17). Teachers also claim that under ideal circumstances, there would be laboratory assistants in all schools to help teachers in arranging the laboratory for practical and activity work and to ensure proper maintenance of the laboratory facilities and equipment including a regular supply of chemicals and reagents (Table 4.20 & Finding 4.17).

Teacher questionnaire data are further corroborated by the teacher focus group data that suggested ideal science classrooms would be well ventilated and devoid of noise and distractions, and also would have enough seats for all students to work on comfortably so that learners can concentrate on what is taught by teachers and find science lesson interesting (Finding 6.1.1). The teacher focus groups also argue that under ideal circumstances, schools would have modern curriculum resources including science textbooks in the school libraries, reference books for teacher and students, and laboratory equipment, facilities, chemicals and reagents that are not obsolete so that teachers can include more experiments in the curriculum (Finding 6.1.1).

Student questionnaire data also corroborate the teachers' views and suggested that ideal science classrooms would have a good lightning system, not to be polluted, and also that computers would be used to support science teaching and learning so that learner would find science learning interesting (Table 5.5.1).

This study reveals that currently, there are not enough laboratories and well-ventilated classrooms for all students due to lack of funding and class sizes are very large, to the extent that there are more than 50 students in almost 40% of sampled classes. Large class sizes make it difficult for teachers to get to recognise individual students as learners, to organise learners into small group for practical and activity work, to monitor learners' learning in order to diagnose their weaknesses and to provide feedback to individual learners. Also most schools currently have insufficient curriculum and other resources including modern textbooks, equipment, chemicals and reagents and so learners rarely engage in scientific inquiry in science and teacher-directed activity predominates. Furthermore, the current state of poor maintenance of laboratory facilities and equipment and low supplies of chemicals and reagents because of lack of laboratory assistants in most schools are rendering laboratory facilities and equipment ineffective over a short period of time (Finding 4.14).

These findings support previous studies in Nigeria (Ajewole, 1994; Folaranmi, 2002; Ogunleye, 1999; Okebukola, 1997; Olaleye, 2002) that indicate overcrowded classrooms or large class sizes, lack of textual materials, inadequate laboratory apparatus and equipment, and lack of provision in many homes for the educational needs of students in science are impediments to effective science education. Also, modern quality resources including computers and Internet access are lacking for improving school administration, teacher record keeping and for teaching and learning. Quality science education therefore cannot be achieved in a classroom environment that lacks enough and modern curriculum materials and resources that could facilitate teaching and learning of science.

This study shows that under ideal science education, additional funds are provided to build more laboratories and classrooms so that class sizes would be reduced for teachers to recognize individual learners, their strengths and weaknesses and also to effectively involve learners in small group practical and activity work in the laboratories rather than in general classrooms.

In addition, this study argues that laboratory assistants are essential in schools to support teachers in preparation for practical work and for ensuring regular supplies of chemical reagents and the maintenance of laboratory equipment and facilities, and adequate supply of lighting. These findings support a recent report in science teaching and learning in Australia by Goodrum et al. (2001) that quality science is supported by excellent facilities, equipment and curriculum resources including instructional technologies, and with manageable class sizes. This view is also supported by Yager (1991) and Venville, Wallace and Louden (1998) who argue that new curriculum materials and excellent classroom environments are essential for learning by inquiry.

This study reveals that lack of resources for effective teaching and learning of science in Nigerian schools has contributed to the poor state of science education in the country so that teacher-centered and teacher-directed activity predominates because learners have limited opportunity to engage in practical and activity work. In developed countries of Australia and Japan information and communication technologies are exploited to enhance learning of science for scientific literacy of the citizens. Also, a large numbers of schools in these countries are well-resourced with curriculum materials including computers connected to the Internet for students to find information beyond the resources of the school.

General Finding 8.2

In actual science, most secondary schools have not enough classrooms and seats for all students because many science classes are very large (i.e., >50 students). Also, the science laboratories do not have sufficient facilities and equipment including, chemicals and reagents and most schools do not have laboratory assistants. Under ideal circumstances, there would be enough classrooms and seats for all students with manageable class sizes so that teachers would know individuals as learners, science laboratories would be well-equipped and have laboratory assistants so that students could do more experiments, school libraries would have modern textbooks, and students would have their own textbooks to study at home. Also, in ideal science, schools are equipped with information and communication technologies like computers and internet access for teacher and students to find information beyond the resources of the school, for school administration work, for teacher record keeping, and for teaching and learning and research activities.

Theme 3: Community Support and Professional Status

Quality teaching and learning of science cannot be achieved in a vacuum, but it requires financial, social and moral supports from individuals, governments and the larger community including the school administration and parents. Teacher questionnaire data show that currently, teachers feel they are not adequately supported by the school administration, parents and the larger community and particularly they lack sufficient opportunity to attend seminars, workshops and conferences and also to collaborate with colleagues for improving their teaching practice (Tables 4.12; 4.19 & Finding 4.11).

Teacher focus group data also corroborate the teacher questionnaire data and reveal that science teachers are not valued by the community like their counterparts in other professions such as doctors, lawyers, accountants and business administrators.

The teacher focus groups explained that teachers in Nigeria are generally not paid adequate salaries and allowances when compared with their colleagues in other professions (i.e., lawyers, pharmacists, accountants, scientists and business administrators) with equivalent qualifications (Table 4.19 & Finding 6.2.4). They further claim that teaching in Nigeria is not accorded professional status and that teachers are generally not being treated as professionals because unlike other practitioners with professional standards and codes of conduct regulating admission, registration, induction and discipline of members, teaching lacks such professional standards and little importance is attached to issues like licensing of teachers to practice, induction of beginning teachers, selection and grading of teachers, and ongoing professional development for teachers to improve practice and to raise the status of teaching as a profession (Finding 6.3.4).

Unlike their counterparts in other professions, teachers are less motivated with incentives including housing allowances and car loans, and teachers' salary and allowances are often delayed or not regularly paid so that most teachers engage in other private businesses to provide for themselves and their families' commitments. These private business commitments result in teachers being absent or being excused from school when they need to attend to business matters. Consequently, the larger community does not recognise and value science teaching and teachers so that teachers' morale is very low and they lack motivation for improving the quality of science education in schools (Finding 6.3.4).

Under ideal circumstances, science teachers suggest that they would feel supported by colleagues, school principals and the local education authorities (Table 4.9), and also would be valued and recognised by parents and the broader community for their contribution to improving the quality of science education and scientific literacy of citizens (Table 4.20 & Finding 4.12).

The teacher focus group further suggest that teachers would be adequately remunerated with good salary and allowances like their counterparts in other professions and would be motivated with incentives like housing and car loans. They also mention that teachers would have their salary and allowances paid regularly to maintain themselves and their families so that teachers do not engage in private businesses which often cause teachers to be absent and/or abscond from school and classes. In addition, teachers would be supported by the school administration and parents to attend seminars, workshops and conferences in science to improve their teaching practice so that they cater for the learning needs of their students (Finding 6.4.4).

The findings from this study reveal that in the actual science, science teaching and teachers are not recognised and valued by the community, teachers are not remunerated with adequate salary and allowances, and teachers do not have sufficient opportunities for professional development to improve their teaching. These results replicate and affirm the assertions from previous studies such as Darling-Hammond (1999) and Dozier and Bertotti (2000) that confirm that the lack of incentives to teach, wrong placement of priorities of school districts to direct their effort into useful professional development for teachers, lack of opportunity for teachers to collaborate with other teachers, general lack of respect for the teaching profession, and the bureaucratic practices associated with teaching in schools as barriers to achieving quality teaching and learning.

Under ideal circumstances, this study indicates that science teaching and teachers would be recognised and valued, teachers would be paid adequate salary and allowances, teachers would be motivated with incentives including car and housing loans and that teachers would be paid their salaries and allowances regularly. These findings corroborate other research studies that argue that for quality teaching and learning, teachers would be treated as professionals, teaching and science teachers would be recognised and valued, and also that there would be professional standards regulating licensing of teachers, induction and ongoing professional development (ASTA & Monash University, 2002; Goodrum & Hackling, 2003; NBPTS, 1999). The findings are also supported by Goodrum et al. (2001) and Darling-Hammond (1999) who argued that teachers would regularly collaborate with colleagues on curriculum content and instruction, and also with the school community including parents and the wider professional communities so that learners appreciate the importance of science and their interest in and attitudes towards science are improved.

The results of this study show that Nigerian teachers are not recognised and valued and that teachers are not motivated with good salaries and allowances unlike their counterparts in other professions. Research evidence, however, shows that in developed countries, teachers are better recognised and valued and they are paid adequate salaries and allowances although not necessarily equivalent to their counterparts in other professions. In Japan and Germany teachers are highly valued, recognised and respected and their salaries are comparable to those of university professors (Stoel & Thant, 2002). For teaching to have professional status in Nigeria, there would also be professional standards regulating licensing of teachers, induction, and ongoing professional development for all categories of teachers in the country.

General Finding 8.3

In actual science, science teaching and teachers are not recognised and valued. Teachers' salaries and allowances are inadequate and not comparable to other professional groups. Teachers' salary and allowances are not paid regularly, and teachers are not supported to improve their teaching pedagogy and skills. Under ideal circumstances, science teaching and teachers would be recognized, valued and remunerated with good salaries and allowances, teachers' salary and allowances would be paid regularly, teachers would be supported to improve their teaching skills through ongoing professional learning opportunities and there would be professional standards to regulate the profession.

Theme 4: Beliefs about the purpose for secondary science education

Quality teaching and learning of science depends on the beliefs teachers' hold about the purpose of education in general and science education in particular. The teacher questionnaire data reveal that in actual science, teachers profess to teach science to develop learners' understanding of science principles and facts, to develop learners' skills and processes of science investigation, to develop learners' interest in science and foster a spirit of creativity and scientific inquiry; and also to prepare learners for senior secondary education and careers in science (Table 4.8). Only a few teachers believed they taught science to help students apply science to understand their environment and their health (Finding 4.4).

Student questionnaire data show that most students learn science to be curious, creative and inquisitive, to build up their careers and also to apply science to understand their local environment and their health (Table 5.6 & Finding 5.7).

This study reveals that in actual science, teachers espoused the beliefs that students are taught science so that they would develop an understanding of science principles and facts, develop skills and processes of science investigation, develop interest in science and foster a spirit of creativity and scientific inquiry. However, teachers' entrenched beliefs revealed their classroom practice indicate they are about preparing learners for senior secondary education and careers in science. The views espoused by teachers thus agree with Bajah (1998) and Cobern (1994) who argue that science education helps to develop creativity in learners so that learners actively contribution towards their own culture.

However, these findings contradict the results reported by Bybee (1997), Craven and Penick, (2001), Goodrum, et al. (2001), Hurd (1993), Millar and Osborne (1998), Resnick (1992) and by the international science education literature (National Research Council, 1996; OECD, 1999) that argues that scientific literacy is the primary purpose for teaching science so that learners develop higher order cognitive thinking skills to understand scientific concepts and processes, to make informed decisions, to participate in societal and cultural affairs and governance, to provide a variety of solutions to any particular problem and contribute to the national and economic productivity and ultimately to become scientifically literate.

The OECD Programme for International Student Assessment OECD/PISA (OECD, 1999) describes scientific literacy as “the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity” (p. 60).

The National Science Education Standards (National Research Council) (NRC, 1996) in the United States of America refer to scientific literacy as “the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” (p. 22). The National Science Education Standards explain further:

> Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that he/she has the ability to describe, explain and make predictions about natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversations about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlining national and local decisions and express positions that are scientifically and technologically informed (NRC, 1996, p. 30).

In Canada, Ryder (2001) however defines scientific literacy as “an evolving combination of science-related attitudes, skill and knowledge students need to develop inquiry, problem solving and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them” (p. 5).

In Australia, Hackling, Goodrum and Rennie (2001) argue that scientific literacy encompasses more than just an understanding of the scientific processes and content, and therefore define scientific literacy as “a high priority for all citizens, helping them:

- to be interested in, and understand the world around them,
- to engage in the discourses of and about science,
- to be skeptical and questioning of claims made by others about scientific matters,
- to be able to identify questions, investigate and draw evidence-based conclusions, and
- to make informed decisions about the environment and their own health and well-being “ (p. 7).

In Nigeria however, the National Policy on Education (FGN, 1998) document presents the objectives of secondary education in relation to science education as “to raise a generation of people who can think for themselves, respect the dignity of labour and appreciate those values specified under our broad aims and live as good citizens” (p. 23), so that learners would apply the knowledge of science to live effectively in the modern age of science and technology.

The Nigerian National Policy on Education (FGN, 1998) has a broad and general aim of general education including science education for national development and better citizenry; however it fails to indicate ‘scientific literacy’ as the general purpose for junior secondary science education so as to aim at developing scientifically literate citizens. This in essence has a consequent effect on the quality of science education in Nigeria that is tailored towards developing learners’ understanding of scientific facts and principles, and also for the preparation for senior secondary education and for careers in science. Consequently, science teachers views about the purpose for secondary science teaching and learning are traditional and narrow, and in every perspective, are at variance with ‘scientific literacy’ which is widely acknowledged purpose for science education in the compulsory years of schooling.

Literacy in science in the context of a developing country like Nigeria therefore currently involves students developing an understanding of science principles and facts so that they pass examination for preparation for senior secondary education and for careers in science related jobs. This is in contrast to that of developed countries like Canada, United Kingdom, Australia and the United States of America that believe that literacy in science would enable the students to understand the world around them, make predictions about natural phenomena, engage in social conversations, make informed decisions about their health and well being and be able to identify and draw evidence-based conclusions (Goodrum et al., 2001; Millar & Osborne, 1998; NRC, 1996; OECD, 1999; Ryder, 2001). This is also an appropriate purpose for science education in Nigeria.

General Finding 8.4

In actual science, most teachers have narrow and traditional views about the purpose for science education and believe that science is taught to prepare students for senior secondary education and careers in science. Literature in science education argues that scientific literacy should be the aim and the general purpose for science education so that learners would understand the world around them and their health, and be able to engage in and contribute to everyday discussions and decision-making in relation to science-related social issues.

Theme 5: Teaching-learning and assessment practices in science

Teaching–learning activities in Science

Quality teaching of science requires regular inquiry-oriented hands-on practical and activity work for all students so that they can develop inquiry skills and an appreciation of the nature of science. Teacher questionnaire data reveal that in actual science more than two-thirds of the 80-minute science lesson is devoted to teacher-centered activities such as explanation, demonstration, whole-class discussion and giving notes. Only about one-third of the lesson time is devoted to student-centered activities including individual work and small-group practical work (Table 4.10 & Finding 4.7). Teacher questionnaire data further indicate that in actual science, students rarely plan their own experiments, learners do not engage in hands-on practical work every week to provide concrete experiences of the concepts being taught and to investigate their own questions, and also that discussion between students is discouraged by teachers so that teachers can cover more content. Consequently, there is not enough time after experiments for teachers to discuss the main findings with students so that students reach the correct conclusions (Tables 4.11; 4.12 & Finding 4.11).

The student questionnaire data corroborate teacher questionnaire data and indicate that in actual science, students frequently listen to teacher explanations and demonstrations, watch the teacher do an experiment, copy notes given by the teacher and follow teachers' instructions in practical work. Twenty-five per cent of the lesson time is actually used for whole class teacher-led exposition and discussion and less than one-third of the lesson time is used for individual work and small-group work where students have opportunities to ask questions and express their own ideas (Tables 5.2.1; 5.3 & 5.4).

Teacher focus group data further support the view that actual science teaching is didactic and theoretical and that students are taught factual and not the conceptual knowledge of science. They also indicate that students could not identify common reagents and equipments found in the science laboratories because they rarely engage in hands-on practical and activity work. Students also lack enough mathematical background and effective communication skills to understand the language of instruction to do well in science (Finding 6.2.2). There is also a conflict between the language of instruction in science and the first language spoken most of the time at home by the learners which limits their learning (Finding 6.3.2).

Under ideal circumstances, 35.9% of the teachers suggest that students would do hands-on group practical work every week all or most of the time and a greater percentage, 41%, indicate not often or never (Table 4.11). Also a greater percentage, 64% suggest that practical work is used to illustrate the concepts that have been introduced all or most of the time and 14.7% believe that practical work should be carried out by students before the theory is introduced to them whereas a significant percentage, 58.6% indicated not often or never so that teacher would be able to identify learners' existing knowledge to guide lesson development (Table 4.11, Finding 4.10). The beliefs espoused by teachers that students would do group practical activity work to illustrate the concepts that have been introduced is not consistent with an inquiry-oriented and constructivist approach in which students engage in practical investigations to provide experiences from which understanding of concepts are developed. Consequently under ideal circumstances, teacher would encourage learners to ask questions and express their own ideas in science so that learners would be able to communicate their findings on the things that relate to their lives (Tables 4.9; 4.11; 4.12 & 5.3).

Under ideal circumstances, students also argue that science teaching would be student-centered and activity-oriented, and also that learners would actively engaged in the learning process, such as; being attentive, reading notes, doing home work, carrying out their own observation, asking and responding to questions, engage in career talks about science, being involved in tutorials and extra lessons, being involved in group work including assignments, practical and projects, and watch science documentaries; so that learners would develop the inquiry skills needed to discover things for themselves and to keep abreast of new developments in science (Table 5.5.1 & Finding 5.5).

Teacher focus groups provided further support for the view that ideal science should be student-centered and activity-based so that learner would engage in scientific inquiry and manipulate their physical learning environment and also that there should be more time allocated to science so that teachers do more practical experiments and take learners on excursion to scientific industries, and to improve their communication skills in science (Findings 6.1.2 & 6.4.2).

These findings show that in actual science, learners rarely engage in hands-on practical work every week, students are not allowed to plan their own experiments, discussion between learners is discouraged so that teachers can cover more content, learners follow teachers' instructions in science, teaching and learning is didactic and theoretical and teacher-directed activity predominates. These findings are in stark contrast with papers by Hackling (1998), Hackling and Fairbrother (1996), Germann, Haskins, & Ausl (1996) and Bell, Blair, Crawford, and Lederman (2003) that argue that students should formulate their own problem to investigate the world around them by actively engaging in scientific inquiry to develop their broad knowledge and understandings of the processes and nature of science through open inquiry. Jenkins (1992) and Hodson (1996) however are not convinced that laboratory practical work accomplishes what it sets out to do in terms of science learning. This is further corroborated by Abell and Smith (1994) that argue that teachers' views are limited about scientific work with regards to the roles of theories and evidence, and of social discourse as a way of negotiating meaning. In Nigeria contexts therefore, it may be necessary to consider alternative ways of entering a science inquiry discourse. This could be achieved as mentioned by Smith and Anderson (1999) when they assert "Scientist share a belief that the sense-making process is not complete until a precise, detailed coordination among data, theories, and authoritative sources has been achieved" (p. 757).

Under ideal circumstances learners should be encouraged to plan their own experiments and to be involved in inquiry learning to investigate phenomena and develop science concepts. Von Glaserfeld (1984) argues that learners do not simply learn what they are told but construct knowledge and understandings and find regularity about the world events and information. The findings are consistent with Hodson's (1991) views that effective learning of science could only be achieved by doing science through developing, constructing and accommodating meaning in a context that builds on learners prior knowledge and experiences (Gardner, 1993; Queensland School Curriculum Council, 1999) so that learners actively engage in the social construction of knowledge (Taylor, Dawson, & Fraser, 1995).

The results of this study indicate that teachers in Nigeria have only 160 minutes per week for teaching science in the school timetable and 68% of the time is devoted to teacher-centered activities and 32% to student-centered activities. The amount of time allocated to science in school not sufficient for teachers to engage learners in fruitful scientific inquiry in a constructivist manner (Von Glaserfeld, 1984). Teacher-student interaction was limited and students copied notes and listen to teacher explanation and demonstration most of the time. Students have limited opportunities for independent practical and activity work and often time discussion between students is discouraged so that teachers can cover more content and thus teacher-directed activities predominate.

Quality science teaching and learning requires more time for practical and activity work and for teachers to monitor students' learning outcomes. For instance, in Western Australia, 240 minutes of school time is allocated for science per week and 90% of lessons include some forms of practical activity and independent practical activities occurred in more than half of the lessons so that learners investigate problems that will be discussed in other lessons (Lokan, Greenwood & Hackling, in press).

General Finding 8.5

In actual science, teaching and learning activities are teacher-centered and teacher-directed so that learners follow teachers' instructions in science and do not engage in independent and self-directed practical and activity work. Under ideal science, teaching and learning would be student-centered and would involve regular interaction and discussions in small groups and whole class settings, and weekly hands-on activity work for all students.

Assessment Practices in Science

Quality teaching is enhanced with regular monitoring of students' learning outcomes (Hattie, 2003). Teacher questionnaire data indicate that in actual science, students are assessed for understanding of science content, and science skills and processes. Only a few teachers assessed students for science attitudes (Table 4.13). Written tests and quizzes are the most commonly employed assessment strategies used by science teachers followed by assignments and projects. Practical work and practical tests are the least commonly used assessment strategies (Table 4.14 & Finding 4.13). Assessment is mainly used for the summative purposes of grading and reporting, and for giving feedback to students on their learning. Only a few science teachers assessed students for the purpose of identifying students' misunderstanding in science (Table 4.15). These findings support a previous study in Nigeria by Ogunjobi (2000) that sees the purpose of assessment for grading and reporting students' performances to their parents.

Analysis of the Nigerian National Policy on Education (FGN, 1998) and Core Curriculum for Junior Secondary Science (FME, 1985) reveals that continuous assessment is used by teachers for measuring students' learning outcomes in preference to basing assessment entirely on the assessment of students' work on one final examination. No mention is made in these documents of diagnostic and formative purposes for continuous assessment. Basically, continuous assessment is used for summative purposes of grading and reporting performance to parents and or guardians and also for giving summative feedback to students (Table 4.15).

Under ideal circumstances, the literature in science education argues that assessment serves various purposes that include to monitor national standards; to compare standards of achievement with those of other countries; to provide information with which teachers, educational administrators and politicians can be held accountable to the wider public; to sort and classify students for education and training and for career placement by employers; to determine the route a student takes through the differentiated curricula that are on offer in school; to report on a student's educational achievement either to the student themselves, or to their parents or guardians; to support learning by identifying obstacles to future learning; and to provide appropriate feedback to learners on what they need to do to improve (Black, 1993; Boston, 2002; Goodrum, et al. 2001; Goldstein, 1996; Helgeson, 1992; Kellough & Kellough, 1999; Wiliam, 2000). Assessment information therefore is used to serve four main purposes, i.e., diagnostic, formative, summative and evaluative (Wiliam, 2000; Wiliam & Black, 1996).

Thus, quality assessment involves monitoring learners' learning outcomes for the purpose of identifying learners' weaknesses and strengths, for giving feedback to learners on their learning progress, for placement into next class and selection for employment, for accountability and certification, for informing parents or guardian about learners' performance, and for teachers to reflect on their teaching practice.

General Finding 8.6

Most science teachers commonly used written tests and quizzes to assess students for understanding of science contents and skills and processes for the summative purpose of grading and reporting students' progress in learning. Literature in science education however indicate that ideal assessment practices in science would serve the purposes of identifying students' learning strengths and weaknesses, identifying alternative concepts, monitoring students' developing understandings, providing feedback to challenge and deepen students' thinking, and to gather evidence needed to determine the extent to which learning outcomes that contribute to scientific literacy have been achieved.

Theme 6: Teacher Education and Professional Learning

Quality teaching of science requires qualified, competent and dedicated teachers with adequate subject matter knowledge and effective teaching skills. In actual science, teacher questionnaire data reveal that the majority of the science teachers (>80%) are females aged between 21 to 50 years (Tables 4.1, 4.2 & Assertion 4.1). More than three-quarters of the teachers majored in science and have had between three to four years of pre-service teacher training in science and education (Tables 4.3 & 4.6). Also, nearly two-thirds of the teachers are experienced and have taught science for between six to 20 years, however; nearly 90% of the teachers had no higher degree in either education or science (Table 4.4 & Finding 4.2).

Teacher focus group data indicated that schools do not have enough qualified, knowledgeable, skilled and dedicated science teachers and also that teachers rarely have opportunities for professional development and collaboration with colleagues so that teachers can improve their teaching skills. Consequently, teachers do not show enough enthusiasm to develop learners' interest in science (Finding 6.2.3). It should be noted, however, that nearly all the sampled teachers had a minimum of three years of initial teacher education.

Under ideal circumstances, teachers suggest that they would have a sound content knowledge and appropriate inquiry teaching approaches to cater for students of different learning abilities (Tables 4.9 & 4.12). The student questionnaire data further indicate that under ideal circumstances teachers would be qualified, competent and interested and would use good teaching approaches from simple to complex, demonstrate and discuss new ideas, and also be friendly and respond to students' problems (Finding 5.5).

Teacher focus group data further corroborate teacher and students survey data and mention that teachers would be well-qualified, dedicated, resourceful and knowledgeable in their area of specialization and also would regularly engage in continuous professional development to improve their teaching practice and would be able to relate classroom activities to the learners' local environment (Finding 6.1.3).

This study shows that science teachers currently lack appropriate subject matter knowledge and pedagogical skills to teach by inquiry and they have limited understanding of the learners (Finding 6.2.2). Large class sizes also make it difficult for teachers to get to know individual students as learners. Also, teachers do not have enough opportunity to engage in continuous professional learning and to collaborate with colleagues and other professionals on policy, curriculum and teaching practices. These findings are in contrast with professional standards documents prepared by the Australian Science Teachers Association and Monash University (ASTA & Monash University, 2002) and by the National Board for Professional Teaching Standards in the United States (NBPTS, 1999) which argue that accomplished science teachers have both content and pedagogy knowledge, use a variety of teaching strategies in their classroom, create an enriched learning environment, engage in continuous professional learning, encourage their students in lifelong learning, and also work collaboratively with other professionals on instructional policy, curriculum and staff development.

Under ideal circumstances, the study findings reveal that teachers would be well-qualified, competent, interested, dedicated and resourceful; would have a sound content knowledge; appropriate inquiry teaching approaches; and also regularly engage in continuous professional learning to improve their science teaching practices. These findings further support the Association of California School Administrator (ACSA, 2000) that argues that accomplished science teachers are constructors, facilitators, collaborators, mediators between learners and what they need to know, providers of scaffolding for understanding, creators of learning environments, and have a rich understanding of the subject(s) they teach and appreciate how knowledge in their subject relates to other disciplines in helping learners to acquire the knowledge.

This study reveals that the academic entry qualifications for science teachers in Nigeria are either a three-year National Certificate in Education (NCE) or a four-year university degree which comprises of 12-week supervised practical teaching for NCE holders and 18-week supervised practical teaching for the degree holders. Research indicates that quality science teachers have sufficient supervised practical teaching experience and mentoring by experienced teachers to improve their teaching practice (Stoel & Thant, 2002). For example, in Germany, teachers undergo a two-year supervised practical teaching in a local school and a new teacher undergoes 18-24 month induction practice that includes seminars. In Japan however, the limited time teachers spent (3-4 weeks) on practical teaching are compensated with by a one-year compulsory induction programme for all new teachers to improve their teaching practice (Stoel & Thant, 2002).

Quality teaching of science requires recruiting competent, dedicated and knowledgeable and interested teachers. In Nigeria, the recruitment of teachers is based on the initial qualifications of applicants (Noah, 2005) and this is followed by oral interviews conducted by the officials of the Ministry of Education and its parastatals. Surprisingly, those who have non-teaching qualifications are sometimes recruited to teach in schools (Ogunmade, 2000) and new teachers are not provided with an adequate induction programme for them to understand the school environment including colleagues, students, the school community and the school administration. Essentially, there is no regulation of admission into the teaching profession, and this has an adverse consequence on the quality of science education in Nigeria.

Currently, the Teacher Registration Council (TRC) is making frantic efforts to address the situation through the registration of only qualified teachers in the country so that those teachers without teaching qualifications undergo training in a Post Graduate Diploma in Education (PGDE). Also, the recruitments of new teachers will be based on holders of a teachers' registration certificate so that the status of teaching profession and the quality of science education are improved. In developed countries of Australia and Japan only qualified and registered teachers are recruited to teach in schools and there are fines attached to any organisations that employ non-qualified or unregistered teachers to teach in their schools (Stoel & Thant, 2002; Western Australia College of Teaching, 2004).

This research also indicates that in Nigeria teachers lack ongoing professional learning opportunities to improve their teaching practice. However, in developed countries teachers regularly engage in compulsory ongoing professional development. For instance, in Hong Kong SAR, teachers attend compulsory in-service programmes including attendance at seminars and presentations and other courses organised by the Education Department and these are used for their promotion whereas in Japan, the law made it mandatory to provide in-service training for school teachers and professional development activities occur throughout the year and during and after school hours, and also scholarships are awarded for teachers to work toward a master degree so as to improve their teaching practice.

General Finding 8.7

In actual science, teachers are qualified and experienced with three to four years of teacher training and six to 20 years of teaching. However, teachers do not have appropriate knowledge and skills for teaching by inquiry and lack opportunity for induction into the profession and for ongoing professional learning and collaboration with colleagues and other professionals on curriculum policy and teaching practice. Under ideal circumstances, teachers are qualified, competent, dedicated and resourceful, and have good mastery of the subject matter and knowledge and skills for inquiry teaching. Also, ideal science teachers are inducted into the profession, engaged in regular professional learning and collaborate with colleagues and other professionals, and the profession is regulated by a set of professional standards.

Summary

This Chapter has analysed and discussed the teacher and student surveys data, focus group and interviews data and also the data from the analysis of curriculum documents in terms of six themes: science curriculum, class sizes and resources in science teaching and learning, community support, beliefs of science teachers about the purpose for secondary science education, teaching-learning and assessment practices in science and teacher education and professional development. Each theme has considered the actual and ideal pictures of science education in three Local Education Districts of Lagos State. Triangulation of data sources has corroborated the main findings. Finally, the summary of general Findings in this study is presented in Table 8.1.

Table 8.1: Comparisons between the actual science teaching and learning and ideal science practices.

Themes	Ideal	Actual
Science curriculum	The science curriculum focuses on in-depth learning of less subject matter content	The science curriculum is overloaded with subject matter content resulting in superficial learning
	The science curriculum is inquiry-oriented and student-centered	The science curriculum is didactic and teacher-centered
	The science curriculum is outcomes-focused and develops scientific literacy	The science curriculum is content knowledge-focused for preparation for further education and careers
	The science curriculum focuses on conceptual understanding and inquiry skills	The science curriculum focuses on transmission and memorisation of factual science concepts
Class sizes and resources	Science is adequate funded	There is not enough funding for science
	There are manageable class sizes	Class sizes are very large
	There is sufficient equipment and consumables	There is insufficient equipment and consumables
	All schools have laboratory assistants	Some schools do not have laboratory assistants for science
	There are enough classrooms and seats for all students	There are insufficient classrooms and not enough seats for all students
	There are adequate and modern science curriculum resources including textbooks that are not obsolete	The science curriculum resources are not adequate and they are obsolete
	Laboratories and equipment are regularly maintained	Laboratories and equipment are not adequately maintained
Community support	Teachers and science teaching are recognized and valued by the community	Teachers and science teaching are not recognised and valued by the community

Themes	Ideal	Actual
	Teachers are paid adequate salaries and allowances like their counterparts in other professions and they are provided with incentives such as car and housing loans	Teachers are paid inadequate salaries and allowances lower than those of other professionals and they are not motivated with incentives
	There is regular payment of teachers' salaries and allowances	Teachers are not regularly paid their salaries and allowances
Purpose for secondary science education	To develop scientific literacy in learners so that they understand their local environment and their health and well being	To develop learners' understanding of science principles and facts for the purpose of examination
	To engaging learners to contribute to everyday issues and discussion about science and develop the skills and knowledge for inquiry, problem solving and decision-making abilities	To prepare learners for senior secondary education and careers in science
Teaching-learning and assessment practices in science	Student-centered and inquiry-based	Talk and chalk
	Less note copying	Lots of note copying
	Regular learner interactions such as whole- group discussion and questioning and small group discussions	Teacher-centered and teacher-dominated
	Weekly inquiry-based practical work for students	Lack of independent student practical and activity work
	Assessment based on understanding of concepts/and processes	Assessment based on recall of science content
	Diagnostic and formative assessment in addition to summative assessment	Summative assessment purpose
	Assessment practices involves more of projects, assignments, practical work and practical tests	Assessment methods are written tests and quizzes

Themes	Ideal	Actual
Teacher education and professional development	Teachers are qualified, dedicated, competent and interested	Majority of teachers are qualified, however, most teachers do not show enough interest in teaching
	There are defined professional standards regulating teachers' activities	There are no defined professional standards regulating teachers' activities
	Teachers are aware of the professional standards in their disciplines	Teachers lack knowledge of professional standards in their disciplines
	All qualified teachers are certified and registered to teach	All qualified teachers are not certified and registered to teach
	Only qualified, certified and registered teachers are employed in teaching	Unqualified and non certified teachers are employed in teaching
	All beginning teachers receive a year or more of induction with less teaching load	Beginning teachers receive no year-long induction and they are overloaded with school work
	Teachers have adequate knowledge of subject matter content	Teachers have sufficient subject content knowledge
	Teachers have adequate knowledge and skills for teaching by inquiry and for identifying individual learners' difficulties	Most teachers' lack the skills for teaching by inquiry and for identifying individual learners difficulties
	All teachers are registered members of professional associations and participate in the association's activities	All teachers are not registered members of professional associations and majority of teachers do not participate in the association's activities
	Teachers have sufficient opportunities for ongoing professional learning and for collaboration with colleagues and experts on curriculum policy and practice	Most teachers have no opportunities for ongoing professional learning and for collaboration with colleagues and experts on curriculum policy and practice

This table compares actual science teaching and learning with an ideal. It is worth indicating that while this study was conducted in a developing country, some of its findings are in agreement with published findings from the Australia study by Goodrum, Hackling and Rennie (2001) on “The Status and Quality of Teaching and Learning of Science in Australian Schools” and those from other developed countries on curriculum, teaching, pedagogy and learning, and also on community support. However, there are contrasting findings in relation to class sizes, resource allocation, maintenance of laboratory facilities and equipment, funding of science education and professional development for science teachers.

This study reveals thus that the poor funding of science education in a developing country like Nigeria has culminated into poor resources in schools including laboratories, classrooms, facilities and equipment and compounded with large class sizes. Importantly, curriculum resources in schools are not sufficient to meet the demands of a large number of the students doing science. To achieve scientific literacy for all Nigerian citizens therefore, government has to intensify its efforts to adequately fund the teaching and learning of science in schools. The earlier we strive to improve the quality of science education in Nigeria the sooner citizens will become scientifically literate and can contribute to effective social, technological and economic development of nation.

The conceptual framework for this study, first presented in Figure 2.1, has been elaborated as Figures 8.1 and 8.2 to illustrate the main findings of the study and these reveal the picture of actual science teaching and learning and picture of ideal science for which the nation can strive toward for developing scientific literacy for its citizens. Essentially, the figures relate the impact of teachers’ knowledge, beliefs and professional learning, nature of curriculum and community support teaching practice in science and the factors limiting opportunities for quality teaching and learning for developing scientific literacy.

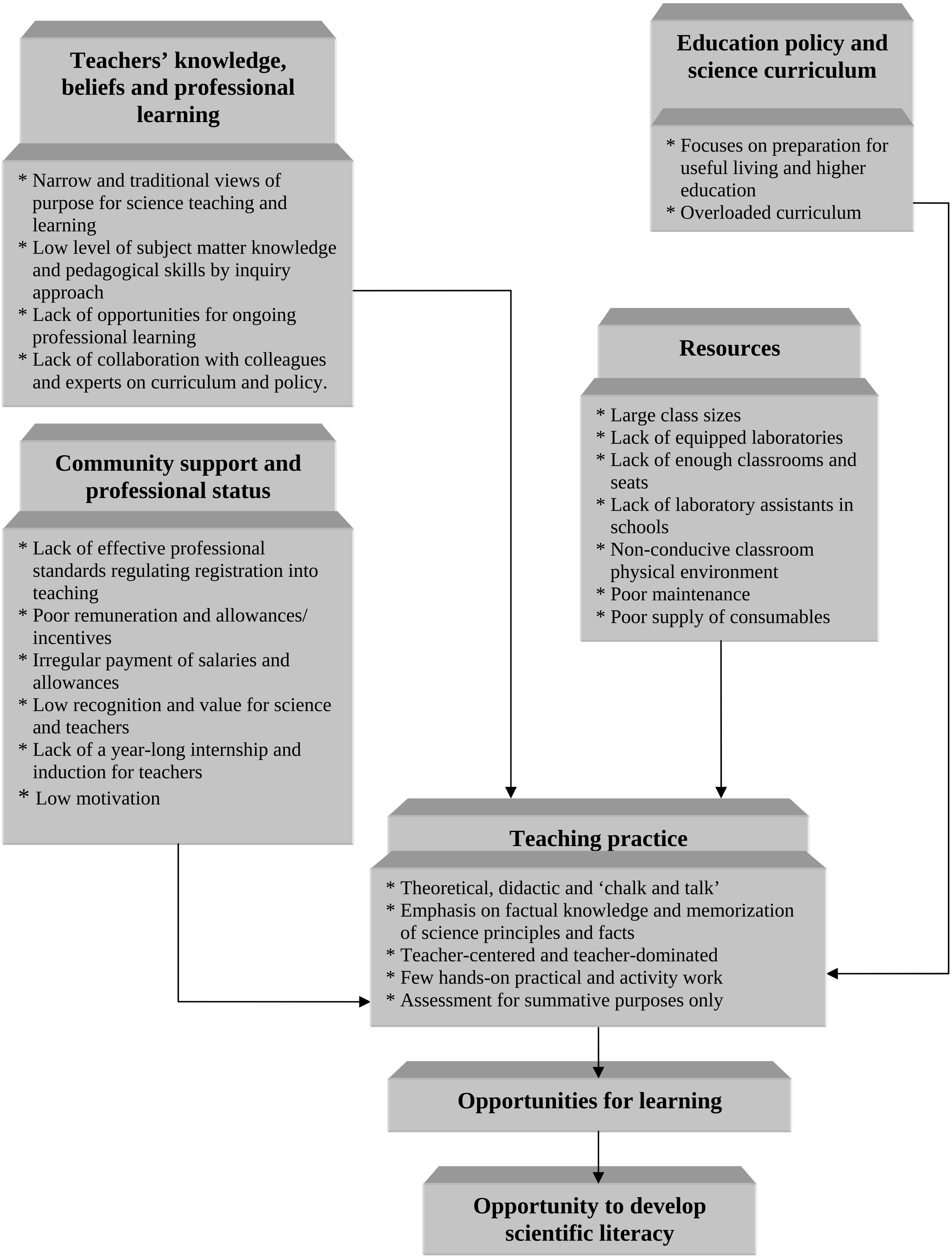

Figure 8.1: Picture of actual science teaching and learning

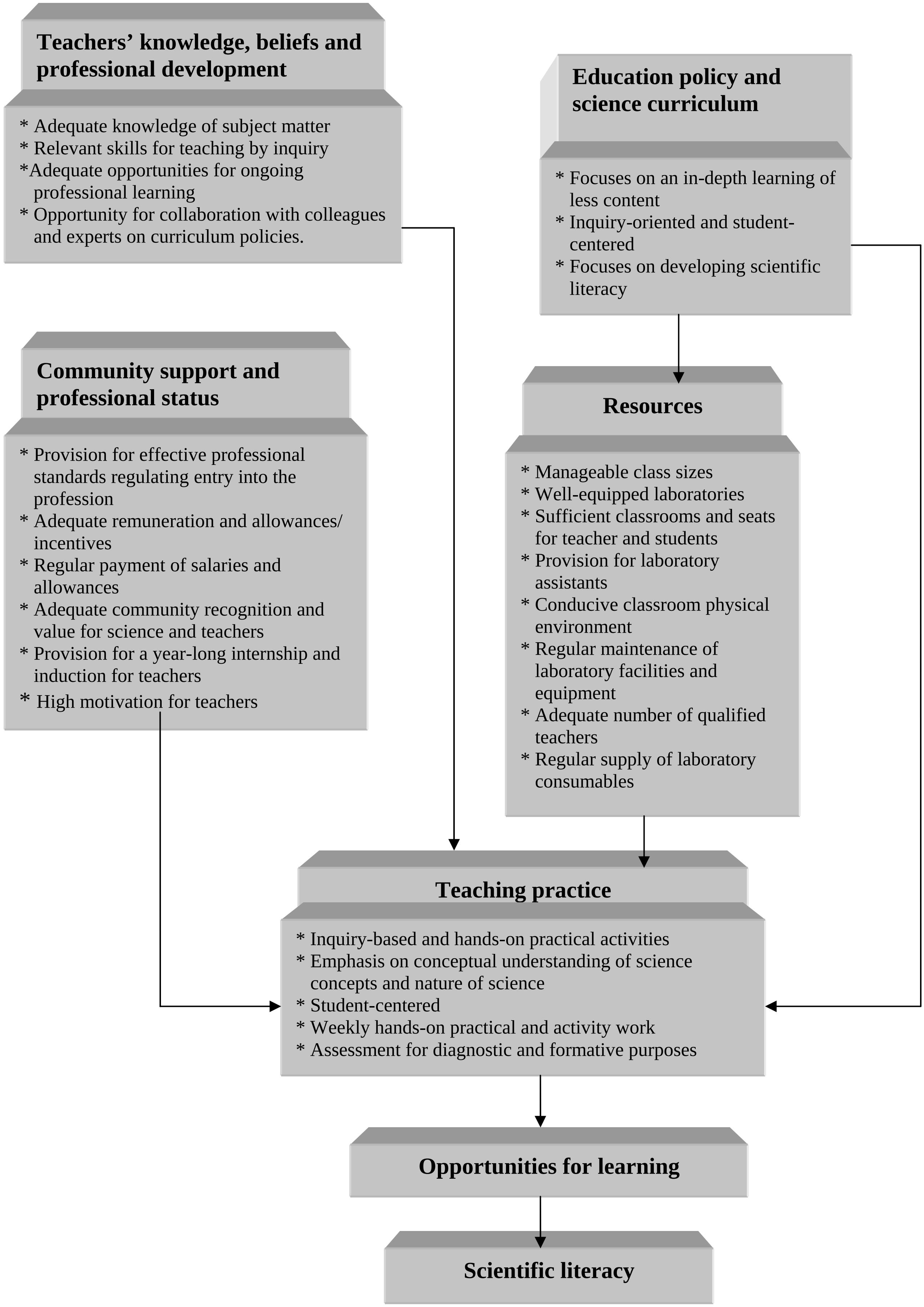

Figure 8.2: Picture of ideal science teaching and learning

CHAPTER 9

LIMITATIONS, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The purpose of this study was to investigate and describe the status and quality of science teaching and learning in junior secondary schools in Lagos State, Nigeria. The study includes surveys of 78 Integrated Science teachers and 500 students, focus group meetings with science teachers, school principals and other key stakeholders, interviews of curriculum officers and scientists working for the government and those working in industry, and analysis of policy and curriculum documents. The study was conducted in three Local Education Districts with a view to reveal pictures of actual science teaching and learning and that of a realistic ideal picture for Lagos State, Nigeria.

This Chapter describes the limitations, conclusions and recommendations of this study. The Chapter is divided into four sections. The first section discusses the limitations of the study. The second section describes the conclusions which are based on the various findings of the study and are reported as responses to the research questions for the study. Recommendations for closing the gap between actual science teaching and learning and ideal science are presented in section three. Finally, section four discusses the contributions of the study to knowledge and research in science education.

Limitations

A major limitation of this study was that data were gathered from science teachers and the key stakeholders from the three Local Education Districts who were purposefully selected from the pool of science teachers and key stakeholders in the whole of Lagos State. The perspectives that were presented by these teachers and stakeholders may or may not be similar to those that would be presented by other science teachers and stakeholders from other Local Education Districts. Therefore, the purposeful sampling technique employed limits the generalisability of the findings in this study to the three Local Education Districts. Also, a limitation of the study was the lack of classroom observations that may have provided further insights into current classroom practice. Furthermore another limitation of this study is the similarity in responses given by the teachers about actual and ideal science teaching and learning based on individual perceptions, and this may not honestly reveal the true picture of the situation at stake.

Conclusions

The picture of actual science teaching was based on reports provided by teachers, students and other key stakeholders. Triangulation of data from various sources corroborated the findings; however, a limitation of the study was the lack of classroom observations that may have provided further insights into current classroom practice. The evidence gathered in this study has been used to create a picture of the actual status of science teaching and learning. Similarly, a realistic ideal picture has been developed. Constraints that limit the actual quality of science education have also been identified. Recommendations are made to bring about change in science education in Lagos State, Nigeria so that constraints are reduced to move the actual picture closer to the ideal picture.

Research Question 1

What is a realistic ideal picture of teaching and learning of science in Nigerian secondary schools as perceived by teachers and other stakeholders?

Teachers and other key stakeholders in science education in Lagos State, Nigeria proposed a number of characteristics of a realistic ideal picture for science education. The characteristics include that ideal science curriculum would be relevant to the need of students and their environment, would enable learners to be engaged in learning (e.g. being attentive, reading notes, doing home work, carrying out own observation, asking and responding to questions), would have less content for an in-depth learning, would be allocated more time in the school timetable and would involve regular interaction between teacher and learners so that learners could work independently of the teacher including working individually from the text and doing inquiry-based and activity-oriented practical work in small groups for a better understanding of the nature of science (Tables 4.9, 5.5.1, Findings 4.5,5.5, 6.1.2, 8.1).

Ideal science teachers would have good mastery of subject matter content and relevant teaching skills and approaches; would be resourceful to relate classroom activities to the learners' real life or local physical environment. Also, teachers would be knowledgeable to assess and monitor students' learning outcomes that contribute to scientific literacy and also to monitor students' progress and give appropriate feedback so that students' learning is improved (Tables 4.9, 5.5.1, Findings 4.6, 6.1.3, 8.6 & 8.7).

In addition, ideal science teaching would be adequately funded by government to build more classrooms and more laboratories with modern facilities and equipment, and there would be a regular supply of consumables. Also, the class sizes would be manageable with sufficient curriculum resources including computer access, modern textbooks and equipment, a conducive school environment (e.g. not noisy, well ventilated, good lightening, and not polluted) and with laboratory assistants so that teachers would do more weekly inquiry-based practical and activity work for the students (Tables 4.9, 5.5.1, Findings 4.5, 4.12, 6.1.1, & 8.2).

Furthermore, under ideal circumstances, science teaching and teachers would be recognised and valued by parents and the larger community and teachers would feel supported by colleagues, school principals, school administration and parents. More so, teachers would be paid adequate salaries and allowances and incentives such as housing allowances and car loans like those of other professionals with similar qualifications so that they are motivated to work to improve the quality of teaching and learning in science (Table 4.9, Findings 4.6, 6.1.4 & 8.3).

Finally, in ideal science, there are good teachers (e.g. qualified, competent, dedicated, interested and resourceful), teachers would have a sound knowledge of the subject matter and use good teaching approaches. Also teachers would have sufficient opportunities for ongoing professional learning and collaboration with colleagues to improve their teaching practice (Table 4.9, Findings 4.6, 5.5, 6.1 & 8.3).

Research Question 2

What do science teachers, students and other stakeholders perceive as the nature of teaching and learning of science in Nigerian secondary schools at present?

The picture of actual science teaching and learning in Lagos State as revealed by teachers and other key stakeholders include that in actual science, the curriculum is overloaded with content for the purpose of preparing students for senior secondary education and for careers in science and focuses on the transmission of content to be memorised for examination purposes. Therefore discussion between students is discouraged so that teachers can cover more content (Table 4.8, Findings 6.2.2, 7.1 & 8.4).

In actual science lessons, only 26% of teachers include hands-on practical and activity work every week in their science lesson because teachers lack appropriate skills and approaches for inquiry-based teaching; and consequently science teaching and learning is didactic and theoretical so that learners only develop factual knowledge of science principles and facts. More than three-quarters of 80-minute lessons are used by teachers for explanation and demonstration, whole class discussion and note copying by students whereas only about one-third of the lesson time is used for student-centered activity including students working individually (e.g. working from text) and students doing practical and activity works in small groups and so teacher-centred and teacher directed activities predominate (Tables 4.10, 4.11, 5.2.1, Findings 4.7, 5.2, 5.3, 6.2.2& 8.5).

In addition, written tests and quizzes are the most commonly used assessment practices and the assessment focuses on understanding of science content, and science processes with little emphasis on students' attitude to science and assessment is mainly used for summative purposes of grading and reporting and giving students' feedback on their learning (Tables 4.13, 4.14, 4.15, Findings 4.13 & 8.6).

In actual science the class sizes are very large and there are not enough qualified teachers, not adequate classrooms and laboratories, and not sufficient facilities and equipment including modern textbooks. Also, there are no laboratory assistants in most schools so that there are poor maintenance of laboratory facilities and equipment (Table 4.7, Findings 4.3, 7.3).

Furthermore in actual science, science teaching and teachers are not recognised and valued by the community, teachers lack effective support from school administrators, parents and community; and also teachers are not motivated with adequate salaries and allowances and teachers' salaries and allowances are not being paid regularly and so teachers' morale is low (Tables 4.12, 4.19, Finding 6.2.4).

Finally, in actual science, teachers are qualified with three to four years of training in science and education and teachers majored in integrated science, chemical sciences and biological sciences and they had between six to 20 years teaching experience. Only a few teachers had master degrees in education or science. However, teacher lack opportunities for professional learning and collaboration with colleagues and experts on curriculum materials and policy, and to improve their practice. (Tables 4.2, 4.3, 4.4, 4.5, 4.6 Findings 4.2, 6.2.3).

Research Question 3

What factors do teachers and other stakeholders perceive as militating against quality of teaching and learning of science in Nigerian Secondary schools?

Important factors that teachers and other key stakeholders mentioned that limit the quality of science teaching and learning include overloaded curriculum content and inadequate time for teaching science; poor teaching skills and lack of effective approaches for inquiry-based teaching; learners' poor communication skills, poor background knowledge in mathematics and students' poor attitude to science. The impact of socio-cultural factors in science also limits the quality of teaching and learning in science (Table 4.19 Findings 4.16, 6.3.2 & 8.1).

Insufficient funding of science, lack of enough well-ventilated classrooms and laboratories, lack of enough teaching resources including modern textbooks further limit the quality of science teaching and learning. More so, lack of enough qualified, dedicated and knowledgeable teachers and laboratory assistants; insufficient laboratory facilities and equipment; poor maintenance of laboratory facilities and equipment; non conducive physical classroom environment; and large class sizes further limit the quality of teaching and learning of science (Findings 4.16 & 6.3.1).

Furthermore, low status of teaching profession in the community, inadequate teachers' salaries and allowances, irregular payment of teachers' salaries and allowances, lack of motivation and opportunities for ongoing professional learning for teachers, lack of collaboration of teachers with colleagues and experts on curriculum materials and policy, low morale and attitude to work and lack of teachers' commitment to the profession also limit the quality of science teaching and learning (Table 4.19, Findings 6.3.3, 6.3.4 & 8.7).

Research Question 4

How can these factors be addressed to improve the quality of teaching and learning of science in Nigerian secondary schools?

Various ways for improving the quality of teaching and learning of science in Lagos State were suggested by teachers, students and other stakeholders. These include that the science curriculum content should be reduced and the content that should be relevant to the needs and aspirations of the learners and their real life physical environment so that learners' develop scientific literacy. They also indicated that there should be more time allocated to science in the school timetable for teacher to do more hands-on inquiry-based practical and activity work for students.

Learners should be engaged in inquiry-based hands-on practical and activity work every week, lessons should relate science to students' real life, there should be regular interactions between teachers and learners, and also teachers should monitor the progress of learners through appropriate assessment and feedback on their learning (Table 4.20). The changes will only be possible with more science teaching time, reduced class sizes, and enhanced teacher knowledge and skills.

Also, teachers and students alike must develop the ability to engage in a discourse of science inquiry by using the language of the environment to improve learners' communication skills in science (Finding 6.3.2).

In addition, there should be adequate funding for science to build more classrooms with enough seats for students, more laboratories with facilities and equipment, more curriculum resources including modern textbooks and provision of laboratory consumables such as chemicals. Also there should be provision for laboratory assistants, good maintenance of laboratory facilities and equipment and well managed class sizes so that teachers would be able to provide more inquiry-based hands-on practical and activity work for students every week (Findings 6.4.1 & 6.4.2).

Furthermore, there should be improved teachers' welfare such as payment of adequate salaries and allowances, regular payment of teachers' salaries and allowances, more incentives and scholarships for teachers for further education, and improved recognition and value for science teaching and teachers by the larger community (Findings 6.4.4 & 8.3).

More so, there should be more qualified, competent, knowledgeable and dedicated science teachers, better or more regular assessment and monitoring for teachers and provision for an internship year for new teachers under a mentor teacher during their initial teacher education to ensure that teachers are competent and dedicated to science teaching and the teaching profession. Also, there is need for students to develop better attitudes in science (Findings 4.17, 5.5 & 6.4.3).

Finally, teachers should be adequately supported by the school administrators, colleagues, parents and the larger community and also teachers should have sufficient opportunities for ongoing professional learning activities and collaboration with colleagues and experts on curriculum materials and policy so that they improve their teaching practice (Table 4.20, Finding 6.4.4).

Recommendations

From the research findings of this study conducted in three Local Education Districts, it is vividly evident that the quality of teaching and learning of science in Lagos State is in a parlous state. Importantly, considerable gaps exist between actual science teaching and learning and a realistic ideal. Achieving scientific literacy for citizens therefore, requires closing the gap between actual science teaching and learning and the ideal by making realistic recommendations to address the limiting factors that constrain the quality of science education. The following recommendations provide direction for reform of science education for Lagos State, Nigeria.

Recommendation 1: The science curriculum should be restructured to meet the needs and aspirations of learners; future citizens and the nation.

Actions:

1. There should be a national curriculum conference to formulate a strategic policy on science education standards in Nigeria that would be geared toward developing scientifically literate citizens.
2. The National Policy on Education should be revised to specify that the purpose for science education in Nigeria is the development of scientific literacy for all of its citizens.
3. The science curriculum needs to be streamlined and reduced to incorporate only those aspects of instructional content knowledge that would enhance learners' conceptual understandings.
4. The amount of time allocated to science teaching and learning in the school timetable should be increased from the current 160 minutes per week to 240 minutes per week so that students can participate in inquiry-based practical and activity work.
5. Assessment practice needs to be reformed so that it is integrated with teaching and learning and is used for both formative and summative purposes.

Recommendation 2: Resource allocation for education and science education should be improved.

Actions:

1. Governments should allocate more funds to education in Nigeria. The current allocation of 0.7% of Gross National Product (Achi, 2004) should be increased to 26% as recommended by UNESCO (Patrick, 2005) to build more classrooms and laboratories and also to provide for the necessary infrastructure and facilities including consumables in science.

2. All schools should have enough classrooms and seats for the students and the class sizes should not exceed 30 to 35 students per class so that teachers would be able to recognise individual students as 'a learner', monitor their progress, and teach them in small groups for effective inquiry-oriented instruction in science.
3. All schools should have laboratories for science with adequate supplies of equipment and reagents for practical work in science. Also there should be laboratory assistants in all schools to help with the proper maintenance of laboratory facilities and equipment and also to assist in the preparation for practical experiments so that teachers include more inquiry-based practical work for students in science.
4. All schools should be equipped with information and communication technologies including computers and Internet access so that teachers and learners would be able to find information beyond the resources of the school. Importantly for now, due to limited funding and resources, all schools should at least be provided with computer access for school administration work, teacher record keeping, for teaching and learning, and research activities.

Recommendation 3: Initial teacher education and ongoing professional learning for teachers should be improved.

Actions:

1. Initial science teacher education programmes in all Nigerian tertiary institutions should be accredited to ensure that teacher educators are competent and knowledgeable and that all preservice teachers have sufficient teaching practice and graduates meet necessary standards for entry to the profession.
2. Graduating teachers should be equipped with the various strategies for conducting inquiry-based teaching and formative assessment practices during their initial teacher education training so as to improve teaching and learning in science.
3. There should be focus on opportunities for ongoing professional learning for all categories of teachers including science teachers.

Recommendation 4: There should be professional standards regulating the teaching profession in the country.

Actions:

1. The Teacher Registration Council (TRC) should make it mandatory that all categories of teachers in the country are registered for teaching.
2. TRC should ensure that all Government and Private schools employ only registered teachers.
3. There should be regular monitoring of all teachers in the school system to ensure accountability and quality.
4. All new teachers should undergo a compulsory year-long induction under the supervision of mentors or experienced teachers with a reduced teaching load, and teachers should be assessed for competency at the conclusion of the induction for confirmation of appointment.
5. TRC should be involved in the assessment of the final teaching practice in all the teacher training institutions.
6. It should be made mandatory for teachers to attend ongoing professional learning workshops at least once a year to maintain their teacher registration.

Recommendation 5: Science teachers should be motivated and supported by colleagues, school administration, parents and the larger community.

Actions:

1. All categories of teachers in Nigeria should be paid enhanced salaries and allowances including incentives that are commensurate with those of their colleagues in other professions.
2. Teachers' salaries and allowances must be paid regularly
3. About 20 scholarships should be awarded annually to teachers for further education to develop a cohort of leading teachers who can provide leadership in education.
4. All categories of teachers should have opportunities to collaborate with their colleagues and experts on curriculum materials and policies and for ongoing professional learning and to be supported by the school administration.

Contributions to Knowledge

Many previous studies in developing countries like Nigeria have investigated actual science teaching and learning, and constraints that are inhibiting effective science teaching and learning. This study has contributed new knowledge by engaging teachers and other key stakeholders in science education in describing the pictures of both actual science teaching and learning as well as that of a realistic ideal science. While the previous studies reveal that availability of resources and laboratories are pressing issues affecting teaching and learning of science, this present study shows also that teachers' beliefs, community support, initial teacher education and opportunities for professional learning are important for improving the quality of science teaching and learning and this is an important contribution to knowledge. By gaining the support of the key stakeholders in revealing these two pictures of actual and ideal science, the Researcher was able to make comparisons and to develop a set of realistic recommendations for closing the gap between actual and ideal science for Lagos State, Nigeria.

To the knowledge of this Researcher, no previous studies in Africa have developed pictures of both actual and a realistic ideal with a view to make comparisons and, to develop realistic recommendations for improving science teaching and learning. In particular, the success of this study is that it has demonstrated that the research design developed by Goodrum, Hackling and Rennie (2001) in Australia, can be effectively applied in a developing country like Nigeria to improve the quality of science education.

Importantly, this study has harnessed the support of key stakeholders within the three LEDs of Alimosho, Oshodi-Isolo and Ojo, and at the national level as participants in this research. An executive summary of this thesis will be prepared and distributed to these key stakeholders so that their ownership over the recommendations can be enhanced so that they can take actions to support their implementation.

Failure to act on these recommendations will limit the scientific literacy of Nigeria's citizens and this will impact on the development of our nation.

REFERENCES

Abd-El-Khalick, F., & BouJaoude, S. (1997). An exploratory study of the knowledge base for science teaching. *Journal of Research in Science Teaching, 34 (7),* 673-699.

Abell, S. K., & Pizzini, E. L. (1992). The effect of a problem solving in-service program on the classroom behaviours and attitudes of middle school science teachers. *Journal of Research in Science Teaching, 29(7),* 649-667.

Abdullahi, A. (1982). *Science teaching in Nigeria*. Ilorin: Atoto Press Limited.

Abdullahi, A. (1984). Science education research in Nigeria. *Nigerian Education Forum, 7*(1), 41-50.

Abell, S., & Smith, D.C. (1994). What is science?: Preservice elementary teachers conceptions of the nature of science. *International Journal of Science Education*, 16, 475-487.

Achi, C. N. (2004). *Issue of quality in Nigeria education system*. Retrieved 23/4, 2005, from http://services.bepress.com/cgi/viewcontent.cgi?article=1020&context=eci/enhancement

Adegbamigbe, A., B. (2002). *Teachers' perceptions of quality teaching in junior secondary school physical education in Lagos State, Nigeria.* Unpublished PhD, Edith Cowan University, Western Australia.

Adepoju, J. A. (1991). *Factors and problems in the teaching and learning of mathematics in Nigerian schools.* Paper presented at the National Curriculum Conference Organised by the Federal Ministry of Education, Lagos, Nigeria.

Adesina, S. A. (1977). *Planning and education development in Nigeria*. Lagos: Educational Industries limited.

Adeyemi, M. A. (1990). Cognitive style as a variable in process skills development in science. *Nigerian Journal of Education Psychology, 5*(1), 45-56.

Afe, J. O. (1989). *Colleges of education in the 1990s: New roles and perspectives*. Benin City: Faculty of Education, University of Benin.

Afe, J. O. (1992). Thirty years of teacher education in Nigeria. In B. Ipaye (Ed.), *A critical survey in Nigeria: Past, Present and Future* (pp. 356-365). Lagos: Macmillan Press.

Afe, J. O. (1995). Strategies for educating migrant fishermen and their families. *The Nigerian Teacher Today: A Journal of Teacher Education, 3(1),* 66-72.

Afe, J. O. (2001). *Reflections on becoming a teacher and the challenges of teacher education*. Retrieved 28/09, 2004, from http://www.uniben.edu/Lectures/Afe64.htm

Aghenta, J. A. (1983). An appraisal of the experimental NCE training programme in Bendel State of Nigeria. *Journal of Research in Curriculum, 1*(1), 17-25.

Ajewole, G. A. (1994). Effects of guided-discovery and expository instructional methods on the attitude of students to biology. *Journal of Research in Science Teaching, 28*(5), 401-409.

Akale, M. A. G., & Nwankwonta, N. A. (1996). A study of students' and teachers perceptions of laboratory/classroom environment in secondary science schools. *Journal of Science Teachers Association of Nigeria, 31*(1&2), 15-22.

Akpan, B. B. (1996). Towards a reduction in the contents of our primary and secondary science curricula. *Journal of The Science Teachers Association of Nigeria, 31*(1&2), 1-5.

American Association for the Advancement of Science. (AAAS, 1993). *Benchmarks for science literacy: A Project 2061 report*. New York: Oxford University Press.

American Association for the Advancement of Science. (AAAS, 1997). *Resources for science literacy: Professional development*. New York: Oxford University Press.
American Association for the Advancement of Science. (AAAS, 1989). *Science for all Americans*. Washington: AAAS.
American Federation of Teachers. (AFT, 2001). *Beginning teacher induction: The essential bridge*. Washington, DC: AFT Educational Issues Department.
Aminu, J. (1995). *Effective management of the Nigeria educational system (1).* Paper presented at the Management Lecture. Nigerian Institute of Management, Lagos, Nigeria.
Anderson, R. D. & Kanuka, H. (1997). On-line forums: New platforms for professional development and group collaboration. Retrieved 13/7, 2003 from http://ascusc.org/jcmc/vol3/issue3/anderson.html
Anderson, R. D., & Michener, C. P. (1994). Research in science teacher education. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 3-44). New York: Macmillan Publishing Company.
Association of Califonia School Administrator. (2000). *Teachers' new role.* Paper presented at the ACSA 30th Annual Conference, Los Angeles.
Australian Education Council. (AEC). (1994). *Science-A statement on science for Australian schools*. Carlton, Victoria: Curriculum Corporation.
Australian Science Teachers Association & Monash University. (2002). *National professional standards for highly accomplished teachers of science*. Canberra: ASTA.
Baird, J. R., & Northfield, J. R. (1995). *Learning from the Peel experience*. Melbourne: Monash University Press.
Bajah, S. T. (1982). How relevant is science education to the school leaver. *Journal of Science Teachers Association of Nigeria*, *20*(7), 183-189.
Bajah, S. T. (1998). Stepping into science: The ELSSA way. *STAN Bulletin, 15*(2), 6-8.
Bajah, S. T., & Bello.O.O. (1996). *History of Science Teachers Association of Nigeria (STAN)*. Ibadan: Intec Printers Ltd.
Ball, & McDiarmid (Eds.). (1990). *The subject-matter preparation of teachers.* New York: MacMillan Publishing Company.
Balogun, T. A. (1983). *Interest in science and technology education in Nigeria.* Paper presented at the 12th International Symposium on Interest in Science and Technology Education, Lagos-Nigeria.
Balogun, T. A. (1987). *Educational research and quality of life.* Paper presented at the Seventh Boleswa symposium on Educational Research for Quality of Life, University of Swaziland, Kwaluseni, Swaziland.
Bell, R. L., Blair, L. M., Crawford, B. A., & Lederman, N. G. (2003). Just do it? Impact of a science apprenticeship program on high school students' understandings of the nature of science and scientific inquiry. *Journal of Research in Science Teaching, 40(5*), 487-509.
Berg, B. L. (1989). *Qualitative research methods for the social sciences.* Needham Heights, Massachusetts: Allyn & Schuster.
Berliner, D. C. (1986). In pursuit of the expert pedagogue. *Educational Researcher*, 5-13.
Bianchini, J. A., & Solomon, E. M. (2003). Constructing views of science tied to issues of equity and diversity: A study of beginning science teachers. *Journal of Research in Science Teaching, 40*(1), 53-76.
Biddulph, F., & Osborne, R. (1984). *Making sense of our world: An interactive teaching approach*. Hamilton: University of Waikato.

Biggs, J. B. (1989). Approaches to the enhancement of tertiary teaching. *Higher Education Research and Development, 8,* 7-25.

Black, P. (1993). Formative and summative assessment by teachers. *Studies in Science Education, 21*, 49-97.

Boston, C. (2002). *The concept of formative assessment. Practical Assessment, Research and Evaluation, 8(9)*. Retrieved 20/06, 2003, from http://edresearch.org/pare/getvn.asp?v=8&n=9

Bouma, G. D. (2000). *The research process.* Oxford, New York: Oxford University Press.

Braimoh, D. S., & Okedeyi, A. S. (2001). Direction of professional development for classroom teachers in effective science, technology and mathematics teaching: Matters arising. *Lagos Journal of Science Education, 5*, 33-37.

Brisard, E. (2002). National visions of initial teacher education. The conceptualisation of the initial preparation of secondary teachers in England, France and Scotland. *Scottish Educational Review, 34*(1), 51-60.

Broh, R. A. (1982). *Managing quality for higher profits.* New York: McGraw-Hill.

Brooks, J. G., & Brooks, M. G. (1993). *In search of understanding: The case for constructivist classrooms*. Alexandria, V.A: Association for Supervision and Curriculum Development.

Brophy, J. (1986). Research linking teacher behaviour to student achievement: Potential implications for instruction of Chapter 1 students. In B. Williams, Richmond, P & Mason, B (Ed.), *Designs for compensatory education: Conference proceedings and papers*. Washington, DC: Research and Evaluation Associates.

Brownlee, J., Boulton-Lewis, G., & Purdie, N. (2002). Core beliefs about knowing and peripheral beliefs about learning: Developing an holistic conceptualisation of epistemological beliefs. *Australian Journal of Educational and Development Psychology*, *2*, 1-16.

Brunner, J.S. (1966). *Toward a theory of instruction*. Cambridge: The Belknap Press of Havard University Press.

Bryan, L. A., Abell, S. K., & Anderson, M. A. (1996). *Coaching reflective practice among preservice elementary science teachers.* Paper presented at the Annual International Conference of the Association for the Education of Teachers in Science (pp.397-411, Pensacola, FL.

BSCS. (1994). *Investigating patterns of changes: Middle school science and technology*. Dubuque, IO: Kendall Hunt.

Busari, O. O. (1996). Teachers' understanding of the integration of theory with practical work in school chemistry. *Journal of Science Teachers Association of Nigeria, 31(1&2),* 71-75.

Bybee, R. W. (1987). Science education and the science-technology-society (S-T-S) theme. *Science Education, 71*, 667–683.

Bybee, R. W. (1993). *Reforming science education. Social perspectives and personal reflections*. NY: Teachers College Press.

Bybee, R. W. (1997). *Achieving scientific literacy: From purposes to practical action.* Portsmouth, NH: Heinemann.

Campbell, D. T. (1974). Qualitative knowing in action research. Paper presented at the annual meeting of the American Psychological Association, New Orleans, USA.

Cevero, R. M. (1988). Effective continuing education for professionals. San Franscisco: Jossey-Bass.

Chaille, C., & Britain, L. (1991). *The young child as scientist: A constructivist approach to early childhood science education*. New York, N.Y: Harper Collins Publishers Inc.

Chang, C. Y., & Mao, S. L. (1998). *The effects of an inquiry-based instructional method on earth science students' achievement.* Paper presented at the Annual meeting of the National Association for Research in Science Teaching, San Diego, CA.

Clermont, C. P., Krajcik, J. S., & Borko, H. (1993). The influence of an intensive in-service workshop on pedagogical content knowledge growth among novice chemical demonstrators. *Journal of Research in Science Teaching, 30*(1), 21-43.

Cobern, W. H. (1994). *Alternative constructs of science and science education.* Paper presented at the plenary presentation for the 2nd Annual Southern Africa Association for Mathematics and Science Education Research, Durban, South Africa.

Colburn, A. (2000). *An inquiry primer*. Retrieved 25/07, 2003, from http://www.nsta.org/main/news/pdf/ss0003_42.pdf

Commonwealth of Australia. (1980). *National inquiry into teacher education*. Canberra: Commonwealth of Australia.

Cooper, C. (1997). *Learner-centred assessment*. Launceston: Global Learning Communities.

Cooper, T. (2002). *Why students retention fails to assure quality*. Paper presented at the HERDSA Conference, Edith Cowan University, WA.

Cosgrove, M., & Osborne, R. (1985). Learning frameworks for changing children's ideas. In R. Osborne & P. Freyberg (Eds.), *Learning in science* (pp. 101-111). Auckland, NZ: Heinemann.

CPRE. (1995). *Helping teachers teach well: Transforming professional development*. Retrieved 21/04, 2003, from http://www.ed.gov/pubs/CPRE/t61/t61c.html

Craven, J. A., & Penick, J. (2001). Preparing new teacher to teach: The role of the science teacher educator. *Electronic Journal of Science Education. Retrieved 24/04, 2003 from http://unr.edu/homepage/crowther/elje/cravenpenick.html*.

Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching, 37(9),* 916-937.

Crowther, S. (1998). Secrets of staff development support. *Educational Leadership, 55(*5), 75-76.

Cuban, L. (1992). What happens to reforms that last? The case of the junior high school. *American Educational Research Journal, 29*(2), 227-251.

Darling-Hammond, L. (1994). *Professional development schools: Schools for developing a profession*. New York: Teacher College Press.

Darling-Hammond, L. (1997). *Doing what matters most: Investing in quality teaching*. New York: National Commission on Teaching and America's Future.

Darling-Hammond, L. (1999). *Solving the dilemmas of teacher supply, demand, and standards: How we can ensure a competent, caring, and qualified teacher for every child*. New York: National Commission on Teaching and America's future.

Darling-Hammond, L., & Ball, D. L. (1997). *Teaching for high standards: What policymakers need to know and be able to do?* Retrieved 15/05, 2003, from http:www.negp.gov/reports/highstds.htm

Darling-Hammond, L., & McLaughlin, M. W. (1996). Policies that support professional development in an era of reform. In M. W. McLaughlin, & I. Oberman (Eds.), *Teacher Learning: New policies, new practices*. New York: Teachers College Press, Columbia University.

Darling-Hammond, L., & Sclan, E. M. (1996). Who teaches and why? Dilemmas of building a profession for twenty-first century schools. In J. Sikula, Buttery, T.J &

Guyton, E (Ed.), *Handbook of research on teacher education (2nd edn) (pp.67-101)*. New York: Macmillan.
Dauchess, A. (2003). *Averting the drought: Keeping mathematics and science teachers through induction and professional development: What strategies are being used by the education community to retain new teachers as school population soar?* Retrieved 25/7, 2003, from http://www.learner.org/theguide/newteach.html
Day, R. A. (1979). *How to write and publish a scientific paper.* Philadelphia: ISI Press
Department of Education Northern Territory Australia (2003). *Using assessment strategies that take account of relationships between teaching, learning and assessment*. Retrieved 17/4, 2003, from http:www.sss.nt.edu.au/co4/co4.2.html
Diaz-Maggioli, G. (2003). *A passion for learning: Teacher-centred professional development*. Alexandria, VA: Association for Supervision and Curriculum Development.
Dozier, T., & Bertotti, C. (2000). Recruiting quality teachers. In T. Dozier & C. Bertotti (Eds.), *Eliminating barriers to improving teaching*. Washington, DC: US Department of Education.
Driver, R. (1989). Students' conceptions and the learning of science: Introduction. International Journal of Science Education, *11(5)*, 481-490.
Duffy, T. M., & Cunningham, D. J. (1996). *Constructivism: Implications for the design and delivery of instruction. In D.H. Jonassen (Ed.), Handbook of research for educational communications and technology (pp. 170-198)*. New York: Simon Schuster Macmillan.
Dzama, E. N. N., Osborne, J. F. (1999). Poor performance in science among African students: An alternative explanation to the African worldview thesis. *Journal of Research in Science Teaching*, 36, 387-396.
Education Department of NorthWest Territories. (2003). *What is teacher induction?* Retrieved 15/08, 2003, from http:www.newteachersnwt.ca/what-is-teacher-induction.html
Education Victoria. (2003). *Report of the Science in Schools 'SiS' research project*. Melbourne: Department of Education and Training, Victoria.
Edwards, C. H. (1997). Promoting student inquiry. *The Science Teacher*, *64*(7), 18-21.
Elmore, R. (1995). Structural reform and educational practice. *Educational Researcher, 24*(9), 23-26.
Entwistle, N. (1998). Approaches to learning and forms of understanding. In B. Dart & G. Boulton-Lewis (EDs.), *Teaching and learning in higher education* (pp. 72-101). Melbourne: Australian Council for Educational Research.
Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 119-161). New York: Macmillan Library Reference.
Eyibe, S. C. (1990). Effective teaching in technological education as a research activity. *Journal of Technical Education Review, 2(2*), 3-12.
Fafunwa, A. B. (1974). *History of Education in Nigeria*. Ibadan: University Press.
Fafunwa, A. B. (1983). *Integrated science education at the junior secondary school level-wanted science and technology in the mother tongue.* Keynote address at the 24th Annual STAN Conference: Ibadan.
Fafunwa, A. B. (1990). Nigerian educational history. *Journal of Education Research and Development*, *1(1)*, 1-8.
Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Researcher*, *38*, 47-65

Federal Ministry of Education. (FME, 1985). *National core curriculum for junior secondary schools*. Lagos: Federal Government Press.

Federal Ministry of Education. (FME, 1982). *National core curriculum for senior secondary schools*. Lagos: N.E.R.D.C.

Federal Government of Nigeria. (1981). National policy on education (2nd edn). Lagos. Government Press.

Federal Government of Nigeria. (1998). *National policy on education (3rd edn)*. Lagos: NERDC.

Feiman-Nemser, S. (1996). *Teacher mentoring: A critical review*. Washington, DC: ERIC DIGEST, ERIC Clearinghouse on Teaching and Teacher Education, AACTE.

Feiman-Nemser, S., & Parker, M. B. (1990). Making subject matter part of the conversation to teach. *Journal of Teacher Education, 41*(3), 32-43.

Feldman, A. (2000). Decision making in the practical domain: A model of practical conceptual change. *Science Education, 84(5)*, 606-623.

Fensham, P. J. (1983). A research base for new objectives of science teaching. *Science Education, 67*, 3-12.

Flick, U. (1992). Triangulation revisited-strategy of or alternative to validation of qualitative data. *Journal for the Theory of Social Behaviour, 2*, 175-197.

Folaranmi, B. A. (2002). The teaching of sciences in our Schools: What hope do we have for the future, bright or bleak? *Journal of Science and Movement Education, 4*, 132-142.

Gardner, H. (1993). *The unschooled mind: How children think and how schools should teach*. Victoria: Harper Collins.

Germann, P. J., Haskins, S., & Ausl, S. (1996). Analysis of nine high school biology laboratory manuals: Promoting scientific inquiry. *Journal of Research in Science Teaching, 33*(5), 475-499.

Gess-Newsome, J. (1999). Delivery models for elementary science instruction: A call for research. *Electronic Journal of Science Education, 3 (3)*. Retrieved on 20/10, 2005 from http://unr.edu/homepage/crowther/ejse/newsome.html

Giddens, A. (1984). *The constitution of society*. Berkeley and Los Angeles: University of California Press.

Gold, Y. (1996). Beginning teacher support: Attrition, mentoring, and induction. In J.P, Sikula; T.J, Buttery; and E. Guyton (Eds.), Handbook of research on teacher education (pp 548-594). New York: Macmillan.

Goldstein, H. (1996). Introduction of assessment in education. *Principles, Policy and Practice, 3*(2), 125-128.

Goodrum, D., & Hackling, M. (2003). *Collaborative Australian Secondary Science Program pilot study*. Edith Cowan University.

Goodrum, D., Hackling, M., & Rennie, L. (2001). *The status and quality of teaching and learning of science in Australian schools*. Canberra: Department of Education, Training and Youth Affairs, Commonwealth of Australia.

Griffin, G. (1982). *Staff development.* Paper presented at the National Institute of Education Invitational Conference, Research on Teaching: Implications for Practice, Arlie House, VA. Washington, DC.

Hackling, M.W. (1998). *Working scientifically: Implementing and assessing open investigation work in science*. Perth: Education Department of Western Australia.

Hackling, M.W., & Fairbrother, R. W. (1996). Helping students to do open investigations in science. *Australian Science Teachers Journal, 42*(4), 26-33.

Hackling, M. W., Goodrum, D., & Rennie, L. (2001). The state of science education in Australian secondary schools. *Australia Science Teachers Journal, 47 (4),* 6-17.
Haimes, D. H. (1996). The implementation of a "Function" approach to introductory algebra: A case study of teacher cognitions, teacher actions, and the intended curriculum. *Journal of Research in Mathematics Education, 27*(5), 582-602.
Halasz, G., Santiago, P., Ekholm, M., Matthews, P., & McKenzie, P. (2004). *Attracting, developing and retaining effective teachers*. Retrieved 14/02, 2005, from http://www.oecd.org/dataoecd/32/48/33732207.pdf
Hattie, J. (2003). *Teachers make a difference: What is the research evidence?* Retrieved 12/8/2005, from http://www.acer.edu.au/workshops/documents/Teachers_make_a_Difference_Hattie.pdf
Hausfather, S. J. (2001). Where is the content? The role of content in constructivist teacher education. *Education Horizon, 80*(1), 15-19.
Helgeson, S. L. (1992). *Assessment in science teaching and learning outcomes.* Paper presented at the Annual meeting of the American Educational Research Association (AERA), San Franscisco, CA.
Hestenes, D. (1987). Toward a modeling theory of physics instruction. *American Journal of Physics, 55*, 440-454.
Higher Education Council. (1992). *Achieving quality*. Canberra: Australian Government Publishing Service.
Hodson, D. (1991). Practical work in science: Time for a reappraisal. *Studies in Science Education, 19*, 175-184.
Hodson, D. (1996). Laboratory work as scientific method: three decades of confusion and distortion. *Journal of Curriculum Studies*, 28(2), 115-135.
Hofer, B. K. (2005). *Teacher preparation and teachers' lives in the United States*. Retrieved 10/5, 2005, from http://www.ed.gov/pubs/Research5/UnitedStates/teacher.html
Hofstein, A., Navon, O., Kipnis, M., & Mamlok-Naaman, R. (2005). Developing students' ability to ask more and better questions resulting from inquiry-type chemistry laboratories. *Journal of Research in Science Teaching, 42*(7), 791-806.
House, E. R. (1994). Integrating the quantitative and qualitative. In C. S. Reichardt & S. F. Rallis (Eds), *The qualitative-quantitative debate: New perspectives (pp. 13 - 22). San Francisco: Jossey-Bass Publishers.*
Howard, V. (1998). *Finding, training and keeping good teachers*. Retrieved 14/08, 2003, from http:www.physics.ohio-state.edu/~wilkins/sciandsoc/k-12teaching.html
Howe, K. R. (1985). Two dogmas of educational research. *Educational Researcher, 14 (8),* 10 - 18.
Hurd, P. D. (1993). Biology in transition. In. Colorado Springs, CO: BSCS.
Hurd, P. D. (1998). Scientific literacy: New minds for a changing world. *Science Education, 82*, 27-30.
Igwebuike, T. B. (1996). Science educatees' perception of science classroom environment. *Journal of Science Teachers Association of Nigeria, 31*(1&2), 62-70.
Ikeobi, I. O. (1995). *Science, technology and mathematics teacher effectiveness.* Paper presented at the Memorial Lecture Presented at the 36th Annual Conference of The Science Teachers Association of Nigeria., Maiduguri, Nigeria.
Ingle, R., & Turner, A. (1981). Science curricula as cultural misfits. *European Journal of Science Education*, 3(4), 357-371.

Ivowi, U. M. O. (1995). *Secondary science education Nigeria.* Paper presented at the UNESCO workshop on Planning Secondary Science Education., Magaliesburg, South Africa.

Ivowi, U. M. O., Okebukola, P. A. O., Oludotun, J. S. O., & Akpan, B. B. (1992). *Raising standard of performance in public examinations in science, technology and mathematics* (*No. 4*): Science Teachers Association of Nigeria.

Jegede, O. J. (1990). Towards a philosophical basis for science education in the 1990's: An African viewpoint. In D. Herget (Ed.), *The history of philosophy of science in the teaching of science* (pp. 185-198). Tallahassee: Florida State University.

Jegede, O. J. (1992). *Factors enhancing meaningful learning in science.* Paper presented at the Faculty of Education Seminar, Lagos State University, Ojo, Lagos-Nigeria.

Jegede, O. J., Fraser, B. J., & Okebukola, P.A.O. (1994). Altering socio-cultural beliefs hindering the learning of science. *Instructional Science*, 22, 137-152.

Jegede, O. J., & Okebukola, P. A. O. (1991). The relationship between African traditional cosmology and students' acquisition of a science process skill. *International Journal of Science Education, 13*, 37-47.

Jenkins, E. W. (1992). School science education: Towards a reconstruction. *Journal of Curriculum Studies, 24*(3), 229-246.

Johnson, K. (2004). The role of field paleontology on teachers' attitudes toward inquiry science. NOVAtions Journal, 2004(2f). Retrieved 12/10, 2005 from http://novationsjournal.org/content/article.pl?sid=04/05/04/0024254&mode=thread&t...

Jonassen, D. H. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Education Technology Research and Development, 39*(3), 5-14.

Jonassen, D. H., & Reeves, T. C. (1996). Learning with technology: Using computers as cognitive tools. In D. H Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 693-719. In. New York: Macmillan.

Kaiser, B. (1996). *Teachers, research, and reform: Improving teaching and learning in high school science courses.* Paper presented at the Global Summit on Science and Science Education, San Franscisco, CA.

Kanstoroom, M. (1999). *Qualified math, science and technology teachers: rethinking the regulatory approach*. Retrieved 24/5, 2003, from http://www.edexcellence.net/library/sccience.html

Kellough, R. D., & Kellough, N. G. (1999). *Secondary school teaching: A guide to methods and resources; Planning for competence*. New Jersey: Prentice Hill Upper Saddle River.

Keys, P.M. (2003). *Primary and secondary teachers shaping the science curriculum: The influence of teacher knowledge*. Unpublished Dissertation, Queensland University of Technology, Brisbane, Australia .

Keys, P. M. (2005). Are teachers walking the walk or just talking the talk in science education? *Teachers and Teaching: theory and practice, 11(5),* 499-516.

King, B., & Newmann, F. (2000). Will teacher learning advance school goals? *Phi Delta Kappan, 81(8),* 576-580.

Krathwohl, D. R. (1998). *Methods of educational and social science research: An integrated approach*. New York: Longman.

Lagos State Ministry of Education (2003). *Scheme of work for junior secondary school in integrated science*. Lagos: Government Press.

Lawson, A. E. (1995). *Science teaching and the development of thinking*. Belmont, CA: Wadsworth Publishing Company.
Layton, D., Jenkins, E., & Donnelly, J. (1994). *Science and technological literacy: Meanings and rationales*. Leeds, UK: University of Leeds, Center for Studies in Science and Mathematics Education, in association with UNESCO.
Lederman, N. G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching, 36*(8), 916-929.
Leinhardt, G. (1986). The cognitive skill of teaching. *Journal of Educational Psychology, 78*(2), 75-95.
Lester, N. (1997). *First year in professioanl development for beginning teachers*. Retrieved 20/07, 2003, from http://www.learner.org/cgi_bin/t/ci/search_user?entry_type
Lester, S. (2003). Qualifications in professional development: A discussion with reference to conservators in the United Kingdom and Ireland. *Studies in Continuing Education, 25(3)*, 269-283.
Little, J. W. (1990). The mentor phenomenon and the social organisation of teaching. In C.B. Courtney (Ed.), *Review of research in education*, (pp. 297-305). Washington, DC: American Educational Research Association.
Lokan, J., Ford, P., & Greenwood, L. (1997). *Maths and Science on the Line - Australian middle primary students' performance in the Third International Mathematics and Science Study, TIMSS Australia Monograph No. 2*. Melbourne: Australian Council for Educational Research
Lokan, J., Hollingsworth, H., & Hackling, M. (In press). *Teaching science in Australia: Result from the TIMSS 1999 video study*. *TIMSS Australia. Monograph No. 8.* Camberwell, Vic.: Australian Council for Educational Research.
London, H. N. (1995). 'Oh No! It's time to hire new teachers again'. *Illinois School Research and Development Journal, 31*(2), 24-33.
London, H. N. (2003). *Creating a new teacher induction program that works*. Retrieved 15/07, 2003, from http:www.icpoline.org/feature_articles/f10_03.htm
Lorsbach, A. W., & Tobin, K. (1998). *Constructivism as a referent for science teaching*. San Fransisco: NARST.
Lott, G. W. (1983). The effect of inquiry teaching and advance organizations upon student outcomes in science education. *Journal of Research in Science Teaching, 20*(5), 437-446.
Luft, J. A., Roehrig, G. H., & Patterson, N. C. (2003). Contrasting landscapes: A comparison of the impact of different induction programs on beginning secondary science teachers' practices, beliefs, and experiences. *Journal of Research in Science Teaching, 40*(1), 77-97.
Marton, F., Watkins, D., & Tang, T. W. (1995). Discontinuities and continuities in the experience of learning: An interview study of high school students in Hong Kong. Paper presented at the 6th European Conference for Research on Learning and Instruction. Nijmegen, Netherlands.
Matthews, M. R. (1997). Introductory comments on philosophy and constructivism in science education. *Science and Education, 6 (1 & 2)*, 5-14.
Matthews, M. R. (1994). *Science teaching*. New York: Routledge.
May, T. (2001). *Social research, issues, methods and process*. Buckingham: Open University Press.
McComas, W. F. (2002). The ideal environmental science curriculum: History, rationales, misconceptions and standards. *American Biology Teacher, 64*(9), 665-672.

Meriwether, N. (2001). *12 easy steps to successful research papers* (2nd edn). Lincolnwood IL: National Textbook Company.

Miles, M. B., & Huberman, A. M. (1984). *Analysing qualitative data: A sourcebook of new methods*. Beverley Hills, CA: Sage Publications.

Millar, R., Leach, J., & Osborne, J. (2000). *Improving science education: The contribution of research*. Burkingham: Open University Press.

Millar, R., & Osborne, J. (1998). *Beyond 2000: Science education for the future (The report of a seminar series funded by the Nuffield Foundation) London. London* King's College: London, School of Education.

Moore, B. (Ed.) (1997). Australian Concise Oxford Dictionary (3rd Ed.). Melbourne: Oxford University Press.

Moussiaux, S. J., & Norman, J. T. (1997). *Constructivist teaching practices: Perceptions of teachers and students*. Retrieved 28/06, 2003, from http:www.ed.psu.edu/ci/Journals/97pap32.htm

Nakagiri, G. (1992). Topics in the science curriculum, grades K-12. In D. Check, R. Briggs & R. Yager (Eds.), *Science curriculum*. (pp. 72-90) Millwood, NY: Kraus International.

National Board for Professional Teaching Standards (NBPTS). (1999). *What teachers should know and be able to do*. Michigan: NBPTS.

National Board of Employment, Education and Training. (1990). *Teacher education in Australia.* A commissioned report No. 6. Canberra: Australian Education Council.

National Commission on Mathematics and Science Teaching. (NCMST, 2000). *Before it's too late*. Jessup, MD: Education Publications Centre, U.S Department of Education.

National Commission on Teaching and America's Future. (NCTAF, 1997). *What matters most: Teaching for America's future*. New York: NCTAF.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academic Press.

National Research Council. (1997). *Improving schooling for language-minority children: A research agenda*. Washington, DC: National Academy Press.

Newman, D., Griffin, P., & Cole, M. (1989). *The construction zone: Working for cognitive change in school*. Cambridge, UK: Cambridge University.

Noah, A. O. K. (2005). *Teacher education in Nigeria*. Unpublished manuscript, Edith Cowan University, Perth.

NSTA. (1992). *The use of computers in science education*. Retrieved 24/6, 2003, from http://www.nsta.org/handbook/computer.asp

Nwangwu, A. N. (1987). Thirty years of primary instruction in Nigeria: A critical survey. *Educational Forum, 10(1)*, 25-32.

O'Brien, T. (1992). Science in-service workshops that work for elementary teachers. *School Science and Mathematics, 92*(8), 422-425.

Odubunmi, E. O. (1981). *Integrated science teaching strategies and pupils attitude to the subject in some secondary schools in Oyo State of Nigeria.* Unpublished P.Hd, University of Ibadan, Nigeria.

Odubunmi, E. O. (1986). Levels of performance of students exposed to laboratory and lecture methods in integrated science. *Journal of Research in Curriculum, 4*(1), 3-9.

Odubunmi, E. O. (1998). Observing science teachers teach. *STAN Bulletin, 15(1)*, 8-10.

OECD. (1994). *Quality in teaching*. Paris: OECD.

OECD. (1999). *Measuring student knowledge and skills: A new framework for assessment*. Paris: OECD.

Ogunbowale, N. B. (2001). Inhibiting factors in the effective teaching of biology in secondary schools- Implication for the teachers. *Journal of Sandwich Education Review, 2*(1&2), 18-24.

Ogunjobi, O. M. (2000). The correlation between continuous assessment and secondary senior certificate examination results in Physics. *Journal of Science and Movement Education, 3*, 113-120.

Ogunleye, A. O. (1999). *Science education in Nigeria*. Lagos: Sunshine International Publications Nigeria Limited.

Ogunmade, T. O. (2000). Towards professionalisation of science teaching in the 21st century in Nigerian schools: Implications for teacher education. *Journal of Science and Movement Education , 3*, 1-6.

Ogunmade, T. O., & Oyeleke, S. O. (1994). Teacher education and chemistry teaching in Schools. *Journal of Science and Movement Education, 1*(1), 113-118.

Ogunniyi, M. B. (1988). Adapting western science to traditional African culture. *International Journal of Science Education, 10*(1), 1-9.

Ogunniyi, M. B., Jegede, O. J., Ogawa, M., Yandila, C. D., & Oladele, F. K. (1995). Nature of worldview presuppositions among science teachers in Botswana, Indonesia, Japan, Nigeria, and the Philippines. *Journal of Research in Science Teaching*, 32(8), 817-831.

Okafor, F. C. (1988). *Nigerian education: A search for new directions*. Enugu: Fourth Dimensions Publishing Company Limited.

Okebukola, P. A. O. (1992). Can good concept mappers be good problem solvers in science?. *Journal of Research in Science Teaching*.

Okebukola, P. A. O. (1997). *The state of science education in Nigeria.* Paper presented at the ELLSA-British Council Primary Science Forum, Kaduna, Nigeria.

Olaleye, E. O. (2002). New training and teaching technologies: Issues, problems and prospects for teacher education programme in Nigeria. *Journal of Science and Movement Education, 4`*, 38-49.

Olanrewaju, A. O. (1994). *New Approaches to the teaching of integrated science*. Ibadan: Alafas Nigeria Company.

Olanrewaju, A. O. (1986). *Doing science in the mother tongue.* Paper presented at the 5th Annual Conference of Curriculum Organisation of Nigeria, Ibadan.

Olanrewaju, A.O. (1991). The language factor in learning science in Nigerian schools. *Journal of the Science Teachers Association of Nigeria*, 27(1), 1-6.

Olubusuyi, P. (2003, 6/3/2003). Education and manpower: Poor teachers' pay, welfare rebound in students' performance. Lagos: *Vanguard Newspaper*.

Omolewa, M. (1977). Some earliest problems of science education in Nigeria (1859-1932). *Journal of Science Teachers Association of Nigeria, 15*(3), 72-92.

Osborne, J., & Collins, S. (2000). *Pupils' and parents' views of the school science curriculum*. London: King's College London.

Osborne, R., & Freyberg, P. (Eds.) (1985). *Learning in science*. London: Heinemann.

Osborne, R. J., & Wittrock, M. C. (1983). Learning science: A generative process. *Science Education, 67*(4), 489-508.

Oversby, J. (1998). Science/technology/society: 21st century science education. *STAN Bulletin, 15*(2), 4-6.

Pajares, M. F. (1992). Teacher's beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62, 307-332.

Palmer, D. H. (1998). Measuring contextual error in the diagnosis of alternative conceptions in science. *Issues in Educational Research, 8*(1), 65-76.

Patrick, S. (2005, 21/04/2005). Better funding for education. *This Day*.
Patton, M. Q. (1980). *Qualitative evaluation methods*. Beverley Hills: Sage.
Patton, M. Q. (1990). *Qualitative evaluation and research methods (2nd ed.)*. Newbury Park, CA: Sage.
Peacock, A. (1995). Access to science learning for children in rural Africa. *International Journal of Science Education*, 17(12), 149-166.
Polland, A., & Tann, S. (1993). *Reflective teaching in the learning school: A handbook for the classroom*. London: Open University.
Punch, K. (1998). *Introduction to social research: Quantitative and qualitative approaches*. Thousand Oaks, CA: Sage.
Queensland School Curriculum Council. (1999). *Science: Years 1 to 10 syllabus*. Brisbane: Queensland School Curriculum Council.
Rascoe, B., Chun, S., Kemp, A., Jackson, D. F., Li, H., Oliver, J. S., Tippins, D. J., Nichols, S. E & Radcliffe, L. (1999). *Scientific literacy: Interpretations of cross-section of our society*. Paper presented at the Annual meeting of the National Association for Research in Science Teaching, Boston, MA. Retrived 21/6, 2003 from http://www.educ.sfu.ca/narstsite/conference/rascoeetal/rascoeetal.html
Reeves, T. (2002). *Mass education and quality*. Paper presented at the HERDSA Conference: Keynote address: Edith Cowan University, Perth.
Resnick, L. (1992). Education and learning to think, in scope, sequence and coordination of secondary school science. *NSTA, II*, 129-149.
Richardson, V. (1997). Constructivist teaching and teacher education: Theory and practice. In Richardson, V (Ed.), *Constructivist teacher education: Building new understandings* (pp. 3-14). Washington, DC: Falmer Press.
Rosario, J., & Ison, F. (1991). *On restructuring teacher education through collaboration: The case of the urban teacher education program*. Paper presented at the 71st annual meeting of the Association of Teacher Educators, New Orleans, Louisiana.
Rutherford, F. J., & Ahlgren, A. (1990). *Science for all Americans*. New York: Oxford University Press pp. xviii-xix.
Ryder, J. (2001). Identifying science understanding for functional scientific literacy. *Studies in Science Education, 36*(*144*), 55-61.
Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, 18*, 119-144.
Salau, M. O. (1995). An analysis of students' enrolment and performance in mathematics at the senior school certificate level. *Journal of Studies in Curriculum*, 28-36.
Salau, M. O. (1996). The effect of class size on the achievement of different ability groups in mathematics. *Journal of The Science Teachers Association of Nigeria, 31*(1&2), 55-61.
Schoon, J. G. (1996). *Transportation system and service policy: A project-based introduction*. New York: Chapman and Hall.
Schon, D. A. (1987). *Educating the reflective practitioner*. San Frascisco: Jossey Bass.
Scott, P., Dyson, T., & Gater, S. (1987). *A constrcutivist view of learning and teaching in science*. Leeds: University of Leeds.
Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick, NJ: Rutgers University Press.
Sheperd, L. A. (2000). The role of assessment in a learning culture. Retrieved 22/6, 2003 from http:www.aera.not/pubs/er/arts/29-07/shep09.htm.

Shroyer, M. G., Ramey-Gassert, & Wright. (1995). *The role of professional development schools.* Paper presented at the Annual meeting of the Association for the Education of Teachers of Science, Charleston, West Virginia.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Havard Educational Review, 57*(1), 1-22.

Shulman, L. S. (1986). Those who understand: Knowledge and growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shymansky, J. (1984). BSCS programs: Just how effective were they? *The American Biology Teacher, 46*(1), 54-57.

Shymansky, J. A., & Kyle, W. C. (1990). *Establishing a research agenda: The critical issues of science curriculum reform.* Paper presented at the National Association for Research in Science Teaching, Atlanta, GA.

Sikula, J. (1996). Handbook on research on teacher education. New York: Macmillan.

Smith , D.C., & Anderson, C.W.(1999). Appropriating scientific practices and discourses wit future elementary teachers. *Journal of Research in Science Teaching,* 36(7), 755-776.

Solaru, J. J. (1964). *Teacher training in Nigeria*. Ibadan: University Press.

Solomon, J. (1988a). Science technology and society courses: Tools for thinking about social issues. *International Journal of Science Education, 10,* 379-387.

Solomon, J. (1988b). Science, technology and society courses: Tools for thinking about social issues. *International Journal of Science Education, 10* (4), 379-387.

Sparks, D., & Loucks-Horsley, S. (1990). Models of staff development. In W.R. Houston (Ed.), *Handbook of research on teacher education* (pp. 234-250). Ney York: Macmillan.

STAN. (1973). Constitution of the Science Teachers Association of Nigeria. Ibadan: STAN

STAN. (1992). *Raising the standard of performance in public examinations in science, technology and mathematics. Position paper No. 4*.Ibadan: STAN

Stoel, C. F., & Thant, T. (2002). *Teachers' professional lives-A view from nine industralised countries*. Washington, DC: Council for Basic Education/Milken Family Foundation.

Taiwo, C. O. (1975). Science curriculum development in Nigeria. *Journal of Science Teachers Association of Nigeria, 14*(1), 21-26.

Taiwo, C. O. (1980). *The Nigerian educational system: Past, present and future*. London: Thomas Nelson.

Tam, M. (1999). *Constructivism: Implications for teaching and learning*. Lingnan: Lingnan Teaching and Learning Centre.

Taylor, P. C., Dawson, V., & Fraser, B. J. (1995). *Classroom learning environments under transformation: A constructivist perspective.* Paper presented at the Annual meeting of the American Educational Research Association, San Francisco, CA.

Teibo, B. O. (1973). Science teaching in secondary schools in Nigeria. *EDULAG, 1*(4), 23-34.

Thomas, J. R., & Nelson, J. K. (1996). *Research methods in physical activity (3rd ed).* USA: Human Kinetics, Champaign.

TIMSS. (1998). *Science teacher questionnaire main survey*. Amsterdam: IEA.

Tobin, K. (1990). *Conceptualizing teaching roles in terms of metaphors and belief sets.* Paper presented at the Annual Meeting of the American Educational Research Association, Boston.

Tobin, K., & Dawson, G. (1992). Constraints to curriculum reform: Teachers and the myths of schooling. *Educational Technology Research and Development, 40*(1), 81-92.

Treagust, D. F. (2002). *Teaching practices in Indonesian rural secondary schools: Comparison between exemplary and non-exemplary science teachers.* Paper presented at the 33rd Annual Conference of The Western Australian Science Education Association (WASEA), Bentley, Western Australia.

Tuchman, B. W. (1980). Decline of quality. *New York Times Magazine, pp.* 38.

Tugwanye, et al. (1979). Curriculum guidelines for early childhood education in home language (mother tongue). *African Curriculum Organization-Curriculum for Early Childhood*. Vol.2

Tytler. (2002). Teaching for understanding in science: Constructivist/conceptual change teaching approaches. *Australian Science Teachers Journal*, *48*(4), 30-35.

UNESCO. (1993). *Report of the International Forum on scientific and technological literacy*. Retrieved 24/5, 2003, from http://www.unescobkk.org/education/aceid/STL/STL2-Sect1.PDF

UNESCO. (1994). *Conceptualising scientific and technological literacy (STL) for all*. Harare: UNESCO.

UNESCO. (2000). *Education in situations of emergency and crisis: Challenges for the new century*. Geneva: UNESCO.

UNESCO. (2002). *Science and technology as a foundation for sustainable development.* Paper presented at the World Summit on Sustainable Development Forth Preparatory Session, South Africa.

van Driel, J. H., Beijaard, D. & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching*, *38(2)*, 105-122.

Van't Hooft, M. (2005). The effect of the "Ohio school going solar" project on student perceptions of the quality of learning in middle school science. *Journal of Research in Technology Education, 37(3),* 221-244.

Vasquez, J. (1998). The teacher's role in inquiry-centred experiences. *STAN Bulletin*, *15(2)*, p. 8

Venville, G., Wallace, J., & Louden, W. (1998). A state-wide initiative: The primary science teacher-leader project. *Research in Science Education*, *28*(2), 199-217.

Von Glasersfeld, E. (1981). An attentional model for the conceptual construction of units and number. *Journal of Research in Mathematics Education*, *12*(2), 83-94.

Von Glaserfeld, E. (1989). Constructivism in Education. In T. Husen & N. Postlewaite (Eds.), *International encyclopedia of education* (pp. 162-163). Oxford, England: Pergamon Press.

Von Glaserfeld, E. (Ed.). (1984). *Radical constructivism.* In P. Watzlawick (Ed.), *The invented reality*. Cambridge, MA: Harvard University Press.

Ware, S. (1992). *Secondary school science in developing countries.* Washington, D.C.: World Bank, Education and Employment Division, Population and Human Resources Department.

Watters, J. J. & Ginns, I. S. (1995). *Origins of, and changes in preservice teachers' science teaching self-efficacy*. Paper presented at the National Association for Research in Science Teaching, San Francisco.

Weiss, E. M., & Weiss, S. G. (1998). *New directions in teacher evaluation*. Washington, DC: ERIC DIGEST, ERIC Clearinghouse on Teaching and Teacher Education, AACTE.

Weiss, E. M., & Weiss, S. G. (1999). *Beginning teacher induction*. Washington, DC: ERIC Clearinghouse on Teaching and Teacher Education (ERIC Document 436487).

Welch, W. W., Klopfer, L. E., Aikenhead, G. S., & Robinson, I. T. (1981). The role of inquiry in science education: Analysis and recommendations. *Science Education, 65*(1), 33-55.

Wenning, C. J. (1997). *A multiple case study of novice and expert problem solving in Kinematics*. Godfrey, IL: Illnois section of the American Association of Physics Teachers.

Western Australia College of Teaching. (2004). *Information for those new to teaching in Western Australia*. Perth: WACOT.

Wiliam, D. (2000). *Integrating summative and formative functions of assessment.* Paper presented at the First annual Conference of the Association for Educational Assessment-Europe, Prague, Czech Republic.

Wiliam, D., & Black, P. J. (1996). Meanings and consequences: A basis for distinguishing formative and summative functions of assessment. *British Educational Research Journal*, *22*(5), 537-548.

Wilson, M., Shulman, L. S., & Richert, E. A. (Eds.). (1987). 150 different ways of knowing: representations of knowledge in teaching. In J. Calderhead (Ed.), *Exploring teachers' thinking (pp.104-124)*. New York: Taylor and Franscis.

Yager, R. (1993). The need for reform in science teacher education. *Journal of Science Teacher Education, 4*(4), 144-148.

Yager, R. E. (1991). The constructivist learning model: Towards real reform in science education. *The Science Teacher, 2*(2), 29-36.

Yager, R. E., & Penick, J. E. (1990). Science teacher education. In W.R. Houston (Ed.), *Handbook of Research on Teacher Education.* New York: Macmillan Publishing Company.

Yakubu, J. M. (1994). Integration of indigenous thought and practice with science and technology: A case study of Ghana. *International Journal of Science Education*, 16(3), 343-360.

Yin, R. (2003). *Case study research design and methods*. Thousand Oaks: Sage Publications.

Yoloye, E. A. (1998). *Science, technology and mathematics education in the 21st century.* Paper presented at the Fafunwa Foundation 2nd Annual Lecture, Lagos, Nigeria.

Zeichner, K. M. & Liston, D. P. (1996). *Reflective teaching: An introduction*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

APPENDICES

Appendix A: Teachers' Survey Questionnaire

Dear Teacher,

This is an anonymous questionnaire. Do not write your name, or any other comments that could identify you on this questionnaire. By completing the questionnaire you are consenting to take part in this research. Please read the information below which explains the purpose of the research.

This questionnaire seeks your opinions and concerns about teaching and learning of science at JSS 1-3. There is no right or wrong answer to each question. Information from this questionnaire will be used to improve the teaching and learning of science in Nigerian secondary schools. The information will be aggregated and summarized for inclusion in research reports. No person or school will be identified in any reports.

Thank you for your participation in this study.

Ogunmade Taiwo. O

SECTION 1: Background Information

1.1. Location of your school: Rural ☐ Urban ☐

1.2. Local Education District:……………………………………………………………….

1.3. Your age:

20 yrs and below	21-30 yrs	31-40 yrs	41-50 yrs	51 yrs and above

1.4. Sex:

Male	Female

1.5. (i) What is your academic qualification? NCE ☐ HND ☐ B.Sc ☐ B.Sc(Ed) ☐

(ii) The major subject area in your qualification is:

Integrated science	Biology	Chemistry	Physics	Agric science	Others

(iii) Any additional qualification(s)? PGDE ☐ M Sc ☐ M Ed ☐ PhD ☐

1.6. Years of Teaching Experience:

0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21 yrs and above

1.7. This term I am teaching:

Only science	Mostly science	Some science, but mostly (please indicate)

1.8. The average number of students in my classes is …………………………….

SECTION 2

2.1 What do you see as the main purpose of teaching science to JSS students?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

2.2. Under ideal circumstances, how should science be taught in your school? List four characteristics of ideal science teaching.

(i)…………………………………………………………………………………………

(ii)…………………………………………………………………………………………

(iii)…………………………………………………………………………………………

(iv)…………………………………………………………………………………………

2.3. Consider **an ideal** science lesson and a typical one of **your actual** Integrated Science lessons (**double period of 80 minutes**) and determine the relative amount of time spent on the following tasks. (Total must be equal to 100%).

	Ideal science lesson (%)	**Actual science lesson (%)**
1. Teacher explaining/or demonstrating to whole class		
2. Whole class discussion		
3. Teacher giving notes to students		
4. Students working individually including working from the text.		
5. Students doing practical and activity work in small groups.		

SECTION 3: Ideal science teaching and learning.

3.1 Examine the following statements carefully and decide how they correspond with your views about quality science teaching and learning. Tick the box to show how often these things should happen under ideal circumstances.

Integrated Science **should** be taught this way under **ideal** circumstances	**All the time**	**Most of the time**	**Some time**	**Not often**	**Never**
(a) Students must carefully follow the teacher's instructions for experiments to reach the correct conclusions					
(b) Students plan their own experiments to investigate their own questions					
(c) Whole-class discussion occurs at the conclusion of activities to summaries the main ideas					
(d) Practical work is used to illustrate the concepts that have been introduced					
(e) Practical work is carried out by students before the theory is introduced					
(f) There is not enough time after the experiment to discuss the main findings					
(g) Students do hands-on practical work every week					

In an **ideal** Integrated Science classroom	**Strongly Agree**	**Agree**	**Agree/ Disagree**	**Disagree**	**Strongly Disagree**
(h) Teachers have sufficient opportunity to attend seminars and workshops to improve their teaching					
(i) Discussion between students is discouraged					
(j) Students' existing knowledge is assessed to guide lesson planning					
(k) Students are encouraged to ask questions					
(l) Students develop the skills which allow them to think independently					
(m) The curriculum is focused on preparing students for study of science in the senior school					
(n) Teachers have a sound content knowledge					
(o) Teachers have knowledge and skills of teaching by inquiry					
(p) Teachers are supported by the school administration					
(q) There is sufficient time to explain topics in depth					
(r) We cover a lot of content to complete the scheme of work					
(s) Teacher are recognised and valued by community					

3.2. Please think about **actual** Integrated Science classes you have taught. Examine the following statements carefully and decide how they correspond with your experiences in the classroom. Please tick the box that best represents how often these phenomena occur in your Integrated Science classes.

In your **actual** Integrated Science classroom	**All the time**	**Most of the time**	**Some time**	**Not often**	**Never**
(a) Students must carefully follow the teacher's instructions for experiment to reach the correct conclusions					
(b) Students plan their own experiments to investigate their own questions					
(c) Whole-class discussion occurs at the conclusion of activities to summaries the main ideas					
(d) Practical work is used to illustrate the concepts that have been introduced					
(e) Practical work is carried out by students before the theory is introduced					
(f) There is not enough time after the experiment to discuss the main findings					
(g) Students do hands-on practical work every week					

In your **actual** Integrated Science classroom	**Strongly Agree**	**Agree**	**Agree/ Disagree**	**Disagree**	**Strongly Disagree**
(h) Teachers have sufficient opportunity to attend seminars and workshops to improve their teaching					
(i) Discussion between students is discouraged					
(j) Students' existing knowledge is assessed to guide lesson planning					
(k) Students are encouraged to ask questions					
(l) Students develop the skills which allow them to think independently					

(m) The curriculum is focused on preparing students for study of science in the senior school					
(n) Teachers have a sound content knowledge					
(o) Teachers have knowledge and skills of teaching by inquiry					
(p) Teachers are supported by the school administration					
(q) There is sufficient time to explain topics in depth					
(r) We cover a lot of content to complete the scheme of work					
(s) Teacher are recognised and valued by community					

3.3. Resources and facilities for teaching and learning Integrated Science in JSS1-3 at your school

Resources	**Yes**	**No**
(a) We have a laboratory assistant		
(b) Most students have a textbook		

Resources and facilities	**Good**	**Satisfactory**	**Poor**
(c) Sufficient laboratory facilities			
(d) State of repair of laboratory facilities			
(e) Supply of chemical reagents			
(f) Amount of equipment for experiments			
(g) State of repair of laboratory equipment			
(h) Quality of the student textbook(s)			

3.4. Assessments practices in Integrated Science teaching.

Indicate the percentages of how often your involvement in the following.

(a) **What do you assess?**	**Percent**
(i) Understanding of science content	
(ii) Science skills and processes	
(iii) Science attitudes	

(b) **How do you assess?**	**Percent**
(i) Written tests	
(ii) Assignments/projects	
(iii) Practical work	
(iv) Practical test	
(v) Quizzes	

(c) **Why do you assess?**	**Percent**
(i) For grading and reporting	
(ii) For student feedback on their learning	
(iii) For identifying students' misunderstanding	

SECTION 4: Limiting factors

What factors hinder you in teaching in a way that you consider to be ideal?

(Please list them in order of importance, i.e. 1= most important, 4= less important)

1………………………………………………………………………………………

2………………………………………………………………………………………

3………………………………………………………………………………………

4………………………………………………………………………………………

SECTION 5: Suggestions for improvement

In your own view, how do you think the factors mentioned in section 4, can be addressed?

(i)……………………………………………………………………………………………
……………………………………………………………………………………………
(ii)…………………………………………………………………………………………
……………………………………………………………………………………………
(iii)…………………………………………………………………………………………
……………………………………………………………………………………………
(iv)…………………………………………………………………………………………
……………………………………………………………………………………………

Thank you

Appendix B: Student Survey Questionnaire

The Status and Quality of Secondary Science Teaching and Learning in Lagos State, Nigeria

Dear Student

This anonymous questionnaire asks for your opinions about the teaching and learning of science in your school. Do not write your name, or any other comments that could identify you on this questionnaire.

There is no right or wrong answer to any of the questions. This is not a test and your answers will not affect your scores and grades. By completing the questionnaire you are consenting to take part in this research. Please read the information below which explains the purpose of this research.

The information you provide will be useful to improve the ways of teaching and learning science. Your answers will remain confidential and any reports about this research will not name any students, teachers or schools.

Thank you for participating in this study.

Ogunmade Taiwo. O

SECTION 1: Background Information

Name of School:……………………………………………………………………………

Type of School: Boys' only ☐ Girls' only ☐ Co-educational ☐

Sex: Male ☐ Female ☐

Age: …………Years

Class Level: JSS1 ☐ JSS2 ☐ JSS3 ☐

SECTION *2:* What percentage (**%**) of your class time does the following things happen in Integrated Science classroom? (Total must be equal to 100%).

Teaching-learning activity	**Percentage of class time**
1. Listening to teacher explaining/or demonstrating to whole class	
2. Engaging in whole class discussion with the teacher and other students	
3. Copying the teacher's note	
4. Working on my own from the text	
5. Doing practical and activity work in small groups.	

SECTION 3: Please indicate by ticking the appropriate options how often the following things happen in your science class?

In my science class	**All of the time**	**Most of the time**	**Some time**	**Not often**	**Never**
1. I copy notes the teacher gives me.					
2. I read science textbooks and form my own notes					
3. I ask questions on what is not clear to me					
4. I watch the teacher do an experiment					
5. I listen to the teacher explaining ideas.					
6. I get excited about what we do in science					
7. I am bored with the science we do in class					
8. I find science interesting to learn					
9. I work in groups with other students					
10. I carry out science experiments					
11. I follow instructions in practical work					
12. We plan our own experiments					
13. I have class discussions with other students on various topics					
14. I learn about scientists and what scientists do					
15.Science lessons deal with things I am concerned about					
16. Science is not related to my life					

SECTION 4:

To do well in science, I need to be able to:	Strongly Agree	Agree	Agree/ Disagree	Disagree	Strongly Disagree
17. think and ask questions					
18. remember lots of facts					
19. understand and explain science ideas					
20. apply science to understand things in my life					

SECTION 5: Please write answers to these questions in the spaces provided.

5.1 How could the study of science be improved?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………

5.2 How will the study of science help you now or in the future?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………

Thank you

Appendix C: Letter to Teaching Service Commission

EDITH COWAN UNIVERSITY
PERTH, WESTERN AUSTRALIA
CHURCHLANDS CAMPUS

Pearson Street, Churchlands
Western Australia 6018
Telephone (08) 9273 8333
Facsimile (08) 9387 7095

The Permanent Secretary,
Teaching Service Commission (TESCOM),
Headquarters, Oba Akinjobi Street,
P.O.Box 9613,
Ikeja,
Lagos
Nigeria.

August 26, 2003

Dear Sir/Madam,

Many countries have been concerned about the quality of science education in their schools and the resultant impact on the scientific literacy of their citizens and national development in science and technology. For this reason the Australian Government commissioned a study by two colleagues and myself to examine the status and quality of science teaching and learning in Australian schools. The subsequent report has had a significant impact in Australia. A copy of the report is available on the following web- site.
http://www.dest.gov.au/schools/publications/2001/science/index.htm

My reason for writing, concerns a Nigeria academic who is studying at my university for his PhD. His name is Ogunmade Taiwo Oludare from Adeniran Ogunsanya College of Education. In discussing possible research topics it has been suggested he may carry out an analysis of science teaching and learning in Nigeria schools using similar research model as that developed in the Australian study. The purpose of the proposed study would be to determine the nature of science teaching and learning in some school districts in Lagos State. From this data, one could develop insights into the actual picture of science teaching in Lagos State and realistic, cost effective ways of improving the situation. This information may be useful in providing information for future policy developments.

If such research were undertaken, the study would be enhanced by the support of the Lagos Education Department. As can be seen from the Australian study the role of all stakeholders is very important in developing a quality report and useful suggestions.

The purpose of this letter is to request your support and advice in conducting a study as briefly outlined. If you are supportive of such proposed research there may be value in nominating a contact person within the Department with whom we could liaise.

The challenges facing all nations regards their science education are considerable. My hope is that the proposed study will provide realistic information and wisdom that may help in meeting those challenges.

We look forward to your reply.

Yours faithfully,

Denis Goodrum
Associate Professor: Science Education
Fax +61 8 9273 8255
Email d.goodrum@ecu.edu.au

cc:Director of Research and Planning,
PP.TESCOM, Ikeja-Lagos.

Appendix D: Letter of Request to Participants

The Status and Quality of Secondary Science Teaching and Learning in Lagos State, Nigeria

Dear Colleague,

I am conducting research as part of my PhD thesis, which involves a study of the status and quality of teaching and learning of science at the junior secondary level.

The process will involve you in completing a questionnaire which seeks your views about the teaching and learning of science in our secondary schools. This will take about 30 minutes. You will also be involved in a two-hour focus group meeting with other key stakeholders in science education to identify ways in which we can improve science teaching. The focus group meeting discussion will be audio taped.

I also intend to collect some information from students in your JSS1-3 classes using an anonymous questionnaire about their perceptions of teaching and learning of science.

All information gathered from teachers and students will be collated and coded so that participants cannot be identified in any report about this research.

Your participation in this research will allow me to identify ideal quality teaching and actual classroom practices with a view to make recommendations for closing the gap between ideal and actual practices.

This research is being conducted under the supervision of Professors Denis Goodrum and Mark Hackling both at Edith Cowan University, Perth, Western Australia. The University's Human Research Ethics Committee has approved the research procedures.

Any questions concerning this research can be directed to me Ogunmade Taiwo Oludare at School of Science, Chemistry Department, Adeniran Ogunsanya College of Education, Otto/Ijanikin, Lagos or through my phone number: +234-803-405-1572, email togunmade@yahoo.com or either of my supervisors can be contacted at Edith Cowan University (Professor Denis Goodrum +6189273 8677 E-mail d.goodrum@ecu.edu.au); Professor Mark Hackling +61893706339 email m.hackling@ecu.edu.au

Please complete the consent form on the next page.

Thank you for being part of this important study.

Appendix E: Letter to Local Education District Office

Edith Cowan University,
2, Bradford Street,
Mount Lawley, Perth, 6050.
Western Australia.
18th January, 2004.

The Zonal Director,
P.P. TESCOM, Ojo Local Education District,
Ojo, Lagos-Nigeria.

Dear Sir/Madam,

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY

I am a research PhD student at Edith Cowan University, Perth, Western Australia, conducting a study on "The Status and Quality of Junior Secondary Science Teaching and Learning in Lagos State, Nigeria".

The primary purpose of the study is to compare ideal quality teaching and learning of science with the actual practices in the classroom. It is envisaged that the study will provide science educators, science curriculum planners and government with detailed information about the actual picture of science teaching, science learning, and educational practices in Lagos State Secondary schools, and realistic, cost effective ways of improving the situation. This in turn can help in planning and formulating further policies for science education practices in Lagos State and Nigeria generally.

The intended participants for the study are the Principals, Science teachers and Students in your Local Education District. Also, curriculum officers, teacher educators, professional organizations, parent-teacher association and other key stakeholders in science education in

Lagos State, Nigeria will be involved in this study. The proposed data collection period will cover the second and third terms of 2003/2004 school year.

I am therefore requesting for your kind approval to conduct the study and a letter of introduction to school Principals in the district in order to facilitate my gaining access to secondary schools and meeting the participants for this study. Also, I would appreciate if you can nominate a contact person within your department to liaise with for successful conduct of the study.

Should you require any more clarification about this research, I could be contacted through my phone number 08034051572 or preferably through my office address:
School Of Science, Chemistry Department, Room 334, Adeniran Ogunsanya College of Education, Otto/Ijanikin, Lagos.

Attached is a summary of my research proposal outlining the major phases in the research and the research ethics.

Your assistance will be greatly appreciated.

Yours sincerely,
Ogunmade, T. Oludare.
Graduate School of Education,
Edith Cowan University, Perth, Western Australia.

Supervisors: Professors Denis Goodrum & Mark Hackling

Appendix F: Consent Form

Project title**: The Status and Quality of Junior Secondary Science Teaching and Learning in Lagos State, Nigeria**

I have read the information regarding this research and I have been informed about all aspects of the study and all questions I have asked have been answered to my satisfaction.

I agree to participate in this research project, realising that I can withdraw at any time.

I also agree that the research data gathered for this study may be published provided that my name, my school and Local Education District are not identifiable.

Participant ……………………………………….. Date:…………………………

Ogunmade, T. O …………………………………… Date: ………………………..

Note: If you have any concerns about this research and will like to discuss them with an independent person, you may contact A/Prof Andrew Taggart at Edith Cowan University, Perth, Western Australia using a.taggart@ecu.edu.au or by telephone +618 9370 6806

Appendix G: Teacher Questionnaire Coding Manual

SECTION 1: Background information

Variable	Column	Question	Variable name	Codes
Subject number	A	-	subj_num	n = 78
Location of school	B	1.1	urbrurl	Rural =1; Urban =2.
Local education	C	1.2	localedu	Ojo =1; Alimoso=2; Oshodi-Isolo =3
School type	D	1.3	schtype	Boys only =1 Girls only =2 Coeducational =3
Age	E	1.4	age	< 20 = 1; 21-30 = 2; 31-40 = 3; 41-50 = 4; > 50 = 5.
Sex	F	1.5	sex	Male =1; Female =2.
Academic qualification	G	1.6 (i)	acadqual	NCE = 1; HND= 2; B.Sc only =3; B.Sc + PGDE/B.Ed/B.Sc(Ed)= 4; NCE + B.Ed/B.Sc = 5; HND + PGDE = 6
Major qualification	H	1.6 (ii)	maj_qual	Int.Sc = 1;Biology = 2; Chemistry = 3;Physics= 4; Agric Sc = 5; Others = 6
Additional qualification	I	1.6 (iii)	add_qual	None = 1 ; M.Sc only = 2; M.Ed = 3; M.Sc+ M.Ed = 4; MPhil/M.Sc\M.Ed+ PhD= 5
Teaching experience	J	1.7	teac_exp	<5 =1; 6-10 =2; 11-15 =3; 16-20 =4; > 20 =5.
Teaching subject	K	1.8	teachsub	Only Sc. =1; Mostly Sc. =2; Some sc. but mostly… =3.
Average no of students in class	L	1.9	avnostud	Actual number

SECTION 2:

2.1: Purpose of teaching science to JSS students

Variable	Column	Variable name	codes
Preparing students for careers in science	M	careers	1 or 0
Helping students to apply science to understand their environment	N	und_envt	1 or 0
Preparing students for senior secondary education	O	prepare	1 or 0
Enabling students develop interest in science and foster the spirit of creativity and scientific inquiry	P	inquiry	1 or 0
Encouraging students develop an understanding of science principles and facts	Q	sc_prin	1 or 0
Enabling students develop skills and processes of science investigations	R	sc_skill	1 or 0
Enabling students to apply science to understand their health	S	apscihea	1 or 0

2.2: Characteristics of <u>ideal</u> science teaching

Variable	Column	Variable name	codes
Students should be encouraged to do more of hands-on group activities	T	hands_on	1 or 0
There should be regular interaction between learners and the teacher in the class through an appropriate feedback of asking and answering questions	U	interact	1 or 0
Teachers must have a sound knowledge of the subject matter	V	soundkno	1 or 0
Teachers must have relevant skills and approaches to cater for students of different learning abilities	W	relskill	1 or 0
Teachers should feel supported by colleagues, school principals and local education authorities	X	support	1 or 0
Teachers should be recognized and valued by parents and the broader community for their contribution to education and scientific literacy of the citizens	Y	recognis	1 or 0
Teachers should be involved in an ongoing professional development to improve their teaching	Z	profdevt	1 or 0
The class size must be manageable with adequate material resources for effective practical work	AA	manclass	1 or 0
The curriculum must be relevant to the need of students and their environment	AB	relcurri	1 or 0
There must be provision for laboratories, textbooks and equipment with conducive school environment	AC	eqcoenvt	1 or 0

2.3 Percentage of time allocation for teaching and learning activities in 80 minutes double period of an <u>ideal</u> science lesson

Variable	Column	Variable name	Codes
1. Teacher explaining /or demonstrating to whole class	AD	expl_dem	Time in percent
2. Whole class discussion	AE	clas_dis	Time in percent
3. Teacher giving notes to students	AF	not_copy	Time in percent
4. Students working individually including working from the text	AG	work_tex	Time in percent
5. Students doing practical and activity in small groups	AH	gru_pcal	Time in percent

2.3 Percentage of time allocation for teaching and learning activities in 80 minutes double period of <u>actual</u> science lesson

Variable	Column	Variable name	codes
1. Teacher explaining /or demonstrating to whole class	AI	expladem	Time in percent
2. Whole class discussion	AJ	clasdisc	Time in percent
3. Teacher giving notes to students	AK	notes	Time in percent
4. Students working individually including working from the text	AL	worktext	Time in percent
5. Students doing practical and activity in small groups	AM	grou#pra	Time in percent

SECTION 3: Ideal science teaching and learning

3.1: Teaching science under <u>ideal</u> circumstances

Variable	Column	Variable name	Codes
(a) Students must carefully follow the teacher's instructions for experiments to reach the correct conclusions	AN	teachins	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(b) Students plan their own experiments to investigate their own questions	AO	planexp	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(c) Whole-class discussion occurs at the conclusion of activities to summaries the main	AP	wholecla	5=all of the time 4= most of the time

ideas			3= some time 2= not often 1= never
(d) Practical work is used to illustrate the concepts that have been introduced	AQ	pracillu	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(e) Practical work is carried out by students before the theory is introduced	AR	practheo	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(f) There is not enough time after the experiment to discuss the main findings	AS	enoughti	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(g) Students do hands-on practical work every week	AT	hands@on	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(h) Discussion between students is discouraged so that we can cover more content	AU	dis_disc	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(i) Students' existing knowledge is assessed to guide lesson planning	AV	exisknow	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(j) Students are encouraged to ask questions and express their own ideas	AW	askques	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(k) The curriculum is focused on preparing students for life	AX	currpre	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(l) The curriculum is focused on preparing students for study of science in the senior school	AY	currstus	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree

(m) Teachers have a sound content knowledge	AZ	teasoukn	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(n) Teachers have the knowledge and skills required for teaching by inquiry	BA	teaknskl	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(o) There is sufficient time to explore topics in depth	BB	explore	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(p) We cover a lot of content superficially to complete the scheme of work	BC	compltsc	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(q) Teachers are supported by the school administration	BD	schadmn	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(r) Teachers have sufficient opportunity to attend seminars and workshops to improve their teaching	BE	semwork	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(s) Teacher are recognised and valued by community	BF	tearecog	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree

3.2: Teaching science in actual science classroom

Variable	Column	Variable name	codes
(a) Students must carefully follow the teacher's instructions for experiments to reach the correct conclusions	BG	teac@ins	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(b) Students plan their own experiments to investigate their own questions	BH	plan#exp	5=all of the time 4= most of the time 3= some time 2= not often

			1= never
(c) Whole-class discussion occurs at the conclusion of activities to summaries the main ideas	BI	whol_cla	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(d) Practical work is used to illustrate the concepts that have been introduced	BJ	pra#illu	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(e) Practical work is carried out by students before the theory is introduced	BK	pra_theo	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(f) There is not enough time after the experiment to discuss the main findings	BL	enoghtim	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(g) Students do hands-on practical work every week	BM	handonpr	5=all of the time 4= most of the time 3= some time 2= not often 1= never
(h) Discussion between students is discouraged so that we can cover more content	BN	discdisc	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(i) Students' existing knowledge is assessed to guide lesson planning	BO	exitknow	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(j) Students are encouraged to ask questions and express their own ideas	BP	ask_ques	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(k) The curriculum is focused on preparing students for life	BQ	curr@pre	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(l) The curriculum is focused on preparing students for study of science in the senior school	BR	cur#stus	5= strongly agree 4= agree 3= agree/disagree

			2= disagree 1= strongly disagree
(m) Teachers have a sound content knowledge	BS	te_sound	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(n) Teachers have the knowledge and skills required for teaching by inquiry	BT	teknskll	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(o) There is sufficient time to explore topics in depth	BU	tim_xplo	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(p) We cover a lot of content superficially to complete the scheme of work	BV	comp_tsc	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(q) Teachers are supported by the school administration	BW	sch@adm	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(r) Teachers have sufficient opportunity to attend seminars and workshops to improve their teaching	BX	sem@work	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
(s) Teacher are recognised and valued by community	BY	te_recog	5=all of the time 4= most of the time 3= some time 2= not often 1= never

3.3 Resources for teaching science

Resources

Variable	Column	Variable name	Codes
(a.) We have a laboratory assistant	BZ	labasst	Yes = 1 No = 2
(b) Most students have a textbook	CA	textbook	Yes = 1 No = 2

Condition of resources and facilities

Variable	Column	Variable name	Codes
(c) Sufficient laboratory facilities	CB	suflabfa	Good =2 Satisfactory = 1 Poor = 0
(d) State of repair of laboratory facilities	CC	replabfa	Good =2 Satisfactory = 1 Poor = 0
(e) Supply of chemical reagents	CD	supchere	Good =2 Satisfactory = 1 Poor = 0
(f) Amount of equipment for experiments	CE	ameqexp	Good =2 Satisfactory = 1 Poor = 0
(g) State of repair of laboratory equipment	CF	strepequ	Good =2 Satisfactory = 1 Poor = 0
(h) Quality of the student textbook(s)	CG	quasttex	Good =2 Satisfactory = 1 Poor = 0

3.4: Assessment practices in Integrated Science teaching

(a) What do you assess?

Variable	Column	Variable name	Codes
Understanding of science content	CH	undscont	Amount in percent
Science skills and processes	CI	scskills	Amount in percent
Science attitudes	CJ	sc_attit	Amount in percent

(b) How do you assess?

Variable	Column	Variable name	Codes
Written tests	CK	writests	Amount in percent
Assignments/projects	CL	ass_proj	Amount in percent
Practical work	CM	pracwork	Amount in percent
Practical test	CN	practest	Amount in percent

quizzes	CO	quizzes	Amount in percent

(c) Why do you assess?

Variable	Column	Variable name	Codes
For grading and reporting	CP	gradrept	Amount in percent
For student feedback on their learning	CQ	feedback	Amount in percent
For identifying students' misunderstanding	CR	misunder	Amount in percent

SECTION 4: Limiting factors

Variable	Column	Variable name	Codes
Lack of well equipped laboratory	CS	lakeqlab	Most important =4 Very important =3 Important = 2 Less important =1
Insufficient teaching resources including equipment, textbooks, specimens, charts	CT	resource	Most important =4 Very important =3 Important = 2 Less important =1
Lack of funds for school building and maintenance	CU	lackfund	Most important =4 Very important =3 Important = 2 Less important =1
Non-conducive classroom environment	CV	classenv	Most important =4 Very important =3 Important = 2 Less important =1
Insufficient qualified and dedicated teachers	CW	qualteac	Most important =4 Very important =3 Important = 2 Less important =1
Lack of professional development for teachers	CX	lackprod	Most important =4 Very important =3 Important = 2 Less important =1
Teachers' lack of subject matter knowledge	CY	laksubma	Most important =4 Very important =3 Important = 2 Less important =1

Poor remuneration and irregular payment of salary	CZ	poremun	Most important =4 Very important =3 Important = 2 Less important =1
Poor teaching skills and approaches	DA	poortesk	Most important =4 Very important =3 Important = 2 Less important =1
Lack of laboratory support staff	DB	suportst	Most important =4 Very important =3 Important = 2 Less important =1
Inadequate teachers' motivation	DC	temotvtn	Most important =4 Very important =3 Important = 2 Less important =1
Large class size	DD	classize	Most important =4 Very important =3 Important = 2 Less important =1
Poor students' attitude to science	DE	poorattd	Most important =4 Very important =3 Important = 2 Less important =1
Students' poor communication skills	DF	commskil	Most important =4 Very important =3 Important = 2 Less important =1
Overloaded science curriculum	DG	curricul	Most important =4 Very important =3 Important = 2 Less important =1
Insufficient time for teaching science	DH	teactime	Most important =4 Very important =3 Important = 2 Less important =1
Lack of supports by school administrators, parents and community	DI	supports	Most important =4 Very important =3 Important = 2 Less important =1

SECTION 5: Suggestions for improvement

Variable	Column	Variable name	codes
Providing more funds to build science laboratories and classrooms	DJ	morefund	1 or 0
Need for more curriculum resources	DK	currreso	1 or 0

Providing better or more equipment and facilities	DL	betequip	1 or 0
Need for regular supply of consumables e.g. reagents	DM	reglasup	1 or 0
Need for better quality science textbooks for students and in school library	DN	quatextb	1 or 0
Need to have a conducive maintenance of classroom	DO	condenvt	1 or 0
Employing more qualified and dedicated science teachers	DP	qual_tea	1 or 0
Motivating science teachers through incentives like science teaching allowance, housing and car loans etc.	DQ	incentiv	1 or 0
Need for more professional development programmes for science teachers	DQ	profdpro	1 or 0
Providing better remunerations and regular payment for teachers'	DS	payment	1 or 0
Giving teachers free hand to operate the curriculum	DT	freehand	1 or 0
Provision of qualified laboratory assistants in schools	DU	labasist	1 or 0
Encouraging teachers to show better attitude to work	DV	betattit	1 or 0
Need for teacher to develop skills for improvisation of equipments not available in schools	DW	improvis	1 or 0
Need for teacher to teach subjects in his/her area of specialisation	DX	special	1 or 0
Need for school administrators and principals to support teachers for acquiring higher degrees	DY	schadmin	1 or 0
Need for students to engage in hands-on activities in science	DZ	engage	1 or 0
Encouraging students to develop interest and better attitudes in science	EA	interest	1 or 0
Need to reduce group size for practical work	EB	pra@work	1 or 0
Need to relate science to students' real life	EC	screalif	1 or 0
Improving teacher-student relationships	ED	tea_stud	1 or 0
Educating students better about the importance of science	EE	importsc	1 or 0
Encouraging students to ask and answer questions in science class	EF	ask_ansq	1 or 0
Reducing the class size	EG	clas_ize	1 or 0
Need for more and better timing for science in the school timetable	EH	betatime	1 or 0
Reducing the science curriculum contents	EI	redccurr	1 or 0
Need for regular assessments and feedback for students	EJ	feed#bak	1 or 0

Need for better community supports for science teaching and teachers	EK	socsupot	1 or 0
Need for better parental concerns about education of their children and provision of textbooks for their children	EL	parentco	1 or 0
Need for regular supervision of science teaching in schools	EM	regsuper	1 or 0

Appendix H: Student Questionnaire Coding Manual

Section 1: Background information

Variable	Column	Variable name	Codes
Subject number	A	subj_num	1,2,3,4, …………540
School	B	school	1,2,3……………...18
School type	C	sch_type	1= boys only 2= girls only 3= coeducational
School location	D	urb_rurl	1= urban 2= rural
Sex	E	sex	1= male 2= female
Age	F	age	actual age ……. Years
Class level	G	classlev	1= JSS 1 2= JSS 2 3= JSS 3

Section 2: Teaching-learning activity

Variable	Column	Variable name	Codes
Q1. explaining/demonstration	H	expl_dem	Time in minutes
Q2. engagement/discussion	I	eng_disc	Time in minutes
Q3. note copying	J	not_copy	Time in minutes
Q4. working from text	K	worktext	Time in minutes
Q5. group practical	L	grup#pra	Time in minutes

Section 3: Actual picture of classroom activities

Variable	Column	Variable name	Codes
Q1. Teacher note	M	teac_not	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q2. read textbook	N	read_tex	5= all of the time 4= most of the time 3= some time 2= not often

			1= never
Q3. ask question	O	ask_ques	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q4. teacher experiment	P	tea_expt	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q5. teacher explaining	Q	tea_expl	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q6. excited about science	R	exci_sci	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q7. bored with science	S	bored_sc	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q8. science is interesting	T	sc_inter	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q9. group students	U	group_st	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q10. science experiment	V	sc_expt	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q11. teacher's instruction	W	tea_inst	5= all of the time 4= most of the time 3= some time 2= not often 1= never

Q12. own experiments	X	own_expt	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q13. class discussion	Y	cla_disc	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q14. learn about scientist	Z	about_sc	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q15. science deals with concerns	AA	scdw_con	5= all of the time 4= most of the time 3= some time 2= not often 1= never
Q16. science not related to life	AB	scnr_lif	5= all of the time 4= most of the time 3= some time 2= not often 1= never

Section 4: To do well in science, learners need to be able to……….

variable	**column**	**Variable name**	**codes**
Q1. think and ask questions	AC	task_que	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree
Q2. remember lot of facts	AD	rem_fact	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree

Q3. understand and explain science ideas	AE	und_expl	5= strongly agree 4= agree 3=agree/disagree 2= disagree 1= strongly disagree
Q4. apply science to understand things in my life	AF	asc_life	5= strongly agree 4= agree 3= agree/disagree 2= disagree 1= strongly disagree

Section 5.1: The study of science can be improved when…………

variable	**column**	**Variable name**	**codes**
1. resources for learning are available (laboratories, science facilities, equipment, access to textbooks)	AG	resource	1 or 0
2. there are good teachers (qualified, interested and competent)	AH	goodteac	1 or 0
3. computers are used to support teaching /learning	AI	computer	1 or 0
4. students have their own materials to study at home(textbooks, writing materials, charts)	AJ	ownmater	1 or 0
5. there is a conducive school environment (not noisy, well-ventilated, good lightening system, and not polluting)	AK	condenvt	1 or 0
6. students are engaged in learning (being attentive, reading notes, doing home work, carrying out own observation, asking and responding to questions)	AL	engagemt	1 or 0
7. students do group work (assignments, practicals, projects)	AM	groupwrk	1 or 0
8. students learn more about the contributions of earlier scientists and watch science documentaries	AN	moreabsc	1 or 0
9. science is related to the learners' environment (using concrete examples and improvised materials from the environment)	AO	envronmt	1 or 0
10. tutorials and extra lessons are organised for students	AP	tutorial	1 or 0
11. students engage in career talks, field trips, excursions, and science clubs	AQ	stud_eng	1 or 0
12. more time is allotted to science teaching/learning	AR	moretime	1 or 0
13. teachers use good teaching approaches (from simple to complex, discuss new ideas, demons	AS	approach	1 or 0

14. teachers respond to students' problems and being friendly	AT	friendly	1 or 0
15. society is educated more about the importance of science (orientation and awareness)	AU	soc_educ	1 or 0
16. there are specialist science schools	AV	spec_sch	1 or 0

Section 5.2: The study of science will help me now or in the future

variable	**column**	**Variable name**	**codes**
1. To build up my career	AW	career	1 or 0
2. To gain respect for being good at science	AX	respect	1 or 0
3. To understand my health	AY	myhealth	1 or 0
4. To understand the world around me	AZ	worldard	1 or 0
5. To be curious, creative and inquisitive	BA	cucreinq	1 or 0
6. To overcome superstitions	BB	over_sup	1 or 0
7. To be a good citizen	BC	goodcitz	1 or 0

Appendix I: Sample Focus Group Data

A FOCUS GROUP MEETING HELD IN OJO LOCAL EDUCATION DISTRICT IN LAGOS STATE, NIGERIA ON 25TH MARCH, 2004

Preamble

Introduction of participants

The reason for inviting you is to participate in a study to try and investigate ways in which we can try and improve the quality of science education in Nigeria. The way we propose to do that is really try to develop two very simple pictures. One picture is the picture of the ideal or the effective type of science teaching and learning. The other is the picture of what actually happening at this point in time and then we are going to examine, create, and brainstorm ways in which we can move from the actual to the ideal. So, to try and facilitate this process, the first thing we would like you to do is perhaps spend a few moment reading through the four questions in your folder and just jot down simple points that will reflect your understanding of how to answer the four questions. If we perhaps have 30 minutes to do that then what we propose to do is to break up into small group of about four people to look into question 1 and just talk about that and then we come back as a large group to first of all look into question 1 the ideal picture and then look at the other questions.

Question 1: What would be the characteristics of an ideal quality teaching and learning of science in our secondary schools?

Response 1: The ideal situation that I have in mind is reducing the number of students going for science such that those going for science are adequately taken care of (Science teacher)

Response 2: There should be active participation of teacher and the learner in the learning process. The teacher should not dominate the class. The students should be made to touch everything that must be touched, to say whatever that should be said. Also, the learners should learn in a laboratory that is well equipped, the materials should be enough, the rooms should be well ventilated, there should be enough seats so that they can seat comfortably and internalize. Students should be given enough assignments to evaluate how far they are going in the learning process. Also, there should be evaluation not only on thing that are written but also on things that are produced, fabricated or manufactured (Parent)

Response 3: The teacher should have basic knowledge, that is, a minimum standard of first degree in the teaching of science. Also, government policy should be geared towards the teaching of science in our schools. The industries that employ scientists should be involved in promoting sponsorship of competitions and others relating to science teaching and learning. The teaching methods to be employed in the teaching of science should be such that the teacher uses local language in addition to lingua franca in communicating with the students (Education Officer).

Response 4: Students from Junior Secondary to Senior Secondary should be given enough guidance and counseling to select science subject. Healthy environment, that is, conducive situation of the laboratory is very important because if the learning environment is not conducive, there would not be effective teaching and learning among the teachers and the students (Science teacher).

Response 5: Teachers should be encouraged to attend seminars, conferences and workshops during vacations so as to update their knowledge. More so, incentives should be given to teachers so as to encourage them from time to time because their job is more laborious. Also, teacher/student population ratio should be considered. The population of students offering science subjects should not outnumber the capacities of the teacher, that is, a manageable class size. In addition, the number of students should not outnumber the equipment available in the school; hence there would not be effective teaching and learning (Parent).

Response 6: The number of period each teacher should teach per week should not exceed 12 periods because they need enough time to prepare, to teach and for practical, that is, science teacher should not be overlaboured or overloaded with work. Also, modern textbooks should be made available both for teachers and students for them to have broad knowledge and for the teacher to have up-to-date information in their fields of teaching (Principal).

Response 7: The ideal class size should be 35 for effective teaching. Also, for effective teaching and learning the 3 domains of learning should be examined, that is, the cognitive, affective and the psychomotor domains (Science teacher)

Response 8: The students need to be involved in productive teaching and learning through their active involvement in learning activities. They could have group meetings, discussion and debate groups in order to bring solution to problems. Also, students should be allowed to touch, since what they see and touch is best internalized. Thus, students should be made to demonstrate and carry out practical of what they are taught theoretically. More so, the industries who are the employers of scientist should be brought in for the students to go for industrial practical attachment. For instance, science students should be made to produce and submit group project or individualized project as part of their final examination to show that they are science students. Students need to be encouraged during science teaching and learning so that they tend to learn. In science teaching, teacher employs different teaching strategies to make sure that learning takes place. Teacher can make use of local language in achieving this but the importance of lingua franca in science teaching and learning cannot be overemphasized. Thus, teachers need to employ every means possible to make sure effective teaching and learning takes place (Education Officer).

Response 9: Language occupies a language chunk of what is learnt in schools. The language of environment is very important in learning science. The use of English in our school as 2nd language has dominated the entire system. Teachers need to incorporate the use of local language alongside the English language to make sure effective learning takes place. Today, teachers spend too much energy talking to the students in our secondary schools due to lack of equipment and thus they repeat and repeat themselves more often during teaching. However, students learn more when they manipulate things themselves. Thus, for an effective teaching and learning of science in our secondary schools, teachers should give students opportunities to talk, ask questions and manipulate things in the classroom (Education Officer).

Question 2: What do you think actually happening in the science teaching and learning at the present time in our secondary schools?

Response 1: Today in most secondary schools in Lagos State, the class size is so large. The population ration of teacher to students in most of our secondary schools is one teacher to about 100 students in science classroom. In the past, the population ration was as high as one teacher to about 150 or more students, thus making the teaching and learning of science difficult. Teachers find the teaching of science bored due to the large number of students per class (Principal)

The value system about education in our society is wrong due to the way the society speaks about education in general and science education in particular. More positive attitude is shown to courses like accounting, pharmacy medicine, law and a lot of others than to education and as such the value such as right attitude, honesty and so on are in short supply among the students nowadays. In essence, the society looks down upon science teachers and the entire teachers in general (Principal).

Response 2: Some of the teachers do not show enough enthusiasm in the teaching of science. They seem to be a sort of coldness on the part of the teachers and hence they do not build that spirit of inquiry and investigation in the students they are teaching because of the way they go about their teaching of science (Parent)

Response 3: Today, in the actual sense of it, the society looks down upon the teachers. Even some of us who are science teachers, we cannot carry ourselves because some of us just got into the universities, obtained the degree and not well grounded in the subject we specialize in. If someone is able to carry himself or herself people will not look down on such a person but will give respect. For instance, most science teachers today are not computer literate unlike their counterparts in other fields. More so, most of today's so called science teachers do not show or have interest in sciences, they just took to science as a means to an end (Teacher)

Response 4: Today in most of our science classrooms, experience shows that when you get into some classes and look at the face of the students, you cannot say whether they are afraid of the teacher or afraid of science, but the expressions on their faces show that they are not or would not be happy that someone is coming to teach them (Education officer)

Question 3: What are the factors that inhibit the quality of teaching and learning of science in our secondary schools?

Response 1: Population is one of the major problems. Most of the students are not properly counselled. They just want to follow their friends to the science class. The numbers of students that offer sciences this day are very large and there are no facilities to teach science and most schools have no laboratories. When you want to teach science without laboratory I wonder the type of science one is teaching. Even where there are laboratories, the facilities are lacking, they are inadequate. In most cases, there is no lighting system for using the microscopes and sometimes slides are not readily available (Science teacher)

Response 2: The problem of language of instruction, that is, language of communication, constitutes an impediment to science teaching. Most students do not understand language of instruction (Science teacher)

Response 3: The problem facing teaching of science in our schools is that most of the teaching is in abstract because there is not enough equipment. Thus, teachers talk and talk and repeat what they are teaching several times due to lack of equipment for imparting the knowledge of science (Parent)

Question 4: How could the factors inhibiting the teaching and learning of science be addressed?

Response 1: The government value system about science teaching and science teachers is poor and need to be changed and improved upon. Government should fund science teaching and science teachers should be well paid. More so, there should be a special allowance for research for science teachers so that at the end of the term a teacher should come up with a project. Science teachers should be encouraged to develop themselves by attending seminars, conferences and workshops (Principal)

Response 2: Concerted efforts should be made to make sure that money allocated to education are properly monitored and channeled to procuring the needed equipments and materials for teaching and learning of science in schools (Parent)

Response 3: Efforts should be made to encourage industries around who employ scientist to contribute to funding of education and science education in particular. This could be in form of engaging science students in an industrial practical attachment, sponsoring of science quizzes and competitions, donation of science textbooks and equipments and building of physical classes and laboratories in schools (Education officer)

Response 4: Science teachers should be encouraged to improvise the needed materials in order to enhance their teaching and students learning despite the limited resources available to them. Also, teachers should be allowed to come together to brainstorm and provide solutions to problems and be able to modify the curriculum such that science teaching and learning could be improved upon (Science teacher)

Response 5: Schools should cultivate the attitude of approaching the nearby industries and especially the multinational companies for help in providing materials and equipments for teaching and learning of science and even in building science laboratories (Principal)

Response 6: There is a need for teacher to modify curriculum based on popular demands. Also, more time, say about 4 periods (160 minutes) should be created for practicals and 2 periods (80 minutes) for theory per week, that is, there should be more room for less talk and more practice on the part of the teacher and the students. More so, students should be encouraged from their primary schools to know the importance and value of science to the society. In addition, the interest of the students should be made to come first as to the offering of science as a subject in schools, that is, students should not be coerce or forced to offer science by either their teachers or the parents. Finally, the curriculum should not be too overloaded but should be modified to enhance the learning abilities of the students (Education Officer).

Response 7: Refresher courses in form of seminars should be organised for science teachers by inviting a more knowledgeable person or a specialist to talk to science teachers. There is need for science teachers to brainstorm and come up with answers to their pressing needs (Parent)

Appendix J: Letter of Approval from Local Education District (LED)

LAGOS STATE GOVERNMENT

Telephone:

All correspondence to be addressed to
The Director of Education (TESCOM) quoting

Our Ref No...

Post-Primary Teaching Service Commission
New Ojo Local Education District
Okokomaiko,
Lagos State.

Date 20th February, 2004

TO:

All Principals,
Ojo, L.E.D.

LETTER OF INTRODUCTION

I hereby introduce Mr. T. Oludare Ogunmade, a research fellow at Edith Cowan University Mount Lawley, Western Australia.

He is conducting his doctoral research in the field of Science teaching and learning, with a view to investigating and describing the status and quality of teaching and learning of science in Lagos State Secondary Schools.

Kindly oblige him in whatever area he might need your assistance.

Thank you.

Adedipe

....

Mrs. E. O. Adedipe
Zonal Director,
PP – TESCOM Zonal Office,
Ojo.

Appendix K: Sample Interview Data

3rd INTERVIEW CONDUCTED ON THE 28TH JULY 2004

Preamble: Good afternoon sir.

Response: Good afternoon.

Question: Can you please introduce yourself, where you work and so on?

Response: I am Mr ……….. a graduate of Physics and Education. I had a Master degree in Curriculum and Instruction and had taught science for about a decade in Lagos State Secondary School. Presently, I am a Senior Science Curriculum Officer with the Lagos State Post Primary Teaching Commission, Ikeja-Lagos.

Preamble: Thank you Sir. The purpose of this interview is for us to compare two pictures of science teaching and learning in our secondary schools. The first picture is that of an ideal science and the other is about what actually is happening in our secondary school system. I would like us to look into these two pictures of science teaching and learning and try to provide answers to the following questions. Though, we may have some other additional questions along the line.

Question 1: What would be the characteristics of an ideal, that is, effective quality teaching and teaching of science in our secondary schools?

Response: Well, the characteristics of an ideal quality teaching and learning of science in our secondary schools should involve firstly, teaching backed up with laboratory practices. In the past, we observed that failure of students in science was as a result of poor performance in science practical or rather in laboratory activities due to the lack of teaching aids for science experiments in our schools. This makes the teaching of science meaningless because students don't seem to get what they are being taught. I believe for effective science teaching and learning there would always be need for teaching aids or laboratory equipment to be available.

Most teachers in Nigeria teach without teaching aids and without apparatus. Also, our students don’t see for themselves what they talk about in science classroom. Therefore, most of the teaching of science is being done in abstract. For us to correct this wrong way or poor approaches to teaching and learning of science, there is a need to apply teaching method that involves the use of apparatus or probably engaging the student in laboratory activities to actually see some of these instruments that will aid their learning of science and once this is put in place then we have an ideal teaching and learning of science in our secondary schools.

Question: Could you think of any other characteristics?

Response: The other characteristics that can be emphasised involve a teacher that actually masters the act of teaching and learning of science. It has been observed that in science; most of the teachers are not good in demonstrating the aspect of teaching and learning. For instance, if a teacher is to teach an aspect in chemistry, he or she is supposed to demonstrate this aspect using improvised materials by which students are familiar with in their local environment in order to learn faster but when these improvised materials are not interesting to classroom settings it makes teaching and learning of science more abstract and more difficult to understand, so our teachers should be involved in demonstration of what the particular aspect of learning is all about.

Secondly the government should fund teaching and learning of science. We have seen that the problem of lack of equipment in our schools is just not the fault of the teachers but is largely due to the lack of government in supplying schools with teaching equipments. So, we don’t have teaching equipments in our schools. Again, most schools don’t have laboratories, but when all of these are put in place, we would have an ideal teaching and learning environment for science in our secondary schools. So, for now these are what I can proffer as necessary factors to be considered for an ideal or quality teaching and learning of science in our secondary schools.

Addendum: Thank you very much sir, for those points raised. Let us go to the next questions. You have rightly given the characteristics of an ideal quality teaching and learning of science in our secondary schools, which involves that of the laboratories, the teaching aids, equipments as well as that of the teacher that will impart the knowledge to the students. You also mentioned something about funding that funding is also important to achieve quality teaching and learning of science in our schools, that is, if schools are properly funded then the necessary equipments will be put in place.

Question 2: How would you describe the teaching and learning of science in our secondary schools at the present time?

Response: In actual fact, the teaching and learning of science in our secondary schools today is nothing to write home about because presently, most of our secondary schools lack well equipped laboratories. It would not be a surprise that most of the students cannot actually identify for instance, some of the reagents use in the course of science practical and also cannot identify some of the equipments that are commonly found in science laboratories.

More so, students have the problem of identification of apparatus or instruments that aid science teaching and learning because they are not available in their school science laboratories. And again, this day our science teachers are not committed to teaching, why? because they are poorly paid. The remuneration of science teachers is so poor that they are not encouraged to give in their best.

Also, this day science students show lukewarm attitude to science and would prefer to forgo science after secondary school education for other lucrative subjects or courses like accounting, political science, Law and so on. The most disappointing aspect of it is that the society believes that those who go science are dropouts or probably those have no all that hope rather than just take up what they see. Today, it is not those that actually have interest in science that go for it but those that found themselves studying science because they could not secure admission into those lucrative courses like law, accounting, banking and finance and so on. It would not be surprised therefore to see those students who studied science in secondary schools dropping science for other subjects, that they believe, are lucrative. So, this day, the interest of students in science has dropped to a level that the government needs to do something critical about it. Besides, government needs to revive the interest of students in the area of science in our secondary schools in this country.

Question: Thank you. What would you say about the class size and what would you suggest as ideal class size for the science teaching and learning in our secondary schools?

Response: According to the National Policy on Education in Nigeria, the ideal class size for art and commercial classes is put at one teacher to 40 students but for the science, it is about 30 students to one teacher. Today, however, what we have in our schools is a student population of about 100 and more of science students to a teacher per class. How then would the teacher teach effectively? And how would the teacher monitor effectively students' progress in the class? How will he monitor their homework or their class work? This situation will not allow for quality teaching and learning in science because there will be no enough space for teacher talk less of how he will communicate with 200 students at a time. So, these are some of the problems teachers of science face in Nigeria today and something has to be done drastically to address these situations.

Question: What can you say about the availability and quality of textbooks for the students?

Response: This is another important issue that needs to be considered. Most students could not afford buying textbooks and if they can afford textbooks, they could not afford quality textbooks. You can see that in Nigeria today, students patronize hungry authors, people that wrote textbooks for personal gains rather than for the sake of knowledge. Even despite the fact that we have textbooks that are not of quality or probably that did not meet up with the standard of teaching and learning of science, yet most students cannot afford the textbooks. So, I believe that there are not enough quality textbooks for the teaching and learning of science in our secondary schools and our parents are not helping matters. Most parents cannot afford or do not have interest in providing textbooks for their children or wards. What do they want the children to practice with or to read in schools? Then it makes the teaching and learning more difficult since it is what you practice that you know better. There is a need for practice but most parents do not have the apparatus that their children or wards could fall back into after getting back home from school for them to practice what they have learnt in schools. So, these aggravate the problems of teaching and learning of science because most students cannot afford textbooks and if they can afford textbooks, they do not have quality or standard textbooks in science in our secondary schools.

Question: Thank you sir, let us go to the third question: What do you think are the most important factors that inhibit the quality of teaching and learning of science in our secondary schools at the present time?

Response: Well factors that inhibit the teaching and learning of sciences in our secondary schools are numerous. Firstly, the quality of the teacher, that is, how sound and knowledgeable the teacher is determines how far he or she can carry along the students. It is one of the major factors that inhibits the teaching and learning of science in our secondary schools.

Also, we need to talk about the teaching and learning resources. Teaching and learning resources are other major factors that inhibit teaching and learning of sciences in our secondary schools. In our schools, there are lack of teaching and learning resources and especially resources for science. When there is availability of the teaching and learning materials, that is teaching resources, then our teaching and learning of science in secondary schools will go to a greater extent and this would bring about a change in our technological development.

There is also a need to consider the lack of availability of industries as factor inhibiting teaching and learning of science. The practices of science in secondary schools should not end in the classroom or laboratories. Students should be allowed on to be involved in industrial training. Therefore, after the laboratory we need enough industries where our students can actually go out and demonstrate some of those things they have learnt and where recommendations can be given concerning their performances and as to the abilities of the teachers as to whether he or she has done his or her job very well or if actually the students have discover their areas of mistakes as a result of learning.

More so, there is a lack of effective testing and follow-up. This is one of the other factors that inhibit the teaching and learning of science. There should be room for testing and also apart from that there is need for follow-up. Parents should do follow-up, teachers should also do follow-up. Then there should be forms of home study series where students could be given assignments to be taken home in science and where students have opportunities of conducting research on their own and discovering some new things about science. There is a need for enough back-up and supports and encouragement from the parents, teachers, and educationists. Once these are done, I think the better it is for teaching and learning of science in our secondary schools.

Lack of personal development by our teachers is another factor that inhibits the teaching and learning of science. Most of our teachers have failed to develop themselves. So, when a teacher is not professionally developed, how could such a teacher be adequately informed about the new discoveries in sciences? Most of our teachers have been teaching a particular subject for over a decade and yet are not conscious of latest discoveries in their fields. Inability of teachers to develop themselves will result in them being deficient in the latest methods, approaches and strategies of teaching and learning of science. Self development is very necessary for teachers of science and as such the school authorities or the government should make room for teachers to develop themselves professionally through regular meetings, such as attending seminars, conferences and workshops or having focus group meetings where they can discuss the problems encountered so far in the course of their teaching and students' learning.

I believe when they discuss or share or brainstorm on problems they come across with in their subject areas, they could provide solution as a body and such solutions will go a long way to improve the quality of teaching and learning of science in our schools. When they are able to come together, share their problems together, they have better solutions to give to such problems and that helps our students a lot but this days most teachers don't have time, they don't even have lesson plans or lesson notes. But where teachers of science don't have time to meet together to share knowledge. Knowledge shared is knowledge gained. It is what they have over the years that they still use to teach. So, I think this will not at least allow for improvement in teaching and learning of science. So, a good teacher in the science must be professionally sound, must develop himself, must acquire more skills, and must always source for knowledge. I think when these are done the better it is for teaching and learning of science in our schools.

Question: Before we round up this interview. Sir, what would you say about the number of teachers to students? Do you think there are enough science teachers in our secondary schools?

Response: Saying that we have enough science teachers in our secondary schools is a fallacy. If you look at the present teacher to student ratio of 1:100, you will notice that we do not have enough science teachers. Take for instance, our senior secondary schools; we have just a teacher to teach chemistry, a teacher to teach physics and just a teacher or two to teach biology. Then we know there is a problem and that is what we have at hand now. So, we don't have enough science teachers. Normally, we should have at least 3 or 4 teachers per subject. For instance, we should have at least 3 science teachers for each of physics, chemistry and biology, that is, a teacher to SSS1, SSS2, and SSS3. However, subject like biology that almost all the students offer should have more than 3 science teachers, say about 6 or 9 science teachers, that is, 2 or 3 teachers to SSS1, SSS2 and SSS3 respectively. Presently, we do not have enough science teachers and so there is need for more science teachers to cope with the large student population in our secondary schools in Nigeria and Lagos State in particular.

Question: Sir, if you are to look at the various factors mentioned which of these do you think is most important?

Response: All of these factors that I have mentioned, the one that is most important is the teacher mastery of the subject and the students' readiness to learn. These two factors are very important. So these will aid qualitative or effective teaching and learning of science in our secondary schools. Then, other factors follow.

Thank you very much sir.

Question 4: How do you think that science teachers can be helped to overcome these barriers that you have mentioned?

Response: Well, helping science teachers overcome the barriers is like one starting a job that he cannot finish, but something drastic might be done. I think it is somehow difficult to do but we can only provide suggestions or probably make recommendations for improvement. Presently, with the situation of things, a class size of more than 100 students to a teacher. The government needs to build more classrooms, laboratories and libraries for the students. It is the shortages of classrooms that lead to a class size of 100 or more students per class. But when the government builds more classrooms, we are going to have a reduced number of students in the classroom. When there are more classrooms that will accommodate students in ratio 40:1 and standard laboratories with equipments. These will go a long way to help the teachers. Also, government needs to provide quality science textbooks for teachers and students and pay teachers good salaries and allowances for them to perform.

More so, the government through the Ministry of Education should put in place programmes that will boost the efficiency of our teachers and not only the science teachers. This could be in form of subject association meetings among various teachers and teachers of various subjects. Like the government should encourage teachers of science to be part of the Science Teachers Association of Nigeria (STAN) and also encouraged them to participate in various programmes of STAN. Government should also help by trying to come up with an avenue where teachers of science can come Teachers can also be encouraged through regular payment of science teachers allowances for practical and such an allowance will encourage those who are teaching science to put in their best.