STUDENTS' AND TEACHERS' PERSPECTIVES ON THE LEARNING OF SCHOOL SCIENCE IN LAGOS, NIGERIA

Victoria Olubunmi Mohammed

Thesis submitted for the Doctor of Philosophy
UCL Institute of Education
2021

ABSTRACT

This study explores the perceptions of students and teachers about the learning and teaching of science with a focus on the role of pedagogy and language in aiding or hindering students' learning in multi-lingual senior secondary science classrooms in Lagos, Nigeria. An emphasis on language arises because the language of instruction is typically different from students' native languages and from the language of science. Other areas examined are teachers' implicit views of learning, the teaching methods that students and teachers perceive as useful for promoting students' learning of science, and the views of students and teachers of the value of science.

The study employs qualitative data collection and analysis within a multiple case study research design in four public senior secondary schools. Collection of data was through lesson observations, individual interviews of students and teachers, group interviews of students in one school and field notes taken by the researcher. Data were analysed inductively, and the interpretation of emerging themes was undertaken using Vygotsky's socio-cultural theory and Watkins' theories of learning. Vygotsky's and Watkins' theories were used as frameworks to explore the extent of students' involvement and collaboration during lessons, how teachers supported students' understanding of concepts, and how different languages influence the teaching and learning of science.

The findings show that students and teachers largely see the value of science as producing scientists who benefit individually, both economically and in terms of prestige. Teachers' implicit view of learning, which is predominantly "learning as being taught", informs their teaching method of transmitting knowledge in classrooms. Students struggle to comprehend science as a result of how they are taught and the language in which they are taught. The study concludes with suggestions of teaching strategies that can be employed to aid students' learning of science within the context of multi-lingual classrooms.

DECLARATION AND WORD COUNT

I, Victoria Mohammed, hereby declare that the study titled ‘Students’ and Teachers’ perspectives on the learning of school science in Lagos, Nigeria’ is my own work and that all sources quoted or used have been acknowledged by means of full reference.

Word count (exclusive of list of references and appendices): 86,317

[redacted]

Victoria Olubunmi Mohammed

17th February 2021

Names of Supervisors: Professor Eleanore Hargreaves and Professor Michael Reiss

DEDICATION

I dedicate my PhD thesis to my darling husband, Brig. Gen. Felix Mohammed (Retired), and my lovely children; Daniel & Rosetti, Pelumi, Tomisin and Olaiya. I appreciate all of them for their love, support, understanding and encouragement throughout the PhD journey. I also dedicate my PhD thesis to my beloved and sweet parents, who have both passed away, and could not witness the successful end of it.

ACKNOWLEDGEMENTS

My PhD journey has indeed been an experience, which would not have been possible without the contributions of many individuals.

First, my profound gratitude goes to my Lord Jesus Christ for giving me life, His blessings and strength throughout my studies. I am also very grateful to my supervisors, Professor Eleanore Hargreaves and Professor Michael Reiss, who dedicated their time, patience, constructive comments and wealth of knowledge to guide and advise me through my PhD journey. Likewise, I am indebted to Professor Shirley Simon, whom I was so fortunate to have as my second supervisor before her retirement in 2019, for her direction and immensely insightful ideas, which broadened my reasoning. Without the encouragement and effective criticism of my supervisors, this study would not have been possible.

My appreciation goes to Mr Adetona, who played a role in having my fieldwork approved by the Lagos State Ministry of Education. Similarly, I appreciate the schools' principals, teachers and students at the schools in Lagos, Nigeria where I collected data, for dedicating their time and sharing their experiences to support this research. My special thanks also go to Susi Earnshaw for her moral and financial support and encouragement during my studies.

I am deeply thankful for the love, fellowship, prayers and encouragement of my lovely sisters Pastor Veronica Fasan, Dr Modupe Ejide, Adetoun Ojo, Adeperosoye Adeniji, Abiola Adekunle, and Agnes Nyabushaka, and my brothers Gbenga Faborode, and Pastor Bola Ojo. Finally, I say a big 'thank you' to others whom I have not mentioned, but who have also contributed to the positive outcome of my work.

TABLE OF CONTENTS

TITLE PAGE 1

ABSTRACT 2

DECLARATION AND WORD COUNT 3

DEDICATION 4

ACKNOWLEDGEMENTS 5

TABLE OF CONTENTS 6

LIST OF TABLES AND FIGURE 12

CHAPTER ONE: BACKGROUND AND STATEMENT OF THE PROBLEM 13

1.1 INTRODUCTION 13

1.2 THE RESEARCH CONTEXT 14

1.2.1 BACKGROUND TO EDUCATION IN NIGERIA 14

1.2.2 ADVOCACY FOR SCIENCE IN THE SCHOOL CURRICULUM IN NIGERIA 17

1.2.3 SCHOOLS IN LAGOS STATE 18

1.2.4 SCHOOL EXAMINATIONS 22

1.2.5 THE NIGERIAN LANGUAGES 23

1.3 BACKGROUND TO MY RESEARCH INTEREST 24

1.4 STATEMENT OF THE PROBLEM AND RESEARCH QUESTIONS 27

1.4.1 RESEARCH QUESTIONS 28

1.5 OUTLINE OF THE THESIS 28

CHAPTER TWO: LITERATURE REVIEW ON SCIENCE TEACHING AND LEARNING 30

2.1 INTRODUCTION 30

2.2 SCIENCE EDUCATION 31

2.2.1 AIMS OF SCIENCE EDUCATION 31

2.2.2 TEACHERS' AND STUDENTS' VIEWS ABOUT THE TEACHING AND LEARNING OF SCIENCE 43

2.3 SCIENCE EDUCATION IN DEVELOPING COUNTRIES: A FOCUS ON AFRICA AND NIGERIA 52

2.3.1 STATE OF SCIENCE EDUCATION IN AFRICA AND NIGERIA 52

2.3.1.1 INADEQUATE FUNDING 54

2.3.1.1.1 IMPACT ON PROVISION OF MATERIALS, EQUIPMENT AND INFRASTRUCTURE 56

2.3.1.1.2 TEACHER QUALITY AND THE IMPACT ON RETAINING WELL-TRAINED TEACHERS 57

2.3.2 SCIENCE TEACHING AND LEARNING IN NIGERIA: FOCUS ON CONTEXT OF STUDY 59

2.3.2.1 CURRICULUM POLICY ON SCIENCE EDUCATION 59

2.3.2.2 TEACHING METHODS AND THEIR IMPACT ON LEARNING 63

2.3.3 RELATIONSHIP BETWEEN SCIENTIFIC KNOWLEDGE AND LOCAL INDIGENOUS KNOWLEDGE 66

2.4 THEORETICAL FRAMEWORK UNDERLYING SCIENCE TEACHING AND LEARNING 71

2.4.1 WATKINS' THEORIES OF LEARNING 72

2.4.2 VYGOTSKY'S SOCIO-CULTURAL PRACTICE THEORY OF TEACHING AND LEARNING 76

2.4.3 LANGUAGE AND SCIENCE 84

2.4.3.1 THE DISTINCTIVE NATURE AND CULTURE OF SCIENCE LANGUAGE 85

2.4.3.2 THE ISSUES, CHALLENGES AND TEACHERS' NAVIGATION OF TEACHING SCIENCE THROUGH ENGLISH 88

2.4.3.3 THE VALUE AND USE OF PIDGIN IN CLASSROOMS 93

2.5 SUMMARY 94

CHAPTER THREE: RESEARCH METHODOLOGY 97

3.1 INTRODUCTION 97

3.2 RATIONALE, RESEARCH QUESTIONS AND RESEARCH DESIGN 98

3.2.1 RATIONALE 98

3.2.2 RESEARCH QUESTIONS 99

3.2.3 RESEARCH DESIGN 99

3.2.3.1 METHODOLOGY **99**

3.2.3.1.1 ONTOLOGY **99**

3.2.3.1.2 EPISTEMOLOGY **100**

3.2.3.2 THE RESEARCHER'S POSITION **101**

3.2.3.3 RESEARCH APPROACH **102**

3.2.3.3.1 CASE STUDY **102**

3.3 RESEARCH METHODS AND ITS DESIGN, PROCESS FOR DATA QUALITY, DATA ANALYSIS, ETHICS AND LIMITATIONS **104**

3.3.1 RESEARCH METHODS **104**

3.3.1.1 RESEARCH SAMPLING **104**

3.3.1.1.1 RESEARCH CONTEXT **105**

3.3.1.1.2 PARTICIPANTS AND SAMPLE SIZE **107**

3.3.1.1.3 GAINING ACCESS TO THE PARTICIPANTS **109**

3.3.2 DESIGN OF RESEARCH METHODS **110**

3.3.2.1 PROCEDURES FOR DATA COLLECTION **112**

3.3.2.1.1 OBSERVATION **112**

3.3.2.1.2 INTERVIEW **116**

3.3.2.1.2.1 SEMI-STRUCTURE INTERVIEWS **117**

3.3.2.1.2.2 GROUP INTERVIEWS **124**

3.3.2.1.3 FIELD NOTES **126**

3.3.3 ENSURING DATA QUALITY **127**

3.3.3.1 TRUSTWORTHINESS **127**

3.3.3.2 TRIANGULATION **129**

3.3.4 DATA ANALYSIS **130**

3.3.5 ETHICAL ISSUES **133**

3.3.6 LIMITATIONS OF METHODOLOGY **135**

CHAPTER FOUR: VALUE OF SCIENCE **137**

4.1 INTRODUCTION **137**

4.2 TO PRODUCE SCIENTISTS **137**

4.2.1 ECONOMIC REASONS **137**

4.2.2 DEVELOPING SCIENTIFIC SKILLS AND ATTITUDES **140**

4.2.3 FOR PRESTIGE 143

4.3 FOR SCIENTIFIC LITERACY 147

4.3.1 FOR HEALTH AND LIFESTYLES 148

4.3.2 ENVIRONMENTAL REASONS 149

4.3.3 CITIZENSHIP REASONS 151

4.4 SUMMARY 152

CHAPTER FIVE: STUDENTS' VIEWS OF LEARNING 154

5.1 INTRODUCTION 154

5.2 STUDENTS' PREPARATION FOR LESSONS 154

5.3 TEACHING METHODS THAT AID STUDENTS' LEARNING 157

5.3.1 GROUP WORK 159

5.3.2 USING FAMILIAR EXAMPLES 164

5.3.3 PERFORMING PRACTICAL WORK 165

5.4 SUMMARY 169

CHAPTER SIX: VIEWS AND USAGE OF LANGUAGE 171

6.1 INTRODUCTION 171

6.2 VIEWS AND USE OF NATIVE LANGUAGE 171

6.2.1 VIEWS ABOUT THE NATIVE LANGUAGE 172

6.2.2 USE OF NATIVE LANGUAGE IN SCIENCE LESSONS 178

6.3 VIEWS ABOUT THE USE OF ENGLISH 182

6.4 TEACHING SCIENTIFIC TERMS AND STUDENTS' RESPONSES 188

6.4.1 NAMING WORDS 188

6.4.2 USE OF EXCAT WORDS 192

6.4.3 USE OF MATHEMATICS: WORDS AND SYMBOLS 195

6.5 SUMMARY 199

CHAPTER SEVEN: TEACHING STRATEGIES 201

7.1 INTRODUCTION 201

7.2 TEACHERS' VIEWS ON TEACHING STRATEGIES 201

7.2.1 GROUP WORK 201

7.2.2 USING FAMILIAR EXAMPLES 207

7.2.3 PERFORMING PRACTICAL WORK 208

7.2.4 USING VISUAL AIDS 212

7.2.5 NOTE COPYING 214

7.2.6 ASSESSING STUDENTS 216

7.3 TEACHERS' USE OF TEACHING STRATEGIES 218

7.3.1 EXPLAINING CONCEPTS 218

7.3.2 QUESTIONING 223

7.3.3 NOTE COPYING 226

7.3.4 PREPARING STUDENTS FOR EXAMINATIONS 227

7.4 SUMMARY 228

CHAPTER EIGHT: DISCUSSION AND CONCLUSION 231

8.1 INTRODUCTION 231

8.2 DISCUSSION OF RQ1 231

8.2.1 VALUE OF PRODUCING SCIENTISTS 232

8.2.2 VALUE OF PRODUCING SCIENTIFICALLY LITERATE CITIZENS 234

8.3 DISCUSSION OF RQ2 236

8.4 DISCUSSION OF RQ3 239

8.4.1 TEACHERS' PERCEPTIONS OF TEACHING STRATEGIES 239

8.4.2 TEACHING STRATEGIES USED IN CLASSROOMS 243

8.5 DISCUSSION OF RQ4 245

8.5.1 THE LANGUAGE OF THE CURRICULUM 245

8.5.2 STUDENTS' NATIVE LANGUAGES 249

8.5.3 THE LANGUAGE OF SCIENCE 250

8.6 LIMITATIONS OF THE THESIS 254

8.7 RECOMMENDATIONS 254

8.7.1 STUDENTS' INVOLVEMENT IN LESSONS 255

8.7.2 LANGUAGE USE IN CLASSROOMS 256

8.7.3 TEACHER TRAINING 257

8.8 IMPLICATIONS FOR FURTHER RESEARCH 258

8.9 CONCLUSION 259

REFERENCES 261

APPENDIX 1 283

APPENDIX 2 284

APPENDIX 3 285

APPENDIX 4 288

APPENDIX 5 291

APPENDIX 6 294

APPENDIX 7 296

LIST OF TABLES AND FIGURES

TABLE 1.1 NUMBERS OF STUDENTS ENROLLING IN LAGOS STATE PRIMARY SCHOOLS 19

TABLE 1.2 NUMBERS OF STUDENTS ENROLLING IN LAGOS STATE JUNIOR SECONDARY SCHOOLS 20

TABLE 1.3 NUMBERS OF STUDENTS ENROLLING IN LAGOS STATE SENIOR SECONDARY SCHOOLS 21

TABLE 2.1 NIGERIAN BUDGET AND FUNDS ALLOCATED TO EDUCATION SECTOR AND UNIVERSAL BASIC EDUCATION (UBE) 55

TABLE 3.1A TEACHERS' BACKGROUND INFORMATION 107

TABLE 3.1B INFORMATION ON STUDENTS PARTICIPATING IN THE STUDY 108

TABLE 3.2 OUTLINE OF RESEARCH QUESTIONS AND METHODS 111

TABLE 3.3A OUTLINE OF LESSONS OBSERVED DURING THE FIRST SET OF DATA COLLECTION 113

TABLE 3.3B SCHOOLS VISITED AND LESSONS OBSERVED DURING THE SECOND SET OF DATA COLLECTION 114

TABLE 3.3C SCHOOLS VISITED AND LESSONS OBSERVED DURING THE THIRD SET OF DATA COLLECTION 115

TABLE 3.4A SUMMARY OF TEACHERS' INTERVIEWS 118

TABLE 3.4B SUMMARY OF STUDENTS' INTERVIEWS 120

TABLE 3.5 RELATIONSHIP OF RESEARCH QUESTIONS TO INTERVIEW QUESTIONS 122

TABLE 3.6 OUTLINE OF GROUP INTERVIEWS WITH STUDENTS 125

TABLE 3.7 TRANSCRIPTION CONVENTIONS 128

TABLE 3.8 AN EXAMPLE OF DATA CODING 131

TABLE 3.9 AN OUTLINE OF THE THEMATIC ANALYSIS OF DATA 132

FIGURE 8.1 AUTHORITIES AT DIFFERENT LEVELS WITHIN NIGERIA'S EDUCATIONAL SECTOR 247

CHAPTER ONE

BACKGROUND AND STATEMENT OF THE PROBLEM

1.1 INTRODUCTION

There are many reasons why we might want people to have a good understanding of science. For example, ensuring the environment and its natural resources are maintained in good condition depends on people's understanding of science and technology (Kaptan & Timurlenk, 2012). However, Kaptan and Timurlenk asserted that a large number of people do not understand science or its valuable potential with respect to economic and social development. They therefore proposed that science and science education should be supported in developing countries through teaching in schools so that students develop an adequate understanding of how science relates to society. However, although scientific knowledge is taught in schools in Nigeria (a developing country), industrially and economically, it continues to lag behind countries classified as developed (Dike, 2015; Investopedia, 2019).

Science education in Nigerian schools is not as successful as it might be in large part because teaching and learning are impeded by multiple issues resulting from reduced funding of the educational system (Ogunniyi, 1996; Okedeyi et al., 2013). Additionally, because science education involves communicating the cultural heritage of a people (Jegede, 1997), it is possible that students' beliefs and first languages are not fully considered when teaching science in multi-lingual classrooms. This study therefore explores both students' and teachers' perceptions of teaching strategies that aid students' learning and the influence of language on science teaching and learning in government-funded (public) secondary schools in Lagos, Nigeria.

In this chapter, I present the research context by describing the background to the educational system in Nigeria in Section 1.2.1, advocacy for science in the school curriculum in Section 1.2.2, an overview of schools in Lagos in Section 1.2.3, the school examination system in Section 1.2.4, and a summary of the languages spoken in Nigeria in Section 1.2.5. I also explain my interest in conducting this study in

Section 1.3, and present a statement of the problem and associated research questions in Section 1.4. Finally, in Section 1.5, I present an outline of the thesis.

1.2 THE RESEARCH CONTEXT

1.2.1 BACKGROUND TO EDUCATION IN NIGERIA

Prior to its independence from the British government in 1960, the colonial administrators of Nigeria participated in the provision of educational facilities and implemented educational policies founded upon the universal framework the missionaries had started when they first introduced education into Nigeria in 1842 (Ikoya & Onoyase, 2008). However, the citizens did not feel the education provided was satisfactory, in part because schools were not adequately funded. They felt that the quality of education provided was low and there were parts of the country that refused to accept education from missionaries who used schooling as a way to evangelise (Duruji, 1978). Thus, educational development was not universal.

Prior to independence being gained, free education programmes were introduced to make primary education accessible to children in the western, eastern and northern regions of the country between 1955 and 1957 (Adetoro, 1966; Duruji, 1978; Ikoya & Onoyase, 2008; Ige, 2013). However, nationalists in the various regions did not plan for the massive enrolment of students in primary schools, which ultimately led to the failure of the programme as insufficient funds were available to sustain it. Furthermore, teacher supply was also a problem as an inadequate number of teachers were trained. This was compounded by the fact that entry qualifications into teacher training institutions and the amount of years spent undergoing training differed between regions (Adetoro, 1966). Hence, the quality of teachers produced in the three regions varied, with some better trained than others (Mohammed, 2013, citing Duruji, 1978; Nwagwu, 1998).

In 1967, states were created from the three regions and three levels of government were established: the federal government, the state government, and the local government (Nwagwu, 1997). To correct the unequal development of education as a result of the unsuccessful free primary education programme, the federal government established universal primary education in 1976 (Ige, 2013). This was followed by the introduction of the National Policy on Education (NPE) in 1977, which was patterned after the United States 6-3-3-4 system of education; however, this did not officially start until 1982 (Ladebo, 2005). This marked a departure from the British 7-5-2-3 system of education (seven years of primary education, five years of secondary education, two years of Higher School Certificate Levels, and three years of tertiary education) that was introduced in 1960 as a form of allegiance to the previous colonial administrators (Imam, 2012).

To this day, to ensure uniform guidelines are followed across all states in Nigeria, the NPE is responsible for the "effective administration, management and implementation of education at all tiers of government" (NPE, 2013). The NPE comprises six years of primary education, three years of junior secondary school, three years of senior secondary school, and four years of tertiary education (Nwagwu, 1997; Ladebo, 2005). The Nigerian educational system is currently structured as follows:

- Early Child Care and Development with children aged 0 – 4 years
- Basic Education for students aged 5 – 15 years, which includes pre-primary education for one year, primary education for six years, and junior secondary education for three years
- Post-Basic Education for students aged 15 – 18 years, which includes senior secondary education and technical colleges
- Tertiary Education provided in colleges of education, polytechnics, and universities.

(NPE, 2013)

Nwagwu (1997) reported an increasing tendency for the federal government to assume greater control and funding of the education system at all levels (primary, secondary and tertiary levels). However, in 1979, three years after the inauguration of the universal primary education scheme, the federal government ended its funding and handed responsibility back to the state and local governments (Ige, 2013). Consequently, federal government funds and the maintenance of federal secondary schools spread across the country along with tertiary level education. Each state government now manages its own junior and senior secondary schools and state tertiary institutions, and helps local government to fund primary schools (UNESCO, 1998). Each of the thirty-six states, which are Abia, Adamawa, Akwa Ibom, Anambra, Bauchi, Bayelsa, Benue, Borno, Cross River, Delta, Ebonyi, Edo, Ekiti, Enugu, Gombe, Imo, Jigawa, Kaduna, kano, Katsina, Kebbi, Kogi, Kwara, Lagos, Nassarawa, Niger, Ogun, Ondo, Osun, Oyo, Plateau, Rivers, Sokoto, Taraba, Yobe, and Zamfara in Nigeria (Olatunji, 2020), has a State Ministry of Education in which state government officials or Secondary School Management Boards inspect and oversee the activities of principals, teachers, and students within secondary schools (UNESCO, 1998). Nwagwu (1997) claimed that the sudden decline in revenue from petroleum products during that period was the reason for the federal government handing over school sustenance to state and local governments. The question that arose was how would state and local governments sustain the universal primary education programme when the revenue they were allocated was small compared to that of the federal government? The short answer was that they could not and the consequent lack of funding and proper planning of the universal primary education scheme resulted in problems similar to that faced by the free primary education programme, ultimately leading to its failure.

To address these problems, the Universal Basic Education (UBE) programme was launched in 1999. Ikoya and Onoyase (2008) report that, despite the substantial funds made available for school infrastructures and the employment and training of teachers, a high proportion of schools continued to lack the physical facilities needed to ensure the success of the UBE programme. This could be because the provision of funds termed 'substantial' by Ikoya and Onoyase (2008, p. 12) was not commensurate with the size of the projects to be tackled under the UBE programme, which is indicative of poor planning and implementation on the part of the government. This explains the failure of the various educational programmes put in place by successive governments to solve problems that continue to persist and have resulted in the poor quality of education within Nigeria (Nwagwu, 1997).

1.2.2 ADVOCACY FOR SCIENCE IN THE SCHOOL CURRICULUM IN NIGERIA

Science, a core subject in the educational curriculum in Nigeria, first appeared in Nigerian schools during the last half of the nineteenth century (Ogunniyi, 1986). Researchers (Ogunniyi, 1986; Jegede, 1997) maintain that the science curriculum employed in schools was designed to meet examination needs and not societal needs. It did not present a view of science sufficient to generate the level of scientific and technological knowledge people required. For instance, Ogunniyi (1986) reported that science teaching in the western region of Nigeria did not adequately prepare students for future careers in science.

According to Ogunniyi (1996), the key consideration in the minds of Nigeria's leaders after gaining independence in 1960 was that without a science and technology base, economic development of the country could not be achieved. This required the establishment of national policies on science teaching and the development of a curriculum that would lead to the generation of scientific and technological products (Ogunniyi, 1986). Nigerian leaders thus adopted this new reform to move away from the system instituted by the colonial dominators and that of the African traditional educational system (Jegede, 1997). This resulted in the introduction of the following programmes: the Bendel State Primary Science Programme?, the Primary Education Improvement Programme, and the Nigerian Integrated Science Project (Jegede, 1997, p. 7).

Additionally, Nigerian leaders expanded the educational intake of students and instituted a policy of science for all schools (Ogunniyi, 1996). According to Jegede (1997), these major steps in the restructuring of science education were misconceived as the leaders did not anticipate in advance what the new science curriculum would accomplish in society. The leaders did not think that a science curriculum imported from another context would have to be adapted to align with the socio-cultural backgrounds of African students (Jegede, 1997). Consequently, the teaching of science resulted in a scientific view that was less concerned with societal needs and more to do with the facts Nigerian leaders believed were essential for the much-needed technological advancement of the country (Urevbu, 1987). This meant that science topics relevant to the environment and societal needs such as environmental pollution, conservation of environmental resources, nutrition, public health and safety, child-rearing practices, and so forth were excluded from the science curriculum (Urevbu, 1985).

Furthermore, the increase in the intake of students into schools led to a sharp increase in student populations, which created issues such as inadequate laboratory facilities, insufficient textbooks, overcrowded classrooms, and poor science teaching (Ogunniyi, 1986). Despite these problems, 'Science for All', which started as a slogan in the 1960s, was made a formal policy in Nigeria with science being taught at all levels of school education (Ogunniyi, 1996).

1.2.3 SCHOOLS IN LAGOS STATE

The Lagos state Ministry of Education follows the guidelines established in the NPE by the federal government. As discussed in Section 1.2.1, the UBE is an education reform programme established in 1999 to improve the quality of education delivered to students and increase school enrolment (Ikoya & Onoyase, 2008). Lagos state is the most populated state in Nigeria with a population of over 20 million people and is expected to take the lead regarding the number of students enrolled into schools (Gbenu & Lawal, 2017). The high population in Lagos state is partly a result of the inflow of people from other states in Nigeria. This has been driven by business and economic growth, especially when it was the designated capital of Nigeria from 1914 to 1991, from whence it has continued to be a major commercial city (www.lagosstate.gov.ng, 2017).

Education institutions funded by the Lagos state government include primary, junior secondary, and senior secondary schools, state universities, state colleges of education, and polytechnics. Regarding the secondary level of education, the Lagos state government has established fifteen subsidised, fee-paying schools (www.lasu-info.com), most likely in order to compete with a burgeoning number of private schools (Tooley & Yngstrom, 2014). These schools are deemed 'model colleges' in which interested students sit placement test examinations into junior secondary school one (J.S.1) in addition to common entrance examinations (www.lagosstate.gov.ng, 2017). Additionally, the infrastructure is better and classrooms are not overcrowded as they receive more funding from the state government. However, the focus in this study is on the non-fee-paying public secondary schools, where there are large class sizes and inadequate equipment (Mohammed, 2013).

Over the years, a large number of students have enrolled in schools in Lagos, which to date has the highest number of public primary and secondary schools in Nigeria (www.lagosstate.gov.ng, 2017). Table 1.1 presents the enrolment figures for Lagos state primary schools from 2013 to 2016.

Table 1.1: Numbers of students enrolling in Lagos state primary schools

YEAR	NUMBER OF PRIMARY SCHOOLS	PRY 1	PRY 2	PRY 3	PRY 4	PRY 5	PRY 6	TOTAL
2013/2014[1]	1007	54002	58295	65371	70369	77358	74882	400,277
2014/2015[2]	1014	51047	57903	65447	71109	80307	80865	406,678
2015/2016[3]	1014	51476	59712	68542	74003	85400	82702	421,835

As shown in Table 1.1, there has been a small increase in the number of schools over these three years and an overall increase in the number of students from primary 1 to 6. There appears to be a notable increase in the number of students enrolled in primary 5. This could be because parents want their children to start primary education at an early age in private schools (due to cheap fees) and then move them to government schools once they reach primary 5 (Tooley & Yngstrom, 2014). The

[1] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Primary-Schools-by-State-Class-and-Gender-2013-2014.pdf
[2] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Primary-Schools-by-State-Class-and-Gender-2014-2015.pdf
[3] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Primary-Schools-by-State-Class-and-Gender-2015-2016.pdf

decrease in the number of students in primary 6 in two of the years could be because some of the students leave for junior secondary school from primary 5. Primary education in government schools is free and becomes the next available option for parents who are poor or near-poor and cannot afford to pay the tuition fees for private schools (Tooley & Yngstrom, 2014 p. 9). Private schools operate alongside government schools in Nigeria from pre-primary to tertiary institutions; however, these will not be discussed in this study as the emphasis is on public (government-funded) schools.

The same increase in enrolment from 2013/14 to 2015/16 can be seen in junior secondary schools (Table 1.2).

Table 1.2: Numbers of students enrolling in Lagos state junior secondary schools

YEAR	NUMBER OF JUNIOR SECONDARY SCHOOLS	J.S.1	J.S.2	J.S.3	TOTAL
2013/2014[4]	348	113,027	108,509	96,076	317,612
2014/2015[5]	349	129,270	101,626	85,523	316,419
2015/2016[6]	348	133,552	110,830	82,484	326,866

As shown in Table 1.2, each of the three years has a large intake of students into J.S.1 compared to the numbers of students that completed primary education. For example, 74,882 students completed primary 6 in the 2013/2014 academic session (see Table 1.1) whereas 129,270 students started J.S.1 in the following 2014/2015 academic session. It is possible that some students attended private schools for their primary education and then moved to the government school for their secondary education. Notably, the numbers also reduce substantially as students progress from J.S 1 to J.S.3, which suggests that considerable numbers withdraw from junior secondary schools. Based on my own experience of Nigeria, students may withdraw

[4] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Junior-Secondary-Schools-by-State-Class-and-Gender-2013-2014.pdf
[5] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Junior-Secondary-Schools-by-State-Class-and-Gender-2014-2015.pdf
[6] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Junior-Secondary-Schools-by-State-Class-and-Gender-2015-2016.pdf

from public secondary schools to attend private schools or learn crafts out of school such as tailoring, carpentry, or becoming a mechanic. The same trend of high enrolment of students in the first year and a subsequent decrease in the number of students across subsequent year groups is also evident in senior secondary schools (Table 1.3).

Table 1.3: Numbers of students enrolling in Lagos state senior secondary schools

YEAR	NUMBER OF SENIOR SECONDARY SCHOOLS	S.S.1	S.S.2	S.S.3	TOTAL
2013/2014[7]	316	116,576	81,859	49,334	247,769
2014/2015[8]	324	125,140	77,835	45,364	248,339
2015/2016[9]	321	111,895	77,351	45,001	234,247
2016/2017[10]	322	95,807	80,590	46,524	221,921

A large number of students withdraw from school due to poor academic performance (Tooley & Yngstrom, 2014). The focus in this study is on senior secondary education because the goal at this level, as stated in the National Policy of Education, is to prepare students for useful living in society and for higher studies in tertiary institutions (Gbenu & Lawal, 2017).

The curriculum for senior secondary education consists of subjects categorised into four fields and four compulsory cross-cutting subjects (NPE, 2013). The four fields and the subjects categorised in each are as follows:

- Science and Mathematics: Biology, chemistry, physics, further mathematics, health education, agriculture, physical education, and computer studies.
- Technology: Technical drawing, general metalwork, basic electricity, electronics, auto mechanics, building construction, woodwork, home management, and food and nutrition.

[7] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Senior-Secondary-Schools-by-State-Class-and-Gender-2013-2014.pdf
[8] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Senior-Secondary-Schools-by-State-Class-and-Gender-2014-2015.pdf
[9] http://education.gov.ng/wp-content/uploads/2019/05/Enrolment-in-Public-Senior-Secondary-Schools-by-State-Class-and-Gender-2015-2016.pdf
[10] National Bureau of Statistics, Nigeria (NBS, 2017)

- Humanities: Christian religious studies, Islamic studies, visual arts, music, history, geography, government, economics, Literature-in-English, French, Arabic, and any Nigerian Language.
- Business Studies: Stores management, accounting, commerce, office practice, and insurance. (NPE, 2013)

Students are expected to complete four compulsory subjects, which are English Language, general mathematics, one trade/entrepreneurship subject, and civic education along with two, three, four, or five subjects from one of four preferred fields to make up a minimum of eight or nine subjects, depending on their potential, interest, and capability (NPE, 2013). With students having to study eight or nine subjects from S.S.1 to S.S.3, it is possible that some find this unmanageable and end up withdrawing from school.

1.2.4 SCHOOL EXAMINATIONS

In the NPE system, students qualify for the senior secondary school after sitting an end-of-year examination in the final year of junior secondary school (J.S.3). Each state education authority coordinates its own end-of-year examinations (UNESCO, 1998). Both the external examinations and the end-of-year examinations are summative assessments of performance (Wallace, 2008).

External examinations in Nigeria are conducted by evaluation agencies or examination bodies to control and monitor the quality of education in schools (Kpolovie et al, 2011). These agencies organise public examinations in which senior secondary school students are assessed at the end of senior secondary level. The examination bodies are the West African Examination Council (WAEC), the National Examination Council (NECO), and the Joint Admission and Matriculation Board (JAMB), the last of which organises entrance examinations into universities in Nigeria (UNESCO, 1998; Kpolovie et al, 2011). In the examinations set by WAEC and NECO, subjects are assembled and questions set on topics covered in the curriculum (Kpolovie et al, 2011). Secondary school teachers do not set questions for these examinations.

My experience of Nigeria's educational system is that students undertake a summative assessment at the end of each term, the questions of which cover topics in the formal curriculum. In senior secondary schools, students are assessed from the first year at the end of each term until the end of the first term in their third or final year. As stated earlier, the focus of this study is on senior secondary science students in Lagos state who are in their second year, which means they have one year to spend in school before they sit their final examination in S.S.3. The grading system in WAEC and NECO is one in which nine grades are assigned to each subject: A1 (75%-100%), B2 (70%-74%), B3 (65%-69%), C4 (60%-64%), C5 (55%-59%), C6 (50%-54%), D7 (45%-49%), E8 (40%-44%), and F9 (0%-39%) (WENR, 2017). Students can receive the West African Senior School Certificate (WASSC), and the Senior School Certificate (SSC) after the release of their results (NPE, 2013). To gain entrance into tertiary institutions, students will need to have at least credit pass in five subjects including English language, mathematics and any three subjects that are relevant to their proposed course of study in the university (WENR, 2017).

1.2.5 THE NIGERIAN LANGUAGES

Language is the key channel of communication. Hence, it is of utmost importance in the context of teaching and learning (UNESCO, 1998). In Lagos state, the main language of instruction in schools is English. However, the majority of residents speak a native language, Yoruba.

Native languages are also termed indigenous languages, of which there are over four hundred within Nigeria. These languages are divided into three categories: developed languages, developing languages, and undeveloped languages (UNESCO, 1988, pp. 103-104). The developed languages are the three major languages of the three largest tribes: at least one out of Hausa, Igbo, and Yoruba is spoken by 60%-70% of the population (UNESCO, 1998, cited in Bamgbose, 1992). These languages are employed as the language of instruction in all subjects, except English, in the early years education and in primary 1 to 3 classes, but not in primary 4 to 6 classes, secondary schools or tertiary institutions where English is used as the language of instruction (Salami, 2008). The developing languages are sixty languages spoken by sub-tribes that emanate from the three major tribes. These languages are not used as a medium of instruction in the educational system, although they are spoken as first languages at home. The undeveloped languages are called 'small group' languages (UNESCO, 1998, p. 104) and are not used in schools due to the *small number of students* who speak them.

To use UNESCO's language and description, Nigerian pidgin is one of these undeveloped languages, and, although it is spoken by a large number of people in the southern part of the country, it is not used in the educational system as it does not have a standard written form (UNESCO, 1998, p. 104). My personal experience of being a teacher in Lagos state is that speaking Yoruba in secondary schools as a medium of instruction or for open communication amongst students is not officially permitted. Nevertheless, teachers often use the language to communicate with one another whereas students speak it quietly amongst themselves for fear of being disciplined.

Lagos state is a commercial city to which 86 persons from other states migrate every hour (www.lagosstate.gov.ng, 2017). Consequently, classrooms in Lagos state are multi-lingual due to the presence of students from various states in Nigeria (Salami, 2008). Teaching science in such multi-lingual classrooms can be demanding for both teachers and students, especially given that the language of instruction differs from that of students' native languages and that of science (Yore & Treagust, 2006). Hence, it is important to understand science teaching and learning within the context of Lagos senior secondary school languages.

1.3 BACKGROUND TO MY RESEARCH INTEREST

I was born in 1970 and lived my entire life in Lagos until I relocated to the United Kingdom in 2013. My parents were educated and lived well within their means. My father, who trained in Scotland to be a Chartered accountant, had high standards regarding the career pathway his children would choose to follow. Thus, at a young age I was enrolled into a private school for my nursery and primary education, although it was not common for parents to do this in the 1970s. In 1980, I was moved to one of the public secondary schools in Lagos to begin my secondary education. This is because, at that time, government secondary schools were better equipped and a superior option with respect to my aim of becoming a pharmacist. I had developed an interest in exploring how pharmacists distributed prescribed drugs to patients and worked in conjunction with doctors and nurses in hospitals.

My parents encouraged me to become a pharmacist and supported me by enrolling me for private lessons after school hours to boost my performance in the three science subjects and mathematics that formed part of the WAEC examination. Whilst at secondary school I recall dreading being asked by teachers to answer questions after a long period of talking or transmitting scientific facts. To avoid being embarrassed or punished for failing to answer questions, I memorised all I was taught in readiness for lessons, which is consistent with Jegede's (1997) claim that students memorise scientific facts in the absence of any practical application of scientific knowledge to social issues. Unfortunately, I forgot almost everything that was said in class after the lessons and only recalled it when I read through the notes provided by teachers as preparation for the examination period. Because the British 7-5-2-3 system of education was in operation at that time, I sat for the final school certificate examination after spending five years in secondary school (Ladebo, 2005; Imam, 2012). I read the textbooks and notes teachers gave us to copy, and memorised scientific concepts, laws, and formulae to prepare for examinations. There were never more than thirty students in the classroom and we were therefore able to carry out practical activities, which helped me retain a few science concepts. I was successful in six of the subjects I sat for in the WAEC examination, but I failed chemistry and physics. To become a pharmacist, I had to obtain at least a credit pass rate in those subjects; therefore, my parents enrolled me in another school in another state starting from form 4 of secondary.

The style of teaching in the new school was no different from my previous school; however, I had already experienced sieving through content given to us in our notes to memorise. As I had done before, I memorised the scientific content for my final examination in form 5 and passed all my subjects, although I did not understand most of the content. Consequently, I struggled in my first year of 'A' levels (AS) where I studied botany, zoology, industrial chemistry, organic chemistry, and physics. This struggle was primarily due to the scientific terms I was introduced to in lessons. Struggling to learn those terms, and know them by heart in order to perform well in examinations, impeded my learning of science (Jegede, 1995; Ogunniyi, 1996). Because I was unable to cope with the number of words I had to memorise, I thought that 'A' levels might be too complicated for me and therefore decided to take the JAMB examination to gain entrance into university (UNESCO, 1998). Unfortunately, I received a mark lower than the cut-off mark needed to read pharmacy. Desperate to escape the 'A' level subjects, I decided to study chemistry education in one of the best federal universities in Nigeria.

While training to be a chemistry teacher at university, the method of teaching I experienced was similar to the transmission style employed by teachers in my secondary schools and the first year of 'A' levels. Despite struggling with the complicated terms I encountered in organic chemistry during my third and fourth year of study, I was able to cope with the combined scientific knowledge contained in the courses I studied at the faculty of education. After graduating, I obtained a job teaching science in a private secondary school where seeing students struggle to understand scientific concepts reminded me of my experience at secondary school. In the 1990s, my four year-old daughter's curiosity in wanting to know about everything around her and asking questions such as 'mummy, where does this breeze come from?' and 'does God have a big fan?' led me to think about how best to explain the concept of an electric fan. (My daughter, now a medical engineer, might have had her interest in science boosted at an early age as a result of our mini-discussions of the environment.) I then wanted to know whether science is actually understood by students within that context, and if scientific knowledge is even applied as most of the appliances we use in Nigeria are not manufactured locally but imported from another country. As a result, I became interested in identifying the best ways to teach science.

Based on my experience of explaining concepts to my daughter at home, I found myself using examples students were familiar with from their environment to teach concepts relating to forces, electricity, magnetism, ecology, human diet, compounds, hydrocarbons, and so forth. This enabled students to become aware of the phenomena around them as they generally experience science in their environment without paying it much attention (Kaptan & Timurlenk, 2012). Additionally, my experience of discussing Bible topics with a small group of people in church led me to employ a similar dialogic approach within a science class size of eighteen to twenty students. Students first discussed the scientific concepts in class by using the existing names for them within their socio-cultural milieu and then translating them into scientific terms. I then gave them additional topics to research at home. Adopting a teaching approach that encouraged interaction between students in classrooms rather than passively receiving transmitted concepts aligns with Vygotsky's socio-cultural perspective on learning and Watkins' third view of learning as building knowledge through doing things with others (Vygotksy, 1986; Watkins, 2005). Such interaction helped achieve my aim of ensuring students made sense of and were able to construct scientific concepts. My interest was also inspired by my experiences (during data collection for my masters dissertation) of observing classes of over ninety students being taught by one teacher in some government secondary schools in Lagos state, Nigeria. I wanted to know how it was possible for students to make sense of science in such a large class.

As discussed in Section 1.2.5, teaching and learning science in a large multi-lingual class can be challenging, especially when coupled with the lack of equipment students needed to perform practical work (Okedeyi et al., 2013). According to Kruckeberg (2006), learning something new depends upon the experience and knowledge one has and brings into the classroom. According to progressive educators, learning itself could be a cultural activity and they suggest that, for students to make sense of science, it needs to be presented to them in a way that is relevant to their prior knowledge (Ogunniyi, 1986). Additionally, the appropriate language used in classrooms, which would enable students to discuss concepts freely, should also be considered.

1.4 STATEMENT OF THE PROBLEM AND RESEARCH QUESTIONS

In this study, it is first proposed that the teachers' implicit views about science are displayed through their teaching methods; hence, the need to explore them.

Secondly, students can be involved in such research by enabling them to discuss their views of what learning science entails and the teaching methods teachers can adopt that would aid their learning of science. Thirdly, it is possible that the teaching methods adopted by teachers within senior secondary schools in Lagos have an influence on students' learning, and this possibility will be explored in this study. Lastly, there has recently been substantial interest in the influence of language on students' learning. To adopt a more nuanced approach, the focus in this study is on the influence of the language of instruction, the language of science, and the use of native languages on students' learning of science.

1.4.1 RESEARCH QUESTIONS

To address the core problem, the following research questions are posed:

1. What are the views of students and teachers in Lagos state secondary schools on the value of learning science?
2. What view of learning is implicit in teaching in Lagos state secondary science classrooms?
3. What are teachers' perceptions on the use of different teaching strategies within Lagos state secondary science classrooms?
4. How is science teaching and learning in Lagos state secondary science classrooms influenced by i) the language of the curriculum, ii) students' native languages, and iii) the language of science?

1.5 OUTLINE OF THE THESIS

To explore the teaching and learning of science, this study is divided into eight chapters. In the current chapter, the thesis is introduced by explaining the background to the educational system in Nigeria and also to my research interest. The core problem is stated and the associated research questions presented. Finally, an overview of the thesis is provided.

Chapter 2 presents the literature review in three parts. In the first part, aims of science education and teachers' and students' views about the teaching and learning of science are explored. In the second part, factors that could be aiding or hindering the learning of science in developing countries with an emphasis on Africa and in particular, Nigeria are examined. Finally, the pedagogical framework underlying the teaching and learning of science in Nigeria is discussed in the third part with a review of the literature on Watkins' theories of learning and Vygotsky's socio-cultural theory of teaching and learning. Furthermore, language issues surrounding the teaching and learning of science in Africa are discussed by examining how teachers teach science in multi-lingual classrooms where the language of instruction is often different from the students' native languages and the language of science.

Chapter 3 discusses the research methodology employed. The rationale behind the study is presented, and the research questions and research design that form the basis of the study are explained. The study adopts a constructionist ontological and interpretivist epistemological paradigm to understand participants' views. The methods described include an account of the pilot study, the sampling techniques employed, the sample sizes, the research context, the design of research methods, ethical issues, and the limitations of the study.

Chapters 4, 5, 6, and 7 present the analysis of the qualitative data and its subsequent findings. Data are analysed and presented thematically. The following broad themes are described in these chapters: teachers' and students' views on the value of science in Chapter 4; students' views on learning in Chapter 5; views of students and teachers regarding the use of language in science classrooms in Chapter 6; and, finally, teachers' views on strategies that aid students' learning and how they enact these in classrooms in Chapter 7.

In Chapter 8, the findings are discussed in relation to the research questions and interpreted with respect to the existing literature. The limitations of the study, practical recommendations, possibilities for further research, and an overall conclusion are then presented and discussed.

CHAPTER TWO

LITERATURE REVIEW ON SCIENCE TEACHING AND LEARNING

2.1 INTRODUCTION

The overall aim of this study is to investigate the teaching and learning of science, with particular reference to the perceptions of teachers and students in Public Senior Secondary schools in Lagos, Nigeria. In this chapter, a review of the literature focuses on existing research on the value of science education, and the role of teaching approaches and language in science classrooms from countries around the world in order to understand the factors that could be aiding/hindering the learning of science in the context of Lagos, Nigeria.

The focus for this study has been chosen because of calls for curricular reforms in science education by researchers in science teaching or other science educators, which point to improving pedagogy, to build a strong foundation for students who wish to follow the science career pathway and to provide knowledge and skills that students can use to solve everyday problems and make decisions (Sarkar & Corrigan, 2014). The call for curricula reforms in science is based on the premise that developments within societies are in no small extent due to contributions that science and technology have made in many fields such as communication, agriculture, medicine, energy and machinery (Furió et al., 2002; Holbrook & Rannikmäe, 2007); hence, the perceived need for continuous learning of science.

To add to the body of knowledge on science education within the context of this study, the first part of this chapter reviews the literature on some key areas. One of these areas is the value of science education to society, discussed in this chapter as the aims of science education. A second area is teachers' and students' views about the teaching and learning of science. The second part describes obstacles to science education in developing countries with a focus on Africa, specifically Nigeria to examine factors that could be aiding/hindering the learning of science in schools. The discussion of the learning of science in Africa concerns teaching approaches adopted in classrooms, science curricula and the relationship between scientific and local indigenous knowledge.

The third part of this chapter discusses the pedagogical framework underlying science teaching and learning in Nigeria. The review of the literature follows Watkins' theories of learning, for reasons that are discussed, and investigates Vygotsky's socio-cultural theory of teaching and learning. Further discussions around the language issues that surround the teaching and learning of science in Africa explore how teachers teach science in a multi-lingual class where students have different home languages from the language of instruction and different again from that of science. In this chapter I explore how these linguistic issues inter-relate with the learning and teaching of science.

2.2 SCIENCE EDUCATION

2.2.1 AIMS OF SCIENCE EDUCATION

Education is considered necessary in any country that is interested in producing citizens who can participate in and contribute to the development of that country. Hence, education is invested in, since people are rated high for their productivity or income generation (McClure, 2014). However, Ozoliņš (2013) expounded the views of Richard Stanley Peters and John Henry Newman, who, amongst others, argue that education is not only about having a successful job but also about acquiring the ability to live a meaningful and fulfilled human life.

To live a fulfilled life entails various factors, such as being able to make reasoned choices, being well nourished with informed ideas, and being able to read, write and communicate, in order to take part in the life of the community (McClure, 2014 citing Sen, 1993). It could also mean living a worthwhile life, which enables humans to understand themselves and how the natural and the social world which they live in works (Ozolin, 2013).

An extension of Ozolin's view is Reiss (2014)'s argument that the central aim of school education should be to enable students to lead flourishing lives and help others do the same. Reiss defined a flourishing life as one in which the individual engages autonomously and wholeheartedly in relationships, experiences and activities. To be autonomous is to be able to make decisions independently and engage in political matters at the local, national and global levels (Reiss, 2014). Another aim of school education situates science as a key element of a school curriculum. Reiss and White (2014) argued that one of the key aims of education is having an understanding of human nature, knowing how social life starts in society and having knowledge of the world in which we live, which entails an understanding of science. Holbrook and Rannikmae (2007) brought forward the notion of being educated through science rather than learning science through education, whereby science becomes the channel through which one gets educated. The inclusion of science in the school curriculum provides scientific backgrounds to students (Reiss & White, 2014) and should therefore have an essential place in schools (DeBoer, 2000).

DeBoer (2000) reiterated the importance of science by claiming that science is part of our intellectual heritage and cultural experience that should be handed over to the younger generations; it provides them with skills and knowledge, which can be used to ascertain the science-related careers they can pursue. On this note, science is linked to the economic development of a nation and this view relates to the human capital argument. Views on how science contributes to the growth of a nation have been expressed by the policy community (Claussen & Osborne, 2013) and by science educators (Jegede, 1997). In addition to this vocational emphasis, a humanistic view advocates for the teaching and learning of science whereby science provides knowledge of how the world works to students; this can help them to become informed about science-related issues in societies and helps them to know the limits of science (DeBoer, 2000). DeBoer further argued that science provides knowledge, which attracts and makes students to develop sympathy towards science and enables them to understand the importance of technology to society and its relationship to science.

Learning science for human capital development and acquiring scientific knowledge for humanistic purpose can be located within Alex Moore (2015)'s delineation of Schiro's four purposes of public schooling. The first purpose (the 'scholar academics' ideology) is that students attend schools to internalise and store academic knowledge that is found accumulated within various subject disciplines. The second purpose (the 'social efficiency' ideology) is for schools to reproduce the curriculum in order to train students to meet the socio-economic needs of the country. This purpose implies training students to have skills and knowledge that can be used for gainful employment and contribute to the economic growth of their nation. These two purposes seem to align with the human capital argument.

Moore (2015) differentiated Schiro's third and fourth purposes of public schooling from the first two. He claimed that the third ('learner centred' ideology) focuses more on the development of the whole being of each unique individual student, by bringing out the best in each student socially, intellectually, emotionally and physically, within an enjoyable and natural school setting. The third purpose relates to the humanistic view, whereby students apply scientific knowledge to live flourishing lives. The fourth purpose (the 'social reconstruction' ideology) is to develop an educated citizenry who will be of vital importance in putting back into society the knowledge and skill acquired from school to bring about a positive and radical change in that society. The intended result of this is that the student will know and reflect on the implications of his/her actions on other people within the society, which suggests that a student influences others to live flourishing lives in a society.

These four purposes of education, as Moore explained, are in a battle with each other within schools for dominance, and the battleground shows itself in various localised education 'wars' (Moore, 2015, p. 151). Consequently, there seems to exist a covert debate and disagreement in different areas regarding what is more important to focus on in schools, which could have spread into various subject disciplines – science amongst them.

Several researchers have expounded on the aims of science education over the years, and these aims seem to fall under the human capital and humanistic arguments of the purposes of education. Wellington (2001) stated two key aims that have evolved from past discussions on the purposes of science education:

- To prepare a minority for science-based careers
- To develop scientifically literate citizens.

These two key aims associate with learning science to live and lead others to live flourishing lives within society. Reiss (2014) in his article on 'What place does science have in an aims-based curriculum?' presents five possible aims of science education as:

- To prepare a minority of students to become scientists
- To enable students to understand the nature and practices of science
- To take up employment in fields related to science
- To make students knowledgeable about choosing the best technological product, which the author refers to as 'science education for consumerism'
- To prepare students to believe that active participation in learning science in and out of school will be beneficial to them, their families and friends by enhancing social justice.

Wellington's two key aims of science education summarised these five aims. The preparation of future citizens for science-based careers was a centre of attention in previous decades because students are taught to acquire scientific knowledge to know about scientific theories, concepts and processes (Furió et al., 2002). Similarly, Roth and Lee (2004) defined the scientific knowledge that students need to know and use in the fields of science-related careers in terms of concepts, theories, principles and models. According to Wellington, the view of schooling and education that people have is to prepare students for the world of work, a view he termed as deferred vocationalism, which is hidden to many parents and students (p. 26). The view of 'science for all' is known to be a utilitarian one and it covers the relevant parts of the science curriculum (Wellington, 2001). And the move in recent years has changed to more of an emphasis on preparing students to achieve scientific and technological literacy, probably due to the need to encourage the valuing and learning of science if 'science for all' is to be promoted (Osborne & Collins, 2001). Hurd (1998) reiterated that science itself is now changing with less emphasis on the development of new laws and theories, an approach that was considered as basic research, to more focus on useful aspects of science/technology that "relates to human welfare, economic development, social progress, and the quality of life" (p. 409).

Regarding discussions on Wellington's first key aim of preparing a minority for science-based careers, Osborne et al. (2003) reported that the dwindling number of students in the United Kingdom making a choice to study science for A-level was becoming a concern for the UK's economic future. The need for science comes from the recognition that life is dependent on sophisticated scientific products, and their usage depends on people who have a high level of scientific and technological knowledge hence, the need to prepare students to take up science-based careers (Osborne et al., 2003; Johnson, 2012). To buttress their views, Osborne et al. presented the findings of Shamos (1995), which showed a relationship between economic performance and the numbers of engineers and scientists within a nation. They concluded by stating that the primary aim of school science is to present a more prospective scientific knowledge that brings about technological advancement rather than offering a backwards-looking view of science that is not exciting to students.

Holbrook and Rannikmäe (2007) argued that science is taught from the perspectives of what scientists regard as important rather than from that of the learners or society because learners are made to act as little scientists. They claimed that although the nature of science education is governed by the curriculum, it is poorly expressed in relation to the goals of education. Scientific knowledge is taught as contents, which are not relevant to students' lives and has resulted in many students finding some aspects of science difficult (Osborne & Collins, 2001).

Johnson (2012) explained that the increase in demand for the quality of life provided by technology has called for the study of science in schools. Johnson stated that despite the dearth in teaching resources, such as laboratories, books and computers, and shortage of qualified teachers in developing countries, students within such contexts respond to taking up scientific careers more than students from developed countries. Johnson attributed the high number of students desiring to pursue science-related careers in developing countries to the good salary that students would have. Supporting the human capital argument and in regards to Nigeria, a developing country, Nwachukwu (2012) mentioned that one of the goals of science education within that context specifies the production of scientists for national development, which suggests that the Nigerian society accepts that science-related careers lead to well-paid occupations, and in the long run will provide the nation with an economic increase. For that reason, Nwachukwu proposed that teachers should teach having this goal in mind when selecting contents to be taught and methods to adopt. In addition, Nwachukwu advocated the need for STEM (Science, Technology, Engineering and Mathematics) professionals within the nation to stay close to teachers to improve science education and scientific literacy. Therefore, it could be concluded that science is learnt within Nigeria for the human capital purpose to raise scientists for technological advancement and for the humanistic purpose of having citizens become scientifically literate. But to what extent are these purposes actualised within that context?

Developing scientific literate citizens is the second key aim of science education (see Wellington, 2001 above), and this aim has been broadly discussed in the literature. According to researchers (Reiss, 2014; Sarkar & Corrigan, 2014) the term 'scientific literacy' does not seem to have a generally accepted meaning, but Laugksch (2000) claimed that the differences in the various meaning of the term may have led to the notion that scientific literacy is not well defined. Scientific literacy can be defined as the ability of students to understand relevant scientific issues (Reiss, 2014) and it is associated with a public understanding of science (Laugksch, 2000), where citizens cognitively use science and technological information to make progress socially and economically in life (Hurd, 1998). According to Reiss and White (2014), many students get fascinated by knowledge, which leads to paid employment and denotes economic progress. Furthermore, DeBoer (2000) stated that scientific literacy shows what people know about science so that they can live more effectively in the natural world. Living effectively in the natural world correlates with Ozolin (2013)'s definition of living a worthwhile life.

Furió et al. (2002) claimed that the need for scientific literacy in schools is one of the issues that has been pointed out in some countries that are working toward reforming their educational systems, and they cite Spain as one of those countries. They stated that the move towards scientific literacy is due to the need to incorporate social and personal aspects of students' lives in the curriculum. Therefore, the authors carried out an experimental design study using a mixed-method approach (questionnaires and interviews) on 58 chemistry and physics teachers in Spain to know their views regarding the goals of science education. The result showed that most of the teachers who participated in the investigation gave priority to preparing students for higher courses in science, while there was an absence of making scientific literacy a core reason for teaching science. The teachers believe that by giving priority to and explicitly focusing on teaching scientific knowledge to students, scientific literacy can be achieved. The authors' findings could be suggested to be evidence of the unpopularity of the aim of scientific literacy within that context of research.

Holbrook and Rannikmäe (2007) considered improving scientific literacy as the aim of teaching of science in school and put forward a model for the nature of science education that will prepare students for scientific literacy. They asserted that enhancing scientific literacy should be the main driving force for science education, allowing students to gain the skills that will enable them to act as responsible citizens in society, function within workplaces and obtain conceptual knowledge and associated skills, giving them a proper public understanding of science.

Sadler and Zeidler (2009) situated the meaning of scientific literacy in the progressive science education movement where it is believed that literacy in science should involve having an understanding of science and integrating science practices in real life, science-related situations. They referred to Roberts' (2007) review of scientific literacy as a foundation on which to build their idea of scientific literacy, and they explicated his two visions of scientific literacy. These are Vision I, which reflects the notion that scientific literacy should promote scientific concepts and processes, thereby helping students to develop a rich understanding of scientific discoveries, skills and processes used within the sciences, and Vision II, which focuses on understanding and using science in making decisions in real-life situations that relate to science, or on socio-scientific issues. They juxtaposed their notion of scientific literacy (as defined by the Socio-Scientific Issues (SSIs) framework) and show similarities to Roberts' Vision II idea, with the PISA program showing the link between both agendas in the application of scientific concepts in real-life situations, in the understanding of the nature of science and how science interacts with society and in the willingness of students to engage with science-related issues. However, Sadler and Zeidler stated that the PISA assessment does not offer support for the promotion of socio-scientific discourses, despite featuring low-level representations of content knowledge. Therefore, they suggested to educators and policymakers that in considering data or results from the PISA assessment in supporting the development of scientific literacy, they should also try to understand its limitations (Sadler & Zeidler, 2009).

Students find science interesting when the content relates to their personal lives (Osborne & Collins, 2001) and shows how science interacts with society. Sadler and Zeidler (2009) explained that content that focuses on socio-scientific issues enable students to reason, reflect, engage socially and give them agency in class. However, Reiss (2014) pointed out that such content is generally regarded as being of lower intellectual worth. Nevertheless, Reiss proposed that schools should teach science that is of relevance to the learners. Therefore, one could suggest that content that focuses on scientific literacy in schools encloses the humanistic argument of education.

There have been further critiques of scientific literacy in the literature. Donnelly (2004) claimed that the inclusion of humanistic characteristics in the science curriculum has weakened the scientific content because there is a risk of losing what natural science stands for; this can result in science educators not having faith in science as a legitimate body of knowledge. He described the drive for curriculum reform as a "humanizing project" (p. 778) and called for the reinstating of the legitimacy of the natural sciences as a body of knowledge and the educational purposes it can serve if adequately taught. He concluded that if the humanistic characteristics will be acknowledged, then its methods and limits needed to be appropriately outlined and addressed to avoid weakening the purposes of science education in the curriculum.

Other researchers (Millar, 2014; Rudolph & Horibe, 2016) have called for the science curriculum to align with the goals of science education so that students having different needs and interest can be engaged in schools. Similarly, Reiss (2014) argued that a science curriculum should include how scientific knowledge is achieved and its limits, and should provide applied material that will inform students practically about the uses of scientific knowledge in employment. In taking into account the views of policymakers, science educators, academic researchers and teachers who belong to the educational community, it is clear that the recent focus in some parts of the world has not only been on producing scientists but also on promoting scientifically literate students. Nevertheless, the approach of making the curriculum less focused on 'pure knowledge' and more geared towards concepts that relate to students' lives seems commendable in the sense that it should help students who do not want to proceed with science careers. However, the knowledge gained in such a curriculum might not be adequate to prepare those capable of continuing with science-related careers in terms of processes and contents.

Wellington (2001) examined the tensions that have evolved in discussions on these aims in the past and suggests a framework to build on these aims and justify what science education is for. He stated that one aspect of the aim should not be stressed over the other. He constructed a framework based on three sets of arguments: intrinsic, citizenship and utilitarian values. Similarly, Millar (2014) stated that there are four arguments presented to explain what school science is for and why it is taught: economic, utilitarian, democratic and cultural.

According to Wellington (2001), the intrinsic value of science education expounds the need to satisfy one's curiosity by making sense of the world we live in. It also promotes science as being a part of past and modern culture that should be known and understood to enable a person to be cultured and educated. Although Wellington mentioned that science is a global activity, he acknowledged the variance that might occur as it is taken on board in different nations or cultures. Part of the intrinsic value is pronounced in Millar (2014)'s cultural argument, primarily where science promotes an understanding of how the earth we live in works. Furthermore, the cultural argument for learning science involves the application of scientific knowledge in using technological products, having medical treatments and understanding the structure of the universe and how we as humans connect with other living organisms and non-living things (Millar, 2014).

The citizenship value of science education reveals how acquired scientific knowledge can enable individuals to participate democratically in their society by making decisions on issues that involve debates (Wellington, 2001). Reiterating this view is Kolstø (2008), who declared that science education for citizenship shows the relevance of science in society because it prepares students to become active, informed and responsible citizens. The democratic argument brought forward by Millar (2014) agrees with Wellington's citizenship value of learning science. According to Millar (2014), the democratic argument entails the use of science ideas by citizens to understand and autonomously engage in discussions and debate about scientific issues that they encounter daily and to have informed views of how such issues impact on their lives. For example, the moves by any government to use environmental-friendly hybrid buses/cars that make less use of hydrocarbon fuels within cities, in a bid to control the emission of carbon dioxide into the atmosphere and thus reduce global warming, must be understood and consented to by the people in that country. A lack of public consent on such environmental policies would mean that such government policies might be unpopular, even unsuccessful, whereas a high-quality science curriculum might enable people to understand and cooperate with the government on such an issue.

The utilitarian value of science explains the usefulness of science either for vocations as scientists or for non-science career paths, for the development of transferable skills such as taking accurate measurements, recording results, tabulating data, analysing them, forming hypotheses, engaging in problem-solving and so forth, and also for developing scientific attitudes (Wellington, 2001). Characteristics of scientific attitudes have been identified by Gauld (1982) as being objective, open-minded, intellectually honest, and willing to suspend judgment if there is insufficient evidence.

These characteristics aid scientists' ways of working as stated in the citizenship argument because evidence supports their claims and prevents them from relying only on their perceptions, which may be subjective. Both Wellington and Gauld agree that developing scientific attitudes would be of direct value in life and work.

In recognition of the utility value of science, Osborne and Collins (2001) reported on students' views, which depict scientific knowledge as what they gain in terms of knowing more about the world, their bodies and how to use technological products like appliances. However, as the authors explained, this view does not show that the students can differentiate between science and technology. In addition to the utility value, students express the value of learning science to gain prestige in terms of academic status and lucrative careers, due to the notion that taking science means that one is intelligent.

Osborne and Collins (2001) claimed that science has a marketing problem, because most of the students from schools in the UK that participated in the study they carried out generally had no knowledge of the wide range of occupations that science can be used for (aside from the well-known ones such as medicine, engineering, pharmacy and so forth). Hence, they proposed that to improve science education, the National Curriculum should give teachers room to interpret it by making a choice and selection of content, which means that competent and confident teachers would need to be recruited and retained in schools. Furthermore, they suggested having a system of assessment that will suitably reflect the aims of science education written into the curriculum. Other researchers (e.g. Archer et al., 2015) mentioned students' views that science is regarded as being for clever students, which can lead to students who cannot pursue science being stigmatised as not being clever. Meanwhile, Archer et al. argued that this notion is produced through the institutional practices of concentrating those from less privileged social groups in schools and areas that are under-resourced. Students in their study perceived a narrowness of pathways from school science (as students in Osborne and Collins' (2001) study did), where students do not know the cultural significance of science. Therefore, they supported the idea that students and their families should be enlightened regarding the various occupations that require science qualifications, which could inspire students to know how science is relevant to them and to their futures.

Science's usefulness also contributes to the economic growth of a nation. Millar (2014)'s economic argument shows that students employed in science-related fields attract high remuneration and contributes to the economic success of a country. Likewise, scientists' innovations and production of technological products would position a nation on an excellent rating in the economic market when compared with other countries. Millar (2014)'s utilitarian argument also explained that science is useful for learning how to safely and skillfully utilise objects of historical interest, and for making decisions regarding health, diet and lifestyle matters. The ability to make decisions about one's wellbeing, to take care of oneself and eat healthy and balanced meals is aided by the knowledge of science, and this will lead to a high level of productivity.

Wellington's three sets of argument and Millar's four arguments build on Wellington's two key aims of science education because they connect the scientific knowledge acquired in schools to the everyday lives of people in societies. Millar (2014) suggested, after explaining the four arguments, that the focus of curriculum reformers in the UK should be on providing more demanding academic goals for students who are best able to follow a science career pathway, while an alternative curriculum would be provided for those who want to pursue technical and non-science career pathways. On the contrary, rather than have separate curricula, Rudolph and Horibe (2016) called for the school curriculum to extend beyond the conceptual knowledge to cover the social and political learning outcomes and cater for the different science and technological needs of society. Also, Symington and Tyler (2003) recommended that the science curriculum should be reformed to enable students to feel comfortable learning science rather than feeling threatened.
Le'na (2012) stated arguments for the support for early science education for all pupils, which are similar to that of Wellington and Millar. Le'na claimed that the first task within the science community is to design a school curriculum in science that will include what science is and its social uses keeping in mind the goals for learning science. The second task is to improve the quality of teachers' relationships with the scientific community to improve the way they teach science.

Therefore, considering these arguments, this study supports the call for a focus on the teaching and learning of science, since science learned in schools is very valuable to students and societies at large. In addition, ascertaining teachers and students' views about teaching and learning of science will shed light on how schools can successfully produce both future scientists and scientifically literate citizens (Sarkar & Corrigan, 2014).

2.2.2 TEACHERS' AND STUDENTS' VIEWS ABOUT THE TEACHING AND LEARNING OF SCIENCE

A view is described as an interaction between what someone knows about something and the beliefs about that thing (Crawford, 2007). In this study, a review of the literature on teacher's and students' views features conceptions and beliefs about teaching and learning. Beliefs, according to Savasci and Berlin (2012), are inclinations to actions that lead to behaviour and they define beliefs as "one's convictions, philosophy, tenets, or opinions about teaching and learning" (p. 66). The focus on teachers' beliefs is based on the premise that these beliefs guide teachers' practice (Wellington, 2001) and various studies have examined teachers' beliefs, and how these beliefs influence their teaching of science (Hewson & Hewson, 1987; Shumba, 1999; King et al., 2001; Furió et al., 2002; Tsai, 2002; Water-Adams, 2006; Lotter et al., 2007; Schroeder et al., 2011; Savasci & Berlin, 2012).

Teachers' beliefs about students' learning ability contribute to students' achievement (King et al., 2001). Teachers in the King et al. study did not believe that their students could learn "higher-order disciplines" (p. 90), which shows a link between teachers' beliefs about students' attitudes and academic performance, and teachers' practice. However, teachers' limited professional and content knowledge, which did not allow them to understand what their students knew about science, could explain why teachers believed that their students could not learn high-order disciplines (King et al., 2001).

Other teachers' beliefs focus on teaching, learning and the nature of science. Tsai (2002)'s exploration of the beliefs of 37 Taiwanese teachers classifies teachers' beliefs about teaching science, learning science and the nature of science as traditional, process or constructivist. The findings showed that most of the teachers have their beliefs about teaching, learning and the nature of science closely associated; hence, he terms this as 'nested epistemologies' (p. 771). Most of the teachers in Tsai (2002)'s study held traditional beliefs about teaching, learning and the nature of science, which entailed students acquiring scientific knowledge from credible sources through memorising formulae, facts and definitions, copying what teachers do, and listening passively in the classroom. These learning approaches entail lower-level thinking skills (Hsieh & Tsai, 2017). Very few teachers held the process belief (which includes discovering knowledge through scientific methods) or constructivist belief (which entails constructing knowledge through social negotiations), and Tsai attributed teachers' beliefs to how they themselves had been taught science in school. Since the teachers had been successful through traditional teaching, they will not have seen the need to develop process- or constructivist-oriented ideas about teaching, learning and the nature of science. Another reason for their traditional beliefs could be their view of their roles to prepare students for higher studies (Furió et al., 2002). Tsai claimed that since the teachers' beliefs are nested, then changing their beliefs about science would mean changing their beliefs about its teaching and learning, and vice-versa. Tsai recommended that researchers should look for how to change teachers' beliefs of teaching and learning by making them develop an understanding of constructivist epistemologies.

An investigation carried out by Water-Adams (2006) looked into the relationship between science teachers' beliefs about the nature of science and their practice in Devon, England. The findings showed that teachers were confident about their success as teachers when their beliefs were consistent across how they should teach science, their actual teaching and their understanding of science. This suggests that being confident and having a productive practice does not only depend on having adequate knowledge of science content but also on inner beliefs.

Schroeder et al. (2011) investigated the relationship between teachers' pedagogical beliefs and what students report about their engagement in reading texts with instructional pictures. The ability to read texts with instructional pictures is a high cognition activity, which many students find challenging, and teachers are generally not aware of this. Schroeder et al. conceptualised students' motivation to learn from instructional pictures as engagement. They reported that the more teachers believe in utilising texts that have instructional pictures in the classroom, the more the students engaged in their learning. Teachers' instructional behaviour mediates the relationship between teachers' beliefs and students' engagement. Therefore, students would find this task easier if teachers would provide the instruction that would connect text to pictures.

Savasci and Berlin (2012) examined four science teachers' beliefs and their classroom practices related to constructivism. The researchers listed the constructivist components as the active construction of knowledge, students having a critical voice (and this helps them to be engaged), and students having shared control of the learning environment by selecting learning activities and what is assessed. From their findings, they reported that the class activities they observed – lectures, the use of worksheets and videos/demonstrations, which are all individual activities – are teacher-centered and are not related to constructivist approaches. Moreover, what distinguishes science from most other subjects is that students come into direct contact with the phenomena and do not rely on what teachers tell them or what they read in books (Oliver & Nichols, 1998). Students' reliance on what teachers convey in class is traditional and does not match what teachers express as their constructivist beliefs (Savasci & Berlin, 2012). Researchers (King et al., 2001; Tsai, 2002) have claimed that teachers' lack of training makes them not have constructivist beliefs and they have called for teacher education to prepare teachers to develop higher-order cognitive skills in students.

Teachers might have different beliefs from such researchers about learning science. Hewson and Hewson (1987) encouraged teachers to incorporate their views of learning scientific concepts as conceptual change into their views of teaching.

However, teachers have alternative beliefs about learning, and these beliefs might not allow teachers to adopt the appropriate methods. Therefore, Hewson and Hewson (1987) recommended developing a conceptual change model, which would provide guidelines for deciding the right teacher education activities to practise in the classroom, and that teacher education should recognise teachers' different views of learning.

Various studies show a mismatch between what teachers express as their beliefs about teaching and learning and what they practise in classrooms. King et al. (2001), using a case study method, examined four science teachers' beliefs about their classroom and students and their practices. Their findings indicated that teachers believed that they were adopting the inquiry-based approach, such as facilitating lessons and allowing students to do hands-on class activities, but the approach observed was more traditional. Similarly, Savasci and Berlin (2012) reported that most of the teachers they studied believe that science concepts should relate to students' lives outside the school to promote a positive attitude and to aid their understanding. However, the observations carried out in their study show that teachers implement a teacher-centered, traditional method in the classrooms. In these two different scenarios, could it be possible that these teachers are not aware that their stated beliefs do not align with their practice (Pimentel & McNeill, 2013)? Different reasons might explain the mismatch between teachers' beliefs and their practices, some of which are described below.

Limitations in the professional and content-area knowledge of teachers are some of the reasons for the mismatch in teachers' beliefs and what they practise in classrooms (King et al., 2001). These limitations have come up due to the insufficient academic preparation of teachers. King et al. (2001) therefore recommended that teachers should receive site-based effective staff development so that they can practise their beliefs of useful teaching approaches. Based on studies that have explored the relationship between professional development and teaching practice, Osisioma and Onyia (2009) stated that teachers should receive training to enable them to put their beliefs into practice. However, Pimentel and McNeill (2013) reported that despite the teachers' participation in professional development and focusing on adopting more student-centered teaching approaches, all the teachers after that training program still took on the authoritative approach in the classrooms. The professional training had little impact on teachers' practice.

The teachers in Pimentel and McNeill (2013) asserted that student factors such as their lack of knowledge and experience of a scientific concept, and their resistance, restrict them (the teachers) from allowing students to interact socially and construct knowledge. Some other researchers identify students' behaviour problems as one of the barriers facing teachers in the classrooms (King et al., 2001), which makes it challenging for them to implement their constructivist beliefs (Savasci & Berlin, 2012). One could understand why teachers comment on students' behaviour because improving students' knowledge in a subject can be hampered when students' behaviour in the classroom is problematic. Inadequate materials such as books, computers, faulty equipment, and poor infrastructure in schools to teach science, also limit teachers' practice (King et al., 2001; Johnson, 2012). Lack of funds to purchase science equipment for schools contributes to the inadequate teaching in schools (Nwachukwu, 2012).

Other research shows that teachers' beliefs and practices need to align with students' personal goals in order to engage them in the classroom (Schroeder et al., 2011). Personal goals could be students' interest in science, which offers satisfaction to them and, if maintained, would make students get motivated to study science (DeBoer, 2000; Logan & Skamp, 2013). It could mean the goals of developing skills and attitudes, which can be used for higher studies in science and in future careers (Laugksch, 2000; Symington & Tyler, 2003; Rudolph & Horibe, 2016). The teacher can know students' personal goals if students are allowed to talk and share their experiences during lessons.

Time pressure makes it difficult for teachers to give room for students to talk and explore ideas during lessons. Teachers are under pressure to cover the curriculum and prepare students for a standardised test (Pimentel & McNeill, 2013), which make class activities more likely to be teacher-centered rather than student-centered (Savasci & Berlin, 2012). A teacher-centered lesson turns students into passive recipients of science content rather than active inquirers; passive recipients forget a large proportion of what they have learned after sitting for examinations (Hurd, 1998). Although teachers might know of student-centered teaching practices, their conceptions of science, their views about students' capabilities, their ideas about effective teaching and their conceptions of the purpose of education could influence the extent of such practices that they adopt in the classrooms (Lotter et al., 2007). If teachers' conceptions of students and how to teach them are not related to their professional development goals, they are not able to make changes to their practice (Lotter et al., 2007). Listening to students speak about their experiences of science and how they can effectively learn science could increase teachers' knowledge of such students, and help them to make decisions about teaching methods that would actualise students' learning in the classroom.

Students' beliefs, knowledge, worldviews and prior experiences are crucial to their learning (Murphy et al., 2012). Tsai (2004) claimed that much recognition and research by educators and psychologists has focused on students' conceptions of learning due to the influence of such conceptions on students' learning approaches, which then results in their learning outcomes. One of the classic studies conducted to look into why relatively few students choose to study science for A-level is that of Osborne and Collins (2001) carried out in the United Kingdom. The findings of their study showed students' views of their dissatisfaction with the school science curriculum. The students declared that they find science difficult to comprehend due to the following: the words and language of science are not familiar to them and some are mathematical; teachers rush them through the contents of the science curriculum; students copy notes and are not actively participating during lessons; teachers do not explain topics clearly to students. Hence, students do not find any similarities between physics, chemistry and biology. Osborne and Collins mentioned that students would like their teachers to use fun teaching methods, and engage them during lessons so that their level of achievement would improve and their confidence to study science grow. Similarly, Braund and Reiss (2006) argued for more opportunities for students to learn science outside the classroom by going on field trips since school science imposes limits on learning activities such as only carrying out experiments in school laboratories. Osborne and Collins (2001) concluded that science content should connect to students' everyday experiences so that students can find science exciting and make a more informed choice as to whether or not to study science. Such connection can be useful and made possible when teachers take cognisance of the impact scientific language and mathematical symbols have on students' learning.

Tsai (2004) carried out a study using a phenomenographic method (a combination of interviews, protocol and discourse analyses) to find out Taiwanese 11th and 12th-grade students' conceptions of learning. From the findings, Tsai reported students' seven conceptions of learning science as memorising, preparing for testing, calculating and practising tutorial problems, increase of knowledge, applying received knowledge, understanding and making sense of acquired scientific knowledge, and learning science to see nature in a new way. Tsai explained that the first four of these students' conceptions of learning are quantitative because they focus on how much is learned, which shows an accumulation and retention of scientific content. As a result, students are likely to adopt surface approaches to learn. Tsai claimed that students have formed these conceptions due to the role played by tests in schools and at the national level in Taiwan to show students' performance. The last three of the conceptions are qualitative, and they depict how well students have learned science, and require them to use deeper approaches to learn science. Tsai (2004) concluded that teachers' conceptions of learning are likely to influence students' conceptions of learning and suggests that further studies should compare teachers' conceptions of learning with those of the students.

Watters and Watters (2007) expounded on the relationship between students' approaches to learning, epistemological beliefs about learning and achievement, and achievement. They reported that students using a deep approach to learning will generate ideas quickly, give explanations by referring to relevant daily life experiences to understand a phenomenon, ask questions to unveil any discrepancies in knowledge, reflectively think through the task at hand to appraise it and, in the approach to the task, tend to think ahead and predict outcomes. On the other hand, the surface approach learner tends to give up thinking more quickly, gives explanations that reformulate the question, asks questions that mainly recall information, reflects less on the learning process and task, and gives up easily on tasks that are challenging. Hence, they suggested that teachers should emphasise problem-solving skills to students without too much content, use teaching approaches that will encourage students' reconciliation of their pre-existing beliefs with a new experience of science, and make students place less importance on learning by rote and memorisation (Watters & Watters, 2007).

In Australia, Logan and Skamp (2013) examined students' views about science and why the number of students choosing science and pursuing science as a career is declining. These researchers reported findings, which are consistent with those of Osborne and Collins (2001), although carried out in different contexts (Australia and England). The Australian students claimed that school science is not having a positive impact on their interest in science because they do not have fun lessons, their teachers do not give adequate explanations but instead repeat and rush through content, teachers give them notes to copy and the school science does not relate to real-world issues which are relevant to their lives. Therefore, Logan and Skamp suggested that teachers should pay attention to students' voices so that they can plan lessons that are more engaging, that involve doing practical and make use of visual aids, computer simulations and novel demonstrations. They make such recommendations based on the premise that teachers play essential roles in inspiring and encouraging students to study science.

Hsieh and Tsai (2017) carried out a study exploring 906 Taiwanese 4th-12th grade level students' views about science learning using drawing analysis. They reported that the lower-grade level students hold the views that school science involves teachers lecturing while the higher-grade level students show science learning as memorising, testing, calculating and increased knowledge. Hsieh and Tsai categorised students' views using some of Tsai (2004)'s seven conceptions of students' learning.

They stated that the conceptions of science learning held by the higher-grade level students are of lower-level thinking skills because these conceptions focus more on reproducing and knowing. They proposed that it is vital for students to develop higher-order thinking skills such as critical thinking so that they will know how well they have learned science rather than how much of science they have learned.

A recent study by Vossen et al. (2018) in the Netherlands examined 1,625 grade 8 and 11 students' views about doing research and design activities using questionnaires. The students are in two groups; one group involves students who performed the research and design projects (also called Dutch subject) and relate to STEM, while the second group did not take the Dutch subject. The Dutch subject is context-based, and uses inquiry, design and projects as learning practices. From the findings, Vossen et al. concluded that the students' involvement in the Dutch subject might have made them develop their positive attitudes toward research and design activities. Besides, allowing students to control their learning in this study could be said to be beneficial to the students by contributing to their positive attitudes toward the Dutch subject. Therefore, Vossen et al. argued that teachers and science teacher educators should use the students' views presented in their study to improve students' confidence and attitudes in conducting research and design activities.

So far in this section, teachers and students' beliefs about science and of learning science have been explored in the literature. The findings of the studies emphasised the crucial role of teachers' practices in the classrooms in making students enjoy learning science. Teaching to arouse students' science interest and satisfy the aims of science education of producing future scientists and science-literate citizens will require an active form of learning, where students are socially involved in deep exploration of their prior ideas and connect these with the new scientific ideas they encounter in the classroom (Lemke, 2001; Watkins, 2005; Watters & Watters, 2007). This view of learning science is socio-cultural, where there is a dynamic exchange and negotiation of ideas when the cultural understanding of the student interplays with the cultural practices of the scientific community (Meyer & Crawford, 2011). It signifies a move away from a traditional form of teaching that lacks this sort of social activity and calls for teaching practices that could promote the learning process. On this note, more cognitively orientated scholars have taken into consideration the role of social and cultural factors in the learning of scientific knowledge (Mason, 2007) and requested that a curriculum and pedagogy that will satisfy the needs of learners should be developed and implemented (Wee, 2012). At the same time, the demands of scientific terminology, which teachers employ in the classroom and is often unfamiliar to students (Osborne & Collins, 2001), do not seem to have gained enough recognition as a possible factor that could impede teachers' effectiveness of practising their beliefs of teaching science and students' comprehension of such concepts.

Too often, science learning associates with the Western ways of knowledge (Meyer & Crawford, 2011), and there is a need for its integration into the culture within any context where it is studied. Students from other cultures, such as African ones, who will learn science will necessarily be influenced culturally by their beliefs, background and values and their society's take on science, all of which will inform and affect their learning of it (Lemke, 2001). Thus, there is an important need to consider factors that could be aiding/hindering the learning of science in schools within other cultures.

2.3 SCIENCE EDUCATION IN DEVELOPING COUNTRIES: A FOCUS ON AFRICA AND NIGERIA

2.3.1 STATE OF SCIENCE EDUCATION IN AFRICA AND NIGERIA

Science is given an elite status in most developing countries because of its importance for industrialisation and the production of technological products (Lewin, 1992). Furthermore, science education in Africa is seen as reducing the massive educational poverty, especially within the Sub-Saharan region (Koosimile & Suping, 2015). Agbowuro et al. (2015) claimed that modern societies depend on science and established technology, and, on this basis, people having scientific qualifications and a public who are scientifically literate are needed. The demand for scientists could have led to the status it enjoys within Africa. However, there is a poor state of science, technology and mathematics (STM) education in most African countries (Ogunniyi, 1996) despite its elite status.

An emphasis on Nigeria (the context of this study) shows that despite the increase in the need for science and technology knowledge, there has been no increase in the basic understanding of scientific ideas and ways of thinking in schools (Agbowuro et al., 2015). Consequently, students perform poorly in science in the National examination (Ogunniyi, 1996; Omorogbe & Ewansiha, 2013). To buttress this claim, Agboghoroma and Oyovwi (2015) outlined the performance of students in biology, chemistry and physics in the National Examination Council (NECO) between 2001 and 2006. From the NECO results shown by Agboghoroma and Oyovwi, the percentages of students who failed the three science subjects were:

49% of 917,992 students failed biology

46% of 284,249 students failed chemistry

45% of 275,728 students failed physics.

Yusha'u (2014) corroborated Agboghoroma and Oyovwi's (2015) claim. Yusha'u cited the 2011/2012 NECO results, which showed that 73,486 students (71%) failed biology, 37,973 students (78%) failed chemistry and 43,905 students (90%) failed physics. These results show that students' mass failure in science is still on-going within Nigeria's context, and it reveals the extent to which students lack an understanding of the fundamental knowledge of science.

Researchers have tried to understand the reasons for students' poor achievement in science in developing countries. Walberg (1991) reviewed past research on science education in low- and middle-income countries. He concluded that the over-emphasis on boosting the economy in many developing countries has led to a failed allocation of resources to secondary and higher education. In contrast, primary education is left out. Walberg claimed that planning in the scientific and technological sector in low-income countries is wasteful and unbalanced because there is an emphasis on the pursuit of scientific discovery and status. He called this pursuit, *high science* (p. 30) because it has little regard for human needs and concerns. Consequently, the adaptation of education to employing workers for scientific and technological development has not taken place. Lewin (1993) argued that any discussion about science education in developing countries should take cognisance of the economic conditions that foster resources used for public-funded schools. He said this to explain why most students in primary and secondary levels have little or no access to science education despite the high rate of enrolments in both levels of education. Walberg (1991) and Lewin (1993) highlighted the lack of adequate funding and unbalanced allocation of resources by the government as factors underlying the poor state of science education within developing countries. A recent study by Okedeyi et al (2013) in Nigeria corroborated the continued existence of reduced funding and its effect on schools. The allocated resources are unbalanced because the government has been focusing more on producing scientists than on having citizens who are scientifically literate. In this chapter, I explain how inadequate funding contributes to some barriers facing the teaching and learning of science within Africa, with a focus on Nigeria.

2.3.1.1 INADEQUATE FUNDING

Insufficient financing of the educational sector has persisted over the years within Africa. An early study (Okebukola, 1986) showed that a low budget allocation to the educational sectors and science education has led to a deficient supply of learning aids and equipment. Ogunniyi (1996) advised that the government of countries in Africa should stop paying lip service to the provision of teaching and learning aids in schools, but should adequately fund schools. He attested to the inadequate facilities found in African schools for the teaching of science. Recently, Okedeyi et al. (2013) attested that poor funding has resulted in too little equipment and poorly equipped laboratories, poor classroom environments and large classes. Table 2.1 shows the budget in Nigeria from 2013 to 2020 and funds allocated to the educational sector, which includes the Universal Basic Education (UBE). The UBE was re-launched in 1999 and it is still in place to provide free education so that all citizens can be literate and acquire numerical, communicative and life skills (Moja, 2000; Mohammed, 2013).

Table 2.1 Nigerian budget and funds allocated to Education sector and Universal Basic Education (UBE)

YEAR	FINANCIAL BUDGET AMOUNT (NAIRA)[11]	AMOUNT ALLOCATED TO EDUCATION SECTOR (NAIRA)	% OF ALLOCATION TO EDUCATION SECTOR OUT OF TOTAL BUDGET	AMOUNT ALLOCATED TO UBE FROM EDUCATION BUDGET IN NAIRA AND PERCENTAGE
2013	4.92 trillion Naira[12]	509,039,713,761[13]	10.3%	80,722,811,000 15.9%
2014	4.962 trillion Naira[14]	495,283,130,268[15]	10.0%	75,822,000,000 15.3%
2015	4.5 trillion Naira[16]	483,183,784,654[17]	10.7%	71,636,000,000 14.8%
2016	6.08 trillion Naira[18]	480,278,214,688[19]	7.9%	79,038,271,348 16.5%
2017	7.44 trillion Naira[20]	540,443,102,615[21]	7.3%	100,626,414,385 18.6%
2018	9.12 trillion Naira[22]	651,226,697,523[23]	7.1%	131,114,663,323 20.1%
2019	8.92 trillion Naira[24]	634,557,159,877[25]	7.1%	121,924,903,544 19.2%
2020	10.59 trillion Naira[26]	686,821,431,517[27]	6.5%	137,968,437,633 20.1%

[11] Exchange rate of 431.950 Naira to 1 GBP (https://www1.oanda.com/currency/converter/)
[12] https://www.vanguardngr.com/2012/10/jonathan-presents-2013-budget/
[13] https://budgetoffice.gov.ng/index.php/2013-budget?task=document.viewdoc&id=514
[14] https://www.premiumtimesng.com/business/161390-jonathan-signs-nigerias-2014-budget-defence-gets-20-per-cent.html https://www.reuters.com/article/nigeria-budget/nigerias-outgoing-president-approves-2015-budget-idUSL5N0YB49M20150520
[15] https://www.budgetoffice.gov.ng/index.php/2014-budget?task=document.viewdoc&id=129
[16] https://www.reuters.com/article/nigeria-budget/nigerias-outgoing-president-approves-2015-budget-idUSL5N0YB49M20150520
[17] https://www.budgetoffice.gov.ng/index.php/2015-budget?task=document.viewdoc&id=67
[18] https://www.dw.com/en/buharis-2016-budget-for-nigeria-released/a-18934977
[19] https://www.budgetoffice.gov.ng/index.php/2016-budget?task=document.viewdoc&id=32
[20] https://www.premiumtimesng.com/news/headlines/230973-breaking-national-assembly-passes-2017-budget.html
[21] https://www.budgetoffice.gov.ng/index.php/2017-approved-budget?task=document.viewdoc&id=620
[22] https://www.reuters.com/article/nigeria-budget/update-2-nigerias-parliament-passes-record-912-trln-naira-2018-budget-idUSL5N1SN5Y6
[23] https://budgetoffice.gov.ng/index.php/2018-approved-budget-details?task=document.viewdoc&id=681
[24] https://www.mondaq.com/Nigeria/Finance-and-Banking/814592/Federal-Government-Of-Nigeria39s-2019-Budget-Signed-Into-Law
[25] https://budgetoffice.gov.ng/index.php/2019-budget?task=document.viewdoc&id=710
[26] https://www.aljazeera.com/ajimpact/nigeria-parliament-passes-record-budget-2020-191205181608971.html
[27] https://www.budgetoffice.gov.ng/index.php/2020-approved-budget-details?task=document.viewdoc&id=750

As shown in Table 2.1, an average of 8.4% of the budget from 2013 to 2020 goes to funding the education sector, out of which an average of 17.6% is spent on Universal Basic Education. Overall, the amount allocated to provide free education every year is relatively small if compared to the total budget allocated for the running of the whole Federation, which indicates that the government is yet to give substantial emphasis to the education of its citizens. Low funding of the educational system within Africa has impacted on the teaching and learning of science within that context as discussed below.

2.3.1.1.1 Impact on provision of materials, equipment and infrastructure

In this study materials are categorised as textbooks, chemicals, and other items such as dusters, board markers etc. Equipment includes beakers, microscopes, measuring flasks, scales, burettes, pipettes, and other apparatus used within the science laboratory. Objects such as science laboratories, classrooms, chairs, desks and storage cupboards constitute the infrastructure.

Back in 1993, Lewin asserted that lack of funding made it impossible to provide well-equipped laboratories in developing countries. To this day, students within the African context face this challenge in addition to finding science difficult (Badmus & Omosewo, 2018), which makes learning for them an arduous experience. Agbowuro et al. (2015) claimed that the lack of resources has resulted in many students learning science by memorisation, which they find boring. Hence, a large number of students are not learning science in schools. Bajah (1985) revealed the public view of science in Nigeria as static because it relates to the study of accumulated facts, which will not prepare students for the future and will not promote the development of science and technology. Bajah mentioned that the public holds this view because of the inadequate funding of schools in Nigeria. Inadequate provision of materials, equipment and infrastructure influences teachers' choice of the teaching method they adopt in classrooms.

Ogunniyi and Rollnick (2015) point out that despite teachers' realisation that students' active participation in classrooms aids their learning, they persistently choose the transmission method because of large class and shortage of resources. The causes of large classes are the high rate of enrolment of students into schools within developing countries (Walberg, 1991; Lewin, 1993) and low funding. The issue of large classes and inadequate resources pose a challenge for teachers to implement interactive teaching strategies based on social constructivist theory in the classrooms (Hardman et al., 2008). In the Nigerian public secondary schools context, where there are large class sizes (Mohammed, 2013), the ability of teachers to perform practical activities with the students is questionable due to the non-availability of well-equipped laboratories. Teachers within that context improvise some of the science apparatus (like plastic bottles cut into two to replace beakers), and they provide some materials themselves (Mohammed, 2013). Although doing practical work could produce satisfactory feelings, the mere presence of science laboratories do not relate to a boost in student achievement (Walberg, 1991). Walberg's statement suggests that it is not only the availability of materials and infrastructure that determines students' success but how teachers utilise them effectively in schools to aid students' learning.

2.3.1.1.2 Teacher quality and the impact on retaining well-trained teachers

Many teachers in low-income countries lack knowledge and skills of science; hence, they hold serious misconceptions about science (Walberg, 1991). As a result, school science is generally badly taught because teachers lack knowledge and skills of science. The teaching of science, which has specific and abstract concepts and modes of communication, by under-qualified teachers makes students find science difficult to comprehend, and this leads to a high rate of student failure (Walberg, 1991). Poor science teaching has been attributed to the wide gap between the demand and supply of qualified science teachers within Nigeria, a situation that continues today (Ogunniyi & Rollnick, 2015). Badmus and Omosewo (2018) reiterated the challenges facing science education in Nigeria as inadequate science teachers, which have led to having under-qualified and unmotivated science teachers teach science, thereby resulting in poor student motivation and performance. Lack of adequate funds allocated to education in most developing countries has contributed to a dearth of qualified teachers in schools (Lewin, 1993; Johnson, 2012).

The irregular payment of teachers' salaries and their poor remuneration has led to the low status of the teaching profession within Nigeria, which makes teachers to be less motivated and committed (Okedeyi et al., 2013). According to Ogunniyi (1996), teachers have low morale due to the government's shabby behaviour towards them by being paid poorly and posted to areas where they are not well treated. Therefore, the government's treatment of teachers could have led to low support from the community, as their salaries are small compared to other professionals (Ogunmade, 2005). A recent publication (Ibenegbu, 2017) explained that teachers are paid less than those in other professions so that fresh graduates are not attracted into the profession. In addition, many well-trained teachers leave the profession for other lucrative fields, thereby leaving unqualified and non-certified teachers employed to teach in schools (Gray, 1999; Koosimile & Suping, 2015).

Lack of high-quality in-service training programme for teachers is one of the problems facing science education in Nigeria (Agbowuro et al., 2015). Inadequate funding has brought about the poor training of teachers; hence, they too often use existing materials ineffectively (Achimugu, 2016). According to Omorogbe and Ewansiha (2013), there are five indicators of teacher quality: academic and professional qualifications, in-service training, teacher experience, teacher salary, and learning resources. They attributed the poor performance of students in the 2009 (November) National Examination Council (NECO) in science to teacher quality. Therefore, they recommended raising the quality of teachers through training and re-training. However, training of teachers requires money, which is not at the disposal of the public schools without the government's intervention, and this explains why Ogunniyi (1996) advised that the government should take the funding of schools seriously. On this note, there is a need for the government to improve science education in Nigeria by providing adequate funds and instituting policies that are workable and effective.

Inadequate funding of the educational sector in Nigeria lowers the quality of science teaching and learning. As discussed in this section, due to inadequate funding, schools are scantily provided with teaching materials, equipment and infrastructure, all of which are needed to promote effective teaching and aid students' learning. Due to the large enrolment of students, there are large classes, and teachers are influenced by these factors to make choices of teaching methods that are not engaging students during lessons. Retention of qualified science teachers is low, in large measure due to poor salaries, which are not regularly paid. Therefore, under-qualified teachers are employed in schools to teach science, and there is no proper in-service training in place to help them develop their skills. Consequently, there is a hindrance to students' learning of science and the effect is seen in the mass failures of science subjects in national examinations such as NECO and WAEC.

2.3.2 SCIENCE TEACHING AND LEARNING IN NIGERIA: FOCUS ON CONTEXT OF STUDY

2.3.2.1 CURRICULUM POLICY ON SCIENCE EDUCATION

Government policies and curriculum developers in any country play roles in shaping science education and its aims, and in determining teachers' responses towards putting objectives into action (Wellington, 2001). Therefore, understanding the teaching and learning of science within the context of this study, Nigeria, entails looking at the curriculum policy within that context, and at how teachers have responded to it through their practice. This may throw further light onto the poor quality of science learning and teaching described above, in addition to lack of funding.

A curriculum can be defined as all the experiences students have under the guidance of their teachers in schools (Achimugu, 2016). A review of the science curriculum reforms in developing countries by Walberg (1991) revealed that the reforms in the 1960s emphasised scientific processes and students' activities. Lewin's (1993) article, where he considered the major areas needing more research in science education in developing countries, corroborates Walberg's statement. Lewin explained that science education became more pronounced in the school system in most developing countries to meet up with the human resources development needs in the 1960s. The science syllabuses were either retained or re-modified to take out some imbalances resulting from colonial administrations. Towards the end of the 1960s, there was the development of projects, programmes and institutions to support science education development. These projects included The African Primary Science Programme (APSP), African Curriculum Organisation (ACO), The African Association for the Advancement of Science and Technology, and the West African Association of Science Teachers. By the end of the 1970s, most developing countries had developed some form of indigenous science curricula (Lewin, 1993).

According to Lewin (1993), in the 1990s, science curricula were developed locally to reflect the educational needs in developing countries. He mentioned several features, which were written in the science curricula developed. These are the substitution of teacher-centred pedagogical practices by student-centred teaching and learning methods, less emphasis on teaching science as an accumulation of facts and dependency on the use of textbooks with more focus on students having an experience of science and developing problem-solving and more intellectual skills, and undertaking practical activities. According to Lewin, these new directions in the science curricula are active methods and they placed more demands on resources and teachers' motivation and skills. However, resource constraints serve as an impediment to the development possibilities of the science curricula within most of these developing countries (Lewin, 1993). Furthermore, these possibilities went out of the secondary school curricula as a result of the withdrawal of the support given to it due to high costs, the requirement for specialised teacher training and their failure to reach large numbers of students (Walberg, 1991). The effect of this has been that the active methods in the science curricula in these countries were not enacted rather, they are still theoretical and decontextualised because of the adaptation to the colonial predecessors even after independence (Gray, 1999).

Emphasis on Nigeria reveals that due to the performance of students in science in national examinations (NECO and WAEC), several researchers have written on the need for curricula reform. According to Ogunmade (2005), the science curriculum in

Nigeria is content-laden, and involves didactic and teacher-driven methods. It allows students to memorise factual science rather than understand science. Based on his findings, Ogunmade advocated for the science curriculum to be restructured and made relevant to students' needs and aspirations. Relatedly, Okedeyi et al. (2013) carried out a study on the perceptions of Junior secondary school science teachers in Lagos on effective science teaching. Their findings showed that teachers wanted the science curriculum to be relevant to students' needs and their environment so that students can be motivated and become engaged with their learning. In addition, a curriculum less loaded with content should promote students' engagement during lessons, and help them not to need to memorise contents in preparation for examination (Okedeyi et al., 2013). Students' memorisation of science contents relates to the transmission or traditional method teachers adopt in class.

Those taught the sciences using the traditional method are at a disadvantage when it comes to understanding science concepts. They are not adequately prepared to be future citizens who have an understanding of science and technological advancements (Ojimba, 2013). Based on this, Ojimba called for an overhaul of the science curriculum with an emphasis on reduction of content, equity and social relevance. Aina (2017) reiterated this view by recommending a review of the science curriculum so that the learning context mirrors the usage of scientific knowledge in real life and the activities that people do in the real world.

McKinley (1996) referred to curriculum development as a political process because it involves negotiations and there are contestations as to how to write the curriculum, and what contents and which students should be included in the curriculum. Onyia et al. (2016) explained the rationale behind the Nigerian government's reforming of the curriculum. They argued that due to the transformation in global economic and technological advancement, many countries, including Nigeria, reformed the curriculum to enhance the lives of the citizens to make them fit into 21st century societal needs necessary for building the nation. Meanwhile, curriculum design brings issues to light, which extend to teaching, learning, administration and the culture of the school and might have resulted in the lack of improvement in students' achievements (Onyia et al., 2016). According to Onyia et al., one of the issues blocking improvement is the government's failure to consider the capacity of the teachers to carry on with the curriculum reform and innovations. In line with this, Omorogbe and Ewansiha (2013) claimed that despite the 1998 National Policy of Education stipulating the adoption of activity-based and child-centred teaching methods, the traditional teaching method is in use in schools and students are passive recipients of concepts. They stated that teachers' capacity in the form of their competence and possession of skills is questionable when they do not undergo professional development and do not have adequate learning resources to use during lessons (Omorogbe & Ewansiha, 2013).

Another issue is that teachers, who are those to implement the curriculum, are typically not involved in its design, which could put pressure on teachers' capacity to perform. Therefore, Onyia et al. (2013) recommended that for the successful implementation of the science curriculum, teachers' input in its development is essential, and creating clusters of subject specialists within the geo-political zones within Nigeria is an advantage. The examination-related factor is another issue brought along by curriculum design. Ogunniyi (1996) described the examination-related factor as the examination syllabuses, which are often not reviewed despite the curriculum being reformed. He explained that syllabuses create a high workload of contents for teachers, which they try to teach in preparation of students for examinations. Most teachers are under pressure to prepare students for excellent performance in national examinations; hence, they adopt the traditional style of teaching (Gray, 1999).

In this section, the review of the Nigerian science curriculum indicates that the curriculum reform carried out over the years has made few or no changes in how teachers respond to it. Teachers face the issue of a content-laden science curriculum coupled with a lack of regular in-service training and a lack of resources. In addition, they are under pressure to prepare students for excellent performance in national examinations, which makes them adopt teaching methods that are contrary to what the science curriculum stipulates. On account of the poor performance of students in the national examinations (Agboghoroma & Oyovwi, 2015), it is necessary to reconcile the various educational needs of different groups of people such as the teachers, students, the public etc. (Lewin, 1993). Also, in designing the curriculum policy, the government should consider paying attention to both those who progress to study science and those who leave the study of science at certain educational levels (Lewin, 1993). Doing this will embrace the facets of the aims of science education and will give clear directions to teachers on how to implement the curriculum through their practices in classrooms.

2.3.2.2 TEACHING METHODS AND THEIR IMPACT ON LEARNING

Omorogbe and Ewansiha (2013) argued that effective learning of science takes place when students develop conceptual understanding and thinking skills, which helps them to incorporate scientific concepts and ways of thinking into how they explain the world around them. To enable them learn science effectively calls for the adoption of student-centred teaching methods to engage students actively in class (Okedeyi et al., 2013). A study was carried out by Nashon and Anderson (2013) in Kenya to see how students experience the learning of science. Nashon and Anderson stated that scientific knowledge taught in the classroom should have relevance to real-world contexts, and that students should be permitted to engage their deeply rooted cultural mode of learning, which is by being in groups to learn. The science curricula designed in most developing countries in the 1990s show activity-based teaching activities (Lewin, 1993; Onyia et al., 2013). However, these activities are not practised in the classrooms within those contexts for reasons discussed above. Several researchers have carried out studies to examine the teaching strategies that could aid students' learning of science within the Nigerian context, which could still be practised despite the inadequate funding of schools, and these studies are discussed below.

Okebukola (1985; 1986a; 1986b) investigated the effectiveness of learning techniques in strengthening students' performances in science classes. The learning techniques identified by Okebukola are the cooperative, the competitive, and the cooperative-competitive methods. From the findings, the cooperative learning technique, which entails students doing the task together and taking the opportunity to help one another, allows students to learn science better than the competitive learning strategy. Considering the scarce learning resources available, Okebukola advocated that adopting the cooperative learning approach would enable the students to share the limited laboratory equipment amongst themselves in groups. Students can also interact with each other, and the teachers can identify any problems they might have.

The competitive learning technique involves students competing with one another in the classroom, and they do not share ideas or help one another. Okebukola claimed that the traditional system of grading students' work induces a competitive approach among students. The cooperation-competition technique involves students working cooperatively within the same group while they compete with students in other groups. Okebukola came to a conclusion regarding the cooperative-competition learning technique as being the best method to aid students' achievement in science. Meanwhile, it is necessary to put students in learning contexts that match their learning approaches. That is students who prefer cooperative-competitive learning approaches should be placed in such a learning context to enable them to perform better.

Aina (2017) claimed that present-day students want to be in activity-based classrooms because they are not passive learners. However, the primary teaching method adopted by Nigerian school teachers is the lecture method, also known as a teacher-centred method, where students memorise and recall facts (Aina, 2017). In a study on authentic science learning experience in Nigerian schools, Aina explained that authentic learning focuses on real-world problems and their solutions using problem-based activities and case studies, and seeks to give students real-world experiences. Aina used two theories in his research: social constructivist theory to explain how students create meanings through their interaction with others, and constructive controversy theory where students deliberate discussions through the act of cooperative learning and focus on creative problem solving to explain the authentic learning environment. Aina also discussed peer instruction as a research-based pedagogy where students are engaged in lessons through the use of the structured questioning processes. This method helps to develop students' conceptual understanding. Aina concluded that Nigerian education should allow students to collaborate more and engage in peer instruction and articulation.

Ayodele and Fatoba (2017) examined the effect of small-group learning instruction on the attitude and performance of Junior Secondary school science students in one of the states in Nigeria. They explained the small-group learning as a form of cooperative or collaborative style of teaching, having groups of six to eight learners. They identified the different types of small-group learning methods as cooperative learning, collaborative learning and inquiry-based learning. Their findings revealed that small-group learning instruction had a large, positive impact on students' performance in science. In another state in Nigeria, Yashim et al. (2018) focused on the effectiveness of team teaching of biology concepts in a senior secondary class. Theirs was a quantitative study with students put in experimental (team teaching) and control (lectures for six weeks) groups. Team teaching entailed having two teachers plan lessons and teach together. The findings showed that students in experimental groups performed better in the biology achievement test than did those in the control group. This study therefore suggests that when teachers collaborate they can overcome some of the obstacles facing them and help students learn effectively.

Studies that have examined teaching strategies that can promote students' learning within the Nigerian context and some of which were discussed earlier have not considered culture as a factor that could influence the teaching methods adopted in class and their impact on students' learning. Okedeyi et al. (2013) regarded inquiry-based teaching approaches as effective methods to teach science. They characterised inquiry-based approaches as increasing students' manifesting attentiveness in class, reading notes, doing homework, asking and responding to questions, and engaging in practical activities. Although they mentioned that students' poor communication skills might limit how they participate in inquiry-based activities, they did not expound on how this happens nor the role that culture (in the form of students' backgrounds and beliefs) plays during the process.

Fasasi (2017) highlighted the importance of considering diverse students' cultural backgrounds when teaching them science. Doing so entails knowing the prior cultural knowledge students bring to the classroom. Fasasi examined the effects of ethnoscience instructions, school location, and parental education status on students' attitudes toward science in Nigeria. Fasasi referred to ethnoscience as an indigenous science and defined it as the knowledge derived from the norms and beliefs of a particular indigenous community as to how the world works. The findings showed that students in groups taught using the ethnoscience instruction method showed a higher positive attitude towards science than students taught using a modified lecture method. It could be that linking scientific concepts to the prior knowledge of students (of what they have seen in their immediate environment) makes the scientific concepts less foreign and more relevant as suggested by Vygotksy (1986). On this note, understanding the differences in the culture of science and that of the learning context should unravel the cultural issues that students in such contexts face while learning science.

2.3.3 RELATIONSHIP BETWEEN SCIENTIFIC KNOWLEDGE AND LOCAL INDIGENOUS KNOWLEDGE

Culture is defined as the "norms, values, beliefs, expectations, and conventional actions" of a group of people (Aikenhead & Jegede, 1999, p. 272 citing Geerz, Phelan et al. 1991). Science education has been seen to be an aspect of Western culture (Cobern, 1996; Jegede, 1997). Learning science in school has been termed an acquisition of the culture of science by travelling from one's everyday world to the world of science situated in the science classroom (Aikenhead & Jegede, 1999). According to Cobern (1996), for science learning to be productive, it must consider the cultural milieu of the society whose needs science is being introduced to serve. Therefore, this suggests considering the cultural background of African students whose culture is different from the culture of school science; because the processing of scientific concepts might not be an easy task for them, due to the differences in their views of the natural world (Mpofu et al., 2014). Such views of everyday concepts are preconceived and agreed upon by the people within the cultural context (Aikenhead, 1996, p. 4) to explain natural phenomena, and are often different from those of science as presented in the classroom (Mpofu et al., 2014). Fasasi (2017) referred to these views as indigenous knowledge because they are derived from the norms and beliefs of people within a particular indigenous community to explain how the world works.

Several researchers have carried out studies to examine (i) the relationship between indigenous knowledge, or students' traditional worldviews, and scientific knowledge, and (ii) the effect of indigenous knowledge on students' learning of science. Baker and Taylor (1995) carried out an integrated research review on the effect of learners' cultural backgrounds on science education. They asserted that students' prior experiences are emotionally-laden because they are developed in their early childhood days by enculturation and socialising with families and peers. Therefore, these prior experiences give another unintended interpretation of what is taught in the classrooms. Furthermore, the traditional explanations given to phenomena are different from that of science; hence, students may struggle to learn scientific concepts. Baker and Taylor argued that students' traditional mores and perceptions in non-Western societies should be considered carefully before presenting science education to them because students can hold both the Western scientific and the traditional view of the world while learning science. Therefore, a teaching approach, which allows students to share their prior conceptions about the scientific topic in class, and enables them to test these beliefs in the context of a scientific model, would aid students' understanding of science concepts.

Jegede (1995), in his article on collateral learning and the Eco-Cultural Paradigm in science and mathematics, portrayed learning science as the condition and ability to seek answers to questions about natural phenomena. He stated that students' socio-cultural environment nurtures their prior knowledge, and he called this interaction a situated cognition, which suggests that students' prior knowledge cannot be separated from their environment. Jegede categorised the African worldview as anthropomorphic, where an African sees everything as having life and relates to them with respect and humane feelings. However, the interaction of students' traditional worldview with the Western worldview portrayed in science complicates an African's cognitive processes because Western science operates within a positivist/empiricist mode, which does not include human considerations (Jegede, 1995). Waldrip and Taylor (1999) claimed that there is a disparity between school science (which has the basis of an imported curriculum) and students' worldview, thereby resulting in students adopting two conflicting explanations of a phenomenon.

Furthermore, students in non-Western cultures face the complication of having to replace their indigenous knowledge with scientific knowledge in the classroom (Jegede, 1995; Waldrip & Taylor, 1999). According to Jegede (1995), the colonising of non-Western societies led to the advent of school science; this led to science being taught with the view that it is superior over any other ways of understanding nature, thereby disregarding the indigenous worldview. Ogunniyi (2007), in his analysis of teachers' views about science, reiterated that science was imposed on students from colonised indigenous cultures without considering their culture, which makes them lose their sense of identity. Meanwhile, Waldrip and Taylor (1999) in their study on how students' worldview permeates their school views in a non-Western developing country claimed that school science is not teaching students the skills and knowledge that they need to survive in their locality. They gave an example of the agricultural practices taught in science being inferior to those of the traditional agriculture. Hence, they called for curriculum adaptation by making Western science relevant to students' lives (Waldrip & Taylor, 1999). To aid students' learning of science, researchers (Jegede, 1995; Ogunniyi, 2007) concluded that students in non-Western cultures should not put aside their indigenous worldview by having it replaced by science but should make it co-exist with science. On this note, some attempts have surfaced in South Africa to integrate indigenous knowledge within the science curriculum and to embed this approach in schools in Africa (Koosimile & Suping, 2015). Similarly, Fasasi's (2017) ethnoscience instruction method, which allows students to reflect on their local beliefs using scientific instructional concepts, matches the approach that pulls indigenous and scientific knowledge together.

Still, in line with the approach that merges indigenous and scientific knowledge in the science classroom, Aikenhead and Jegede (1999) argued that potential non-Western scientists could construct scientific concepts side by side with students' traditional views and interacting with them. These authors called this 'Collateral Learning'. They identified four different steps that constitute collateral learning. These steps lie along a spectrum that shows a degree of interaction between scientific concepts and indigenous knowledge. The researchers explained that when a scientific concept is introduced to students, the students are at one end of the spectrum called the 'parallel' – where there is no interaction between the two cultures and students do not use the scientific concepts they learn in the science classroom in their everyday lives. After teaching a concept in the classroom and students encounter a situation in their socio-cultural milieu outside the classroom that makes the science concept real to them; this will lead them to the second step on the spectrum, called the 'simultaneous'. According to Aikenhead and Jegede, students can simultaneously think of both encounters and not put either of them aside. At the simultaneous step of the spectrum, students could use the example they come across to try to understand the science concept. An example given by Aikenhead and Jegede (1999) is that of a student who tries to cook vegetable soup at home after being taught the concept of photosynthesis and about chlorophyll (the pigment that gives plants their green colouration) in class. This student will find that the vegetable leaves lose part of their green colour when soaked in hot water before being added to the soup. On account of this, the student can know more about scientific terms such as chlorophyll and denaturation mentioned in the classroom while teaching the concept of photosynthesis. A third step of learning on the spectrum is the 'dependent' – where a student's view of a concept conflicts with what he or she comes in contact with in the science classroom. This conflict makes the students adjust their existing view, rather than reshaping it under the influence of another view. The fourth and last step of learning on the spectrum is the 'secured' – where views of an idea or concept in the two cultures are conflicting and students consciously interact and resolve such conflict. Aikenhead and Jegede (1999) claimed that meaningful learning of science, which involves cognitive conflicts, results in parallel, dependent or secured learning (p. 278), depending on the resolving of such conflicts.

The above suggestions of teaching strategies for the effective learning of science in Africa take on board the recognition and incorporation of the traditional culture within the science classroom. A good example that illustrates science application together with traditional beliefs in non-Western cultures is the work of Wangari Maathai, who started 'The Green Belt Movement' (GBM) in Kenya (Maathai, 2003). Maathai founded the GBM in the '70s when she was inspired to protect the environment against deforestation and forest loss, which have led to desertification in Africa and threatened many other regions of the world. The GBM is an indigenous initiative set up at the grassroots level to plant trees as its core activity using local capacity, knowledge, wisdom and expertise of members living in both rural and urban areas (p. 6). The GBM recognised the need to build a healthy society of strong environmental conservationists who would preserve resources and reduce conflicts over them (Maathai, 2003).

Most of the GBM members are women and, at the beginning, these members rejected the professional approach, instead using their local knowledge when they were trained by foresters who used technical terms to describe the gradient of the land, the type of soil, the depth of the seabed and the specialised tools and inputs that were needed to run a successful tree nursery (p. 27). Afterwards, for so many years, the members applied their prior experience of cultivating crops on their farms, their traditional skills, wisdom and common sense to plant trees across the country, Kenya. Eventually, the foresters acknowledged and applauded the rural women's accomplishments. A local tree-planting strategy was developed, which entailed planting of seedlings in rows of at least one thousand to form green belts of trees to adorn the bare land, and this led to the name *Green Belt Movement* (GBM) (Maaithai, 2003, p. 28).

Some of the activities of the GBM, which included the tree-planting campaign, food security and water harvesting at the household level, involved the applied combination of scientific knowledge with that of the local indigenous knowledge. Furthermore, the GBM promoted civic education to address the importance of cultural and spiritual values, thereby allowing the Kenyans to appreciate their cultural values, which had been eroded and trivialised in the process of colonisation. Provision of community education took place to educate the people about the nutritional values, cultivation and cooking of traditional indigenous foods, which are nourishing but were consumed in low quantities due to people's ignorance (Maathai, 2003, pp. 34-49).

Integrating indigenous knowledge into the science curriculum as advocated by various researchers (Koosimile & Suping, 2015; Fasasi, 2017) could enable students to make sense of scientific concepts introduced to them in classrooms within non-Western contexts. Teaching methods that teachers can adopt would need students to talk about their prior ideas of scientific phenomena. Having a more proficient person, such as the teacher, facilitating learning, enabling students to interact collaboratively and allowing them to exchange ideas about their everyday knowledge relates to Vygotsky's social-cultural perspective of learning (Vygotsky, 1986). Students' everyday knowledge could include some indigenous beliefs about the phenomena introduced in science lessons. At the very least, *starting* a science lesson using Vygotsky's approach to learning could promote students' gradual understanding of science concepts presented to them in classrooms. Therefore, it is important to review the literature on the different views of learning in order to know the teaching methods that can enable students to understand scientific concepts within a non-Western context.

2.4 THEORETICAL FRAMEWORK UNDERLYING SCIENCE TEACHING AND LEARNING

This section elaborates on the previous ones by examining theorists such as Watkins, who discusses views of learning and how teaching relates to these views, and Vygotsky, who considered students' construction of scientific knowledge within a social context. The focus on Watkins in this study is because his arguments encapsulate a fruitful contrast between three different understandings of teaching and learning that is useful in highlighting tendencies that were observed. Furthermore, I discuss the role languages (of learners, context and of science) play in the process of learning science. The recognised need for continuous learning of science calls for a focus on improving pedagogy. Pedagogy can be considered as a social practice, which shapes and forms the cognitive, affective and moral development of learners (Daniels, 2016). Therefore, looking at the underlying views of learning is crucial in this study because these relate to teachers' conceptions of teaching (Watkins, 2015).

2.4.1 WATKINS' THEORIES OF LEARNING

In the book *Classrooms as Learning Communities*, Watkins defined learning as a key process that humans go through to seek a product, in this case, knowledge (Watkins, 2005). On the learners' part, Watkins et al. (2001) claimed that there is a connection between students' conceptions of learning and how they learn. Following Dweck (2006), they suggested that students' conceptions of learning relate to their beliefs about success, what motivates them to learn and their response to difficult tasks. According to Watkins et al. (2001), students that have a "learning orientation" as their motivational theory have the following attributes: they believe that effort leads to success, believe in their ability to improve and learn, prefer challenging tasks, which gives them satisfaction when they succeed in such tasks, and self-instruct when engaged in tasks. On the other hand, students having the motivational theory, he names a "performance orientation" believe that ability leads to success, and they are concerned about being judged as able to perform. Also, they are satisfied to do better than others; their emphasis is on standards, competition and public evaluation, and, they evaluate themselves negatively when faced with a difficult task (Watkins et al., 2001). In summary, the motivational theory he calls "learning orientation" emphasises *improving* learning, while in contrast, the "performance orientation" focuses on *proving* learning.

According to Watkins (2006), when students' focus is on learning, performance is enhanced, and when it is on performance, performance is depressed. A reason for this is that students' conceptions of learning shape their learning approach and ultimately their performance. Watkins et al. (2002) assert that students' conceptions of learning depend on their experiences of styles of teaching, the disciplines followed and the assessment system in place. A synergy between students' and teachers' conceptions of learning leads to outcomes such as: knowledge; skills; actions; positive feelings and emotions, such as success and satisfaction; creative ideas and strategies about learning; affiliation to learning; having a sense of oneself as a learner; having knowledge of others and interacting with them; and having a sense of membership of a community (Watkins et al., 2002). Watkins described different types of learning communities (2005), which will be discussed later in this section, and stated that there are different views of learning that convey various implications for teaching, for curriculum, for assessment and leading learning.

The three views of learning identified by Watkins are: learning as being taught, learning as individual sense-making and learning as building knowledge through doing things with others (2005, pp. 15-17). Learning as 'being taught' is likely to pervade sites of traditional teaching, where the teacher transmits contents to the students, and they learn by being told this information and memorising it. Watkins claimed that policymakers favour this form of teaching (2005). The reason given was that it allows the overloaded curriculum to be covered by teachers within the short instruction time that they have (Watkins, 2005; Lyons, 2006). In other words, this form of teaching is curriculum-driven. It also means that students will have to depend more on textbooks (Watters & Watters, 2007).

Furthermore, the view of learning as being taught does not involve interactions among the learners (Kaptan & Timurlenk, 2012), and pupils find it challenging to discuss and express their thoughts when they believe that learning means being taught (Kempa & Ayob, 1991). Therefore, learners are less likely to develop understanding of scientific concepts (Osborne & Freyberg, 1985; Harrison et al., 1998; Kruckeberg, 2006), and are more likely to consider themselves as passive recipients of knowledge (Watkins, 2005; DiBiase & McDonald, 2015). As a result, most authors in the field of science see this view of learning as unhelpful for understanding science in a lasting way. Watkins related this view of learning to the instruction approach, where the focus is on teachers who deliver the curriculum and tell students what to do and produce (Watkins, 2005).

The process whereby learners make sense of their experiences, relate them to past experiences and take learning forward into the future is the second view of learning presented by Watkins (2005). This view is related to the constructivism described by Piaget (Mercer & Howe, 2012). In this case, the learner is involved, and the teacher is not seen as transmitting knowledge but as helping the learner to construct it. Teachers' construction approach to learning puts the focus on learners, and tasks given to them promote their thinking and processing. The learners have active roles to play during the process of learning; they plan and reflect on their style of learning and how they will engage themselves during the process of making sense of knowledge. Also, the learner is encouraged to help him or herself understand concepts by using experiences within and outside the classroom as resources for learning. Watkins claimed that learning in this sense is a process of adaptation, which depends on, and is continuously adjusted by, learners' experiences of the world. Therefore, long periods are spent on a topic because teachers are more involved in dialogues of enquiry. Kruckeberg (2006) stated that constructivists refer to knowledge as the "internal mental constructions of the individual" (p. 9). This implies that this form of learning is personal and internal, and it brings to light some questions: is knowledge construction a task taken up by an individual, or is it a social process? Does the product of knowledge exist in the learner's mind or some public space? Watkins addressed these questions. He stated that this view of learning focuses on the individual learner and not on the social process of interaction within the classroom (2005), and hence the term "individual sense-making".

The third view of learning brings in a social facet to knowledge construction and places importance on the context where this takes place. According to Watkins (2005), human behaviour is 'fundamentally social' and therefore discourse among interactors play key roles during the social construction of knowledge. Watkins connected this view of learning to the co-construction approach to learning, which focuses on the classroom as a community of learners where tasks involve the creation of knowledge by all learners in the school in mutual interaction (Watkins, 2005). Knowledge generation is contextually relevant and affects both the learner and his/her interactants. It indicates why Watkins argued that a curriculum reform should reflect learning communities of learners and should cover social, ethical and civic dispositions, attitudes toward school and learning motivation, and metacognitive skills (Watkins, 2005). Watkins' third view of learning draws on the socio-cultural perspective of Vygotsky because it gives weight to the central role of social interaction for learning to take place and sees it in the Vygotskyan tradition (Lemke, 2001). This socio-cultural framework also considers the learning approach that students bring to the context, which will determine how such interaction will aid in the construction of scientific knowledge, both externally amongst them and internally within each student (Chin & Brown, 2000; 2002). Furthermore, it considers important the mediating role of cultural tools such as language and other learning aids that are made available to students to help them to shape and construct new knowledge.

To answer the question 'what helps learning in the classroom?', following the socio-cultural traditions, Watkins (2005) described three types of learning communities of learners: classrooms as communities; classrooms as communities of learners; and classrooms as learning communities. Watkins claimed that the differences in classrooms relate to the approach to learning that is in operation in each of those classrooms and this explains why some schools operate more like learning communities than others (Watkins, 2005). He argued that students' sense of membership influences their patterns of behaviour both inside and outside of school. On this note, Watkins emphasised that a focus on control in classrooms through punishment or reward could divert teachers' attention from being managers of students' learning while students' focus will be on compliance instead of on learning (Watkins, 2011). In classrooms as communities, Watkins stated that students actively collaborate to choose and promote their learning. As students become more involved in lessons, their senses of membership will increase. In such classrooms, the more supports students receive, the more they become engaged, and there is a low risk of dropping out of school. Also, there are class meetings where discussions on issues or concerns hold, and solutions are proffered. Hence, governance is shared, and students take responsibilities.

In classrooms as communities of learners, engagement of students extends into intentional learning and high level of involvement in, for example, science as a discipline. Besides, students as participants learn from each other, and they help one another to learn. Furthermore, students are more likely to be motivated towards learning, and they take responsibility for their choices and their outcomes. They reflect on what they are learning, and they act as researchers. In classrooms as learning communities, students have regulated discourses; they share responsibilities and control for knowledge, which means that students develop cognitively and socially at the same time. Students co-construct knowledge; therefore, the knowledge gained is richer and deeper because they talk about their understandings and put these in writing (Watkins, 2005). Meanwhile, learning in classrooms is influenced by schools' organizational culture such as if the style of management focuses on performance or learning, how they talk about learning, and the extent to which collaboration and dialogue are allowed (Watkins et al., 2002). On this basis, Watkins concluded that the development of learning communities should be a key feature for schools in the twenty-first century because such communities bring emphasis on students' active involvements during the learning process (Watkins, 2005).

In a learning context, there is an interaction between learners' characteristics and teaching characteristics, which forms the teaching-learning process and leads to outcomes (Watkins et al., 2002). Students' characteristics include their conceptions about learning and their learning approach. Teachers' characteristics of assessment and conceptions about learning have an impact on their views of teaching and the process and outcome of learning (Watkins et al., 2002).

In classrooms as learning communities, the co-construction and sharing of new knowledge is supported, indicating that language and conversation are important during the learning process. Teachers help learners to engage in generative rather than passive learning activities, and these make them become part of the learning community (Watkins, 2005). Students' engagement in the form of social interactions with each other, and with the teachers guiding, directing and encouraging such interactive activities, draws on Vygotsky's socio-cultural model of learning (Howe, 1996; Powell & Kalina, 2009).

2.4.2 VYGOTSKY'S SOCIO-CULTURAL PRACTICE THEORY OF TEACHING AND LEARNING

Emphasis on learners and the context during the learning process brings into focus the role played by teaching methods, which promotes students' co-construction of concepts. As a socio-culturalist, Vygotsky believed that a person tries to construct knowledge or make sense of a concept, and during this mental process the role of the social and cultural milieu of such a person cannot be underrated (Vygotsky, 1986; Howe, 1996; Powell & Kalina, 2009; Stears, 2009). Vygotsky proposed some basic principles on students' learning, which are explored in this section as many researchers have interpreted them. One of Vygotsky's propositions is his belief in the great importance of culture in development (Vygotsky, 1986). Vygotsky held that culture transforms that which is produced by nature to fit with an individual's purpose (Van Der Veer & Valsiner, 1994).

A researcher who positions himself or herself as a supporter of Vygotsky's approach by focusing on his socio-cultural perspective of learning is Neil Mercer (Mercer, 2008). In line with this, the use of the term 'neo-Vygotskian' portrays the work of Vygotsky by regarding culture and social interactions as the starting point of an individual's learning (Mercer & Fisher, 1992), and by extension the consideration of the joint activity of students in a learning context to facilitate their cognitive performances (Mercer, 1996). This suggests that when students carry out activities and share experiences by communicating with one another they are more likely to be able to overcome their learning difficulties. Hence, Mercer sees dialoguing to reason amongst students as aiding their joint cognitive development simultaneously alongside individual development (Mercer & Fisher, 1992; Wegerif et al., 1999). Relating Mercer's view to Vygotsky's proposition, social interaction would be aided if it occurs between the students and a more proficient person (typically, a teacher), using an acceptable method of communication to enable the students to develop knowledge through which in turn they contribute to the community more widely.

Considering the classroom context, Howe (1996) explained that a broader view has surfaced, which integrates learning with culture using social interaction within that context, which can result in a better understanding and application of concepts. According to Howe (1996), a curriculum and method of teaching that the Vygotskian perspective of teaching supports is one that will not ignore the cultural context in which science concepts are embedded, because cultural context is considered important, not just the cognitive demand of the activity. Howe's (1996) claim could explain why Vygotsky's approach to learning has been proposed to support the teaching and learning of science, in addition to Vygotsky's own emphasis on teaching scientific concepts (Vygotsky, 1986; Bächtold, 2013). Using the students' prior ideas acquired through the experience of scientific phenomena has been emphasised as necessary in science education as a way of aiding the students' understanding of scientific concepts (Stears, 2009). The unveiling of such ideas takes place through the social interaction between such students, the teacher and the cultural context. In this case, teachers' mere transmission of scientific knowledge might not allow the revelations of students' prior ideas of phenomena, and this will not help students to understand science in a culturally specific way (Cobern, 1996). Hence, teachers and other students interacting collaboratively with students should lead to greater understanding of scientific concepts in a culturally appropriate way.

Vygotsky's second proposition is to do with the role of language as a mediating tool. Language as a means of communication through dialogue in a learning context implies its use as a tool to aid and improve thinking in culturally appropriate ways, whereby students deliberate upon and talk about their prior ideas of a scientific concept in order to understand the same concept which is being newly introduced to them (Vygotsky, 1986). This is a Vygotskian approach, in that students use their language to think and express verbally their personal experience of a phenomenon, thereby understanding how it fits into scientific knowledge, and to gradually be acculturated into the use of scientific terms to explain concepts. They try out their understandings, through language with others, as these are emerging, refining the understanding little by little. Having students converse effectively amongst each other using a common language, despite their diversity in ethnicity, biology, identity and so forth, will help them understand the assumptions they bring to the classroom, which can aid their understanding of the scientific concepts (Powell & Kalina, 2009). This process of enculturation takes place if we accept Vygotsky's explanation that thought is born through words, due to the substantial role words play in the formation and reorganisation of mental processes (Vygotsky, 1986). According to Howe (1996), Vygotsky's translators (cites Rieber & Carton, 1987) stated that the reference to 'words' by Vygotsky refers to speech, although people have interpreted it to mean language more generally. Speech as a communication tool is used within a social context, and speech uttered during this social contact is broken into pieces by a child and transferred to "the sphere of inner-personal psychic functions" (Vygtosky, 1986, p. 35) for inner processing. It is within this sphere of mental processes that 'egocentric speech' emerges when the child thinks aloud and is talking to him- or herself, trying to make sense of or think through internalised words to make them become meaningful and logical thoughts. Vygotsky termed this internalised use of words as 'inner speech' (p. 35). According to Vygotsky, inner speech is speech almost without words, and it is what a person carries alongside the spoken words used in social interaction, to make sense and provide meaning for sentences within such a social context (Vygotsky, 1986). Therefore, this logical thought or inner speech could be assumed to be an internalised language used by a student to enable him or her to comprehend concepts in a context of learning. And language and speech are said to occupy two key roles within a psychological system according to Vygotsky: first, as tools used to aid mental function as already explained above, and second, as one of those functions that undergo a cultural development via interactions with others (Vygotsky, 1986).

Ahmed (2014) built on Vygotsky's idea of cultural tools used in the learning context and discussed two other people who worked with Vygotsky in the 1920s. These men, Alexander Luria and Alexei Leontiev, worked with Vygotsky on several studies pursuing instrumental, developmental and cultural-historical issues. They tried to discover how natural processes of maturation and thinking in children under the influence of cultural tools become entwined to produce the higher mental function of an adult (Vygotsky, 1986). Ahmed (2014) claimed that Vygotsky, Luria and Leontiev see activity as an interaction between a ‘subject’ and an ‘object’ through the mediation of tools such as speech, books and equipment (p. 4). The subject refers to the students in a learning context, while the object is what is worked upon or the idea learned. The thinking process would entail relating the object to previous experiences held in the subconscious mind of the subject. These previous experiences of scientific phenomena introduced in the classroom contribute to the students' worldview, which could differ from that of science.

Vygotsky made his third proposition in his quest to understand the development of scientific concepts in a child’s mind. He proposed that there is a contention between the everyday concepts the child experiences and that which is learned in school (Vygotsky, 1986). Borrowing from Piaget (who differentiated between these two concepts and gave the name ‘spontaneous concepts’ to the everyday concepts and 'non-spontaneous concepts' to the scientific concepts taught in schools), Vygotsky’s interest was in seeing how to use spontaneous concepts to make sense of the non-spontaneous concepts (Vygotsky, 1986). In his study of the development of concept formation, Vygotsky concluded that the child’s spontaneous concepts work their way upward towards abstractness and clear the way for scientific concepts, which work their way down towards being concrete (Vygotsky, 1986). When the child is unable to link these two concepts, there will not be comprehension and development of scientific knowledge. Therefore, if students are to be enabled to develop scientific knowledge, they must be aided to bring forward and apply what they experience within their environment to make sense of the concepts taught in class.

Relating for example, spontaneous and non-spontaneous concepts to Nigeria’s secondary school science classroom, students might have experienced the phenomenon of heat transfer, especially when they cook at home and use napkins to hold a hot pot by the handle to avoid hurting themselves. To them, the scientific term ‘conduction’ might be foreign, and being able to discuss their everyday experience of this concept among themselves and with their teacher should aid their understanding of the scientific concept. This connection to the social context is the beginning of the development of this concept. Students can go home, where they experience this phenomenon, and can begin to fit their experience into the scientific conceptual system, using scientific language to explain this process of heat transfer. This process signifies a back and forth movement in students' minds between spontaneous and non-spontaneous concepts (Vygotsky, 1986). However, is this what takes place within Nigeria's secondary school science classroom? Are students within that context able to make such links by reflecting on and discussing their spontaneous concepts? Cobern (1996) alluded to the possibility of students in developing countries not making sense of scientific concepts that are foreign to them, and this could be due to the method of instruction adopted within the science classroom.

Speaking of the mode of instruction, Vygotsky proposed his fourth idea. He argued that the progress a child makes during the formation of concepts when he or she cooperates with an adult is a proper gauge of the child's mental abilities (Vygotsky, 1986). On this note, he used the term zo-ped (the Zone of Proximal Development, ZPD) as "the place at which a child's empirically rich, but disorganised, spontaneous concepts meet the systematicity and logic of adult reasoning." (p. xxxv). Researchers have expounded on Vygotsky's term of ZPD over the years. Jaramillo (1996) reiterated Vygotsky's argument that a teacher can teach any subject to any child at any level of development if the teacher encourages students to learn by doing an activity in interaction with others. This activity would be beyond students' current level of skills and knowledge, thereby promoting them to achieve that higher level. Other researchers (Howe, 1996; Jaramillo, 1996; Powell & Kalina, 2009) stated that in this Zone the adult who scaffolds students must be more capable than the students, to help the students to think logically to form concepts. Meeting each student at his or her level of mental capabilities could be a considerable task, especially in a learning context of large class size, and this seems to limit the usefulness of this idea of Vygotsky because each student would have a different ZPD. But could this be possible when the adult allows each student to bring their assumptions to the social group for collaboration? The view of Mercer and Fisher (1992) seems to shed light on this issue; the ZPD is not a trait of the student, but a trait of an activity that takes place between individuals in a context. In this case, the adult can identify the ZPD of students in a learning context, through their speech during interactions. This view also reveals the need to consider planning activities that will facilitate learning by all students within a context through interactions.

Van Der Veer and Valsiner (1994) advanced that there could be an oversight of the existence of educational interference that could occur within this ZPD, as researchers write about the role of the 'social order' of the teacher, more capable peers, and parents within the learning context (p. 6). These authors claimed that Vygotsky mainly focused on the role of culture within a learning context, unlike what investigators say about Vygotsky on ZPD and the role of the teacher. As explained above, the more capable adult or peer who would scaffold the student is not necessarily a more knowledgeable person, but one who can identify the type and extent of assistance that must be rendered to students to bring about their development of concepts and learning. Considering this interference within a learning context suggests the necessity of employing trained adults or teachers to act as guides, ascertain the current level of development of their students and set practices that will lead them to a higher level of development. However, in a large class that may have as many as ninety students for one teacher, are teachers trained to facilitate the large number of students to intuitively engage with each other's level of understanding? In this section, Vygotsky's four propositions have been discussed: the importance of culture within a learning context; the role of language as a mediating tool; spontaneous and non-spontaneous concepts and the Zone of Proximal Development.

In this modern age, where the rate of technological advancement in the world is fast and on the increase and nations holding the front in this development are recognised globally as leading nations, science learning is regarded as very important to the growth and development of a nation (Claussen & Osborne, 2013). To promote science learning within developing countries, I see the relevance of Vygotsky's ideas within classrooms, regarding the effect that students' discussions have, of the hidden thoughts of the phenomena they experience within their environment on their understanding of scientific concepts that might be foreign to them. Integrating social interactions into the classroom to promote learning might place higher demands on teachers (Stears, 2009). However, science learning can be accomplished if it finds a place in the reasoning and socio-cultural environment of students (Cobern, 1996). That is, if teaching strategies that promote students' collaborations and interpersonal interactions are adopted in classrooms, they can develop their understanding of scientific ideas intra-psychologically.

Using talk while collaborating, students are allowed to practise language and use it to develop ways of reasoning (Mercer, 1996). This strategy poses reasoning as a collective activity amongst the students, and talk as a tool for joint interaction and construction of knowledge by students and teachers (Mercer, 1996). However, not all collaborative activities and talk produce this result in a classroom, unless, as Mercer advocated, the reason for the activities to be carried out and the process for it is spelt out to the students, and the teacher guides such actions (Mercer, 1996). According to Mercer (1996), teaching students the ground rules means establishing "implicit norms and expectations that [it] is necessary to take account of to participate successfully in educational discourse" (p. 363). If students observe them, they will produce the kind of talk that will result in the expected form of reasoning and knowledge construction amongst them. On this basis, having rules laid out is essential to guide the collaborative activities among a group of students, prevent the domination of any problem-solving strategies by some students over others, and permit talk that will make realisable the development of cognitive thinking within that group. Of vital importance is whether students themselves enable the use of rules in their groups.

From a socio-cultural or social constructivist stance, language transforms into a form of talk that influences the development of both collective and individual cognitive reasoning (Mercer & Howe, 2012). The use of language amongst students to critically examine their ideas and views of a scientific concept, and reveal such to arrive at a shared understanding of the concept, is what typifies exploratory talk (Mercer, 1996). Exploratory talk promotes the sharing of constructive information, where everyone's ideas are valuable, and critically-challenged explanation and reasoning takes place (Mercer, 1996; Wegerif et al., 1999). According to Vygotsky (1986), the use of language in a classroom is fundamental to understanding social interactions between students, and ultimately for knowledge construction. Meanwhile, in a multi-lingual context, such as a science classroom in a public senior secondary school in Lagos, Nigeria (the context of this study), where the language of instruction is different from learners' first language and from scientific language, there could be some complexities arising out of the social interactions between students. These complexities are to do with language issues, to which I now turn.

2.4.3 LANGUAGE AND SCIENCE

In science education, language is a tool employed in constructing understanding within a learning context, and it is also used to convey information on science to people (Yore et al., 2003; Yore et al., 2004). Language as a tool shapes the conceptualization of scientific ideas in the classroom because of the cultural differences in learners and how these could influence learning within that context (Yore, 2008). Teachers' considerations of learners' ideas of phenomena within their socio-cultural milieu before being introduced to science relate to Vygotksy's socio-cultural model of science learning (Seah et al., 2014).

The socio-cultural view identifies language as a cultural tool for social interactions in the classroom, and as a cognitive tool within a learner to think through ideas, and consequently make sense of these ideas (Seah et al., 2014). According to Yore et al. (2007), having social interactions, which include intense debate, argument and conversation, could enhance students' understanding of concepts, and language is essential during this process (Yore et al., 2004; Yore, 2008). In relation to science, which has specific and abstract concepts, students connect these concepts to their prior ideas when they interact socially in class to make sense of the scientific ideas. Hence, the focus on the role of language in science learning for more than two decades by researchers (Seah et al., 2014; Seah & Yore, 2017).

During the learning of science in the classroom, three 'languages' are involved: home language, instructional language and science language (Yore & Treagust, 2006). Seah and Yore (2017) declared that science language is different from the home and instructional languages. Science language also differs from other disciplines such as history, economics or geography (Seah et al., 2014). The grammatical structures account for the differences in languages generally, but the extensive specialist vocabulary of science sets it apart from the languages of other disciplines (Seah & Yore, 2017). Studies have shown the existence of the three-language problem faced by most science learners as they cross borders from their home language to instructional language and science language (Yore & Treagust, 2006; Yore et al., 2007; Yore, 2008; Seah & Yore, 2017). To extend this finding, researchers attest that students from non-western cultures face language hindrances while learning science because of the differences in grammatical structure and use of words of the three languages (Jegede, 1995; Ogunniyi, 1996; Aikenhead & Jegede, 1999). Therefore, one could suggest that in Lagos, Nigeria the English language, which is the instructional language and students' second language, could form barriers to their successful learning of science. In this literature review, the distinctive nature and culture of science language will be examined along with the challenges of teaching science through the English language and teachers' beliefs about the language of instruction.

2.4.3.1 THE DISTINCTIVE NATURE AND CULTURE OF SCIENCE LANGUAGE

In classrooms where the language of instruction differs from the home language of students, learning science entails learning through the communication of teaching, and learning of and about the science language simultaneously (Msimanga & Lelliott, 2014; Van Laere et al., 2014; Seah, 2016; Seah & Yore, 2017). Song and Carheden (2014) claimed that students are presented with new vocabulary words in science in greater measure than their capacities to learn new vocabulary. Therefore, students could find science learning particularly demanding (Qhobela & Rollnick, 2010; Seah 2016).

The language of science in its lexicon and grammar is characterised by precision, an extensive specialist vocabulary, use of expressive analogy such as nominalisations, mathematical symbols and the use of the passive voice to construct sentences (Sutton, 1992; Warren et al., 2001; Halliday & Martin, 2003; Ahmad, 2012; Seah et al., 2014; Song & Carheden, 2014; Seah & Yore, 2017). Halliday and Martin (2003) stated that scientific language's lexical resources consist of "vast numbers of new technical terms" (p. 7) and the grammatical resources are the clauses and words put together to describe a concept and make reasoned argument. These qualities of the language of science are what makes it distinct from language used as a medium of instruction in schools and students' home languages. Even when students converse in English and in a native language at home, they will need to learn the scientific technical terms because they are used more to describe concepts than as a conversation tool.

Precision and clarity are values that scientists adopt to give definitions of and express ideas about concepts (Seah et al., 2014). To provide exact definitions, scientists develop new specialist vocabulary from everyday languages and their meanings are uniquely for science (Seah et al., 2014). In addition, scientific vocabulary also includes words that are similar or identical (in spelling and pronunciation) to words used in everyday life but have different meanings (Wellington & Osborne, 2001). A qualitative study carried out by Song and Carheden (2014) looked into such words, which they term 'Dual meaning vocabulary' (DMV), having both scientific and everyday meanings; examples include work, energy, power, salt, theory and mass. They investigated how college science students understood DMV before and after they were taught chemistry and how these students adopted the scientific meaning of these words for their own use and understanding. Their findings revealed that the everyday meanings of the DMV words were more deeply ingrained in the college students' minds than the scientific meanings, and they were not able to retain the correct scientific meaning of the words even after instruction. One of their recommendations was that science concepts should first be explained to students in plain everyday language before the scientific vocabulary is taught to enable them understand the differences between the specialist vocabulary and the one they are familiar with, and to allow them to fully understand the concepts being presented.

Another type of lexicon and grammar resource that scientists use to convey ideas is called nominalisation (Seah et al., 2014). Nominalisation entails using verbs or adjectives to describe a phenomenon and rewording the sentences by using nouns to replace the verbs or adjectives (Ahmad, 2012; Seah et al., 2014; Probyn, 2015; Seah & Yore, 2017). Examples include remodeling the verb 'evaporate' to the noun ‘evaporation’ (Seah et al., 2014), and using the noun ‘acceleration’ rather than saying ‘accelerate’ Wellington & Osborne, 2001). Scientists use nominalisation so that they can present complex ideas in an “economic and efficient manner” (Wellington & Osborne, p. 66). The language of science includes the “combination and interaction of words, pictures, diagrams, images, animations, graphs, equations, tables and charts”, which display meaning in different ways (Wellington & Osborne, 2001; Yore & Treagust, 2006; Seah, 2016). The use of connective words, such as hence, as to, alternatively, consequently, in practice etc., is commonly found in science textbooks and spoken by teachers in class and these connective words may be a complete mystery to students (Wellington & Osborne, 2001). But using these connectives is unavoidable since they are used to express two key ideas in science: “sequence (one event follows another chronologically) and causality (one event causes another)” (Wellington & Osborne, 2001 p. 17). Seah (2016) stated another challenge facing students as the use of pronouns such as ‘it’, which can hinder the intended meaning for students. Therefore, science teachers should use these language resources explicitly to convey scientific knowledge to students in meaningful ways.

The emphasis on formulae in science makes people think that the language of science is mainly mathematics, but this is not the case for many branches of science (Yore et al., 2003; 2004). Formulae show the relationships between concepts (Yore et al., 2007) and are used to enhance comprehension of scientific ideas and improve discourse (Yore & Treagust, 2006). Meanwhile, teachers report that students find science challenging due to the use of mathematics in science topics (Oon & Subramaniam, 2013; Taskinen et al., 2013). Notwithstanding this, to become scientifically literate, students should be able to engage with scientific discourses by moving between their home language, the official school language and scientific language including formulae (Yore et al., 2007).

The passive style of writing in science leads to im-personalisation, where the actors or any sense of personality is removed from words put together to explain a scientific idea or process (Wellington & Osborne, 2001; Ahmad, 2012; Seah et al., 2014; Probyn, 2015; Seah, 2016). According to Wellington and Osborne (2001), the reason for the passive style of writing is because science seeks to portray itself as a source of objective knowledge (p. 65). The vital idea of what was done and not who did something is what science describes (Ahmad, 2012).

Halliday and Martin (1993) claimed that people find science difficult to learn due to the technical language, which they refer to as "jargon" (p. 172). However, science will not be what it is if the language of science is not employed as an important tool during discourse because the language describes scientific concepts (Halliday & Martin, 1993; Seah & Yore, 2017). Teachers' attempts to introduce students to the language of science entail helping students to learn the "stylistic conventions" used by the scientific community (Wellington & Osborne, 2001 p. 65). Part of the way of helping students learn the technical language of science is by encouraging the discussion of concepts using scientific language in order to make students more familiar with scientific terms (Wellington & Osborne, 2001).

2.4.3.2 THE ISSUES, CHALLENGES AND TEACHERS' NAVIGATION OF TEACHING SCIENCE THROUGH ENGLISH

Learning science through a language of instruction involves using that language to construct scientific knowledge; hence, the need to know the elements, customs and traditions of both the languages of instruction and of science (Seah & Yore, 2017). As mentioned earlier, learning both languages could be a very substantial task for students to handle and could be one of the reasons why they find learning science difficult (Halliday & Martin, 1993). In Lagos state, as is the case throughout Nigeria, English language is the language of instruction in schools.

Nigeria was one of the African countries ruled by the British colonial government until the 1st of October 1960 when she gained independence. Being a multilingual country comprising of over 400 different ethnic languages, the English language spoken by the colonial masters serves as a contact language between Nigerians from different ethnic groups and between Nigerians and Europeans (Danladi, 2013). Thus, historically, English was transmitted to Nigeria as the 'result of a peaceful mechanism', where Nigerians chose to use English for social and economic mobility reason. Sociologically, it eased tensions between the large ethnic groups within the country since it is ethnically and ideologically neutral (Schulzke, 2014). Therefore, the English language became a second language and the language of education, commerce, politics, law and administration (Danladi, 2013). Based on my experience as a Nigerian, only a small percentage of citizens speak and write Standard English both inside and outside their homes. Consequently, Nigerian school students face the three-language problem as they cross the borders of non-standard English or another language at home to academic English in school and finally to the language of science (Yore & Treagust, 2006).

Marshall et al. (1991) in their study in Papua New Guinea on students' comprehension of 45 non-technical words used in science classes reported that teachers define scientific and technical words when they are first used while they assume that students understand the non-technical words they use normally in English sentences. Their results show that students do not have the required understanding of non-technical words and their limited knowledge makes them confuse words that are similar phonetically. In a context where students struggle with English (non-technical) words, how is it possible for them to understand science taught through the use of English? How do teachers within such a context navigate the teaching of science, using English more so that the students are likely to bring a well-developed home language, rather than standard English, to the classrooms (Yore, 2008)?

Van Laere et al. (2014) investigated the role of home language and language of instruction on students' achievement in science. Data were collected from fourth grade students, parents and teachers from 67 primary schools in Belgium. The students' home language differed from the language used in their schools for teaching. Their findings revealed that students with a home language different from the language of instruction had difficulties performing at a high level in science, thereby suggesting the need for students to be competent in the language of instruction. They concluded that home languages should be brought into the classroom as a form of scaffolding to aid students' comprehension of concepts. The inability to use the home languages of students in class could promote rote learning and poor achievements by students (Asabere-Ameyaw & Ayelsoma, 2012).

Regarding the role of the home language in the learning of science, Msimanga and Lelliott (2014) carried out a study in South Africa to look at how learners engage with science topics during small group discussion. They observed that the learners changed back to speaking their home languages in their groups during discussion of concepts and they spent a longer time engaged on task given to them. They recommended that teachers should allow interactions among students in the classrooms using their first or home languages, in order to promote conceptual understanding. However, can such interactions take place in a classroom where students speak different home languages?

Researchers have identified strategies used by teachers and students to cope with the challenges of language in teaching and learning. These strategies include code switching and transliteration, both commonly practised in South African classrooms (Qhobela & Rollnick, 2010; Brock-Utne, 2012; Msimanga & Lelliott, 2014; Probyn, 2001, 2006, 2009, 2015; Webb, 2017). Research carried out by Probyn (2001) examined the perceptions and practice of South African teachers as they use English as an additional language in their classrooms. Lessons of five teachers were video-recorded and the teachers were interviewed afterwards, using the video recordings for stimulated recall. Probyn found that the teachers switched to home language or their mother tongue to support students' understanding, to emphasise points, to probe students, to support students' responses, to manage students' behaviours in class and for affective purposes to relax the students and crack jokes (p. 263). The strategy is termed 'code switching' as it is when speakers move from one language to another for better communication (Msimanga & Lelliott, 2014). In addition, the teachers supported students' comprehension of content by drawing on familiar examples as explanations, they assisted the students by limiting their English input to what the students could manage, and they spoke slowly and repetitively to enable students to take in and retain what they were saying.

Probyn (2005) stated that academics have called for an extension of students' home language as the medium of instruction in the classroom in order to overcome the three-language problem faced by learners (Yore & Treagust, 2006). However, Probyn (2005)'s research that examined the language practices and attitudes of six science teachers in South Africa revealed that the students have a strong preference for English as the language of instruction, regardless of the challenges of teaching science through English. Probyn suggested that a strong argument for the benefits of teaching through the home language should be made to students and their parents, according to the country's Language-in-Education Policy. Having this policy in South Africa aligns with the view that African children learn science better if they are taught in a familiar language (Brock-Utne, 2012). Meanwhile, there is little training in South Africa (and generally in Africa) targeted towards training teachers on how to teach using more than one language (Probyn, 2009).

Aside from the lack of training of teachers to be bilingual in class, one reason why using home language in the classroom to teach is unpopular is the desires of parents and students to speak English fluently (Probyn, 2009). Webb (2017) stated that since the 1950s, black African parents see the use of home language in school as a game plan by the government to prevent their children from having upward mobility in the career ladder so that there will be a constant supply of cheap labour. My anecdotal experience of the Nigerian context shows that children from educated homes speak mostly Standard English with their parents, and such children attend top private schools within the country where Standard English is the medium of instruction. Semi-educated parents (having education below university level) occasionally speak native languages but their children are expected to respond in English. Non-educated parents speak native languages at home to their children and although their children respond back in native language, the parents expect them to have a good knowledge of English. So, in such homes, students speak English to flaunt their dexterity before their parents and their parents beam with smiles. The affinity for English in the Nigerian context shows the existence of a linguistic hegemony, where English is taken as being superior to native languages (Lodge, 2017). Therefore, code switching in classrooms might not be warmly welcomed, since the teachers may be feeling guilty that they are depriving the students of the opportunity of acquiring English (Webb, 2017).

Another strategy adopted by teachers in addition to code switching is transliteration, where teachers allow a student proficient both in English and the most common home language to explain concepts to other peers using both languages (Msimanga & Lelliott, 2014). However, very many languages are yet to develop terms, words, expressions and modes of meaning that would enable a precise translation of the language of science into home languages (Strevens, 1976). A more recent concept, which shows how teachers navigate the teaching of science through bilingual classroom practices, is translanguaging (Probyn, 2015). Translanguaging is when the language of instruction and the home language of students are used in a combined and coherent way to aid students' mental reasoning and understanding of concepts (Probyn, 2015). According to Probyn (2015), translanguaging builds bridges between students' home language and English, the language of instruction.

Overall, using the discourse of science, which includes reading, writing, talking and listening to science, will aid students' comprehension of science (Webb, 2017). According to Watkins (2005), human learning is 'fundamentally social' and therefore language and having exploratory talks play key roles during the construction of knowledge. This resonates with Vygotsky's idea of socio-culturalism, where students are supported to develop an understanding of science concepts through social interaction within their culture (Vygotsky, 1986). At this juncture, it is of importance to consider the role of languages (home language, English and science) in the science classroom in Lagos, which will make possible the free discourse of science.

With a focus on Lagos, where children come to school with a diversity of home languages, the discourse of science aligned with Vygotsky's idea of socio-culturalism is a welcome move away from the transmission of content as seen to be prevalent in Lagos state public schools (Mohammed, 2013). According to Schulzke (2014), the alterability of languages suggests that languages can be adjusted to suit speakers' ways of expressing words and that no language is solely suited to represent a particular culture. On this note, science may not be totally expressed by a single language to learners of heterogeneous cultures. Also, using English to communicate transnationally in a way that cultural differences and identities are preserved can be encouraged within the Nigerian context. This type of English might not totally conform to the grammatical structures and vocabulary size of Standard English.

2.4.3.3 THE VALUE AND USE OF PIDGIN IN CLASSROOMS

Pidgin is a language picked up as a foreign language by millions of speakers and it is learned with ease due to its grammatical simplicity (Strevens, 1976). According to Danladi (2013), the pidgin language develops when there is a need for speakers of different languages to communicate using a shared language. In Nigeria, the pidgin was the first type of English used for communication amongst the people since it is an altered form of English. Drawing from my experience of the pidgin spoken in Nigeria, examples include: 'una wan chop?' for 'Do you want to eat?'; 'wetin dey do you sef?' for 'what is wrong with you?'; and 'I no wan go' for 'I don't want to go'. These show how people who can't speak the standard form of English adopt a simplified version of English for easy use. They use English words mixed with the native languages in Nigeria; hence, the pidgin language is seen as a code of non-literate people and as a bastardisation of English (Danladi, 2013). In addition, pidgin is understood as substandard, and this explains why it is often restricted to jokes and entertainment (Balogun, 2013). Pidgin is also denied and rejected by the colonial masters in Nigeria as official and proper English (Balogun, 2013, p. 92).

Balogun (2013) explained that Nigeria pidgin is widely criticized in Nigeria on the grounds that it has no generally agreed tenses, there is no recognition of gender in sentences, spelling is not uniform and repetition is common (p. 96). In addition, pidgin is considered to have a negative impact on people's English language proficiency (Igboanusi, 2008). For these reasons, pidgin has received limited attention in printed or electronic forms and has been marginalized politically (Balogun, 2013). However, despite these criticisms, there seems to be a shift now in the status conferred on pidgin in Nigeria, possibly due to the ease with which it can be learnt (Balogun, 2013). Millions of people in Nigeria are now fluent speakers of pidgin, and the language now seems to be competing with students' home languages

(Danladi, 2013). The Nigerian government has recognised the important role of pidgin in the country; therefore, they make political campaigns for national awareness and broadcast in pidgin, although they are yet to legalise its use in the constitution (Danladi, 2013).

In a multilingual classroom in Lagos where the teacher and students speak different home languages and the students are not fluent speakers of the English language, it could be suggested that using pidgin could serve as a unifying language to aid the discussion in and comprehension of science. To make this feasible, language planners need to improve pidgin's expressions and lexicon (Balogun, 2013). And the government should recognise it as one of the Nigerian languages in the Constitution or in the National Policy on Education (Igboanusi, 2008).

2.5 SUMMARY

This chapter began by reviewing the literature on the value of science to society and discussing this as an aim of science education. The appreciation of science education as contributing to the development of societies due to scientific and technological innovations has led to the increased study of science. Furthermore, there is a widespread belief that studying science leads to an improvement in the quality of life of citizens in a nation (Johnson, 2012).

The goal of educating students to enable them to live fulfilled lives means allowing students to be consumers of science and producers of future scientists. This makes sense and implies that if technological advances are to be sustained, then the world will need more scientists rather than fewer. Furthermore, it does not rule out the notion that science-literate citizens are needed "to hold and defend informed views on social, moral, ethical, economic and environmental issues related to science; and prepare them for further, more specialised learning by developing their secure understanding of the 'big ideas' and concepts of science" (Day & Bryce, 2013, p. 1534, citing the Scottish Executive Education Department). Therefore, this study advocates that further attention should be given to understanding the teaching and learning of science.

Teachers' beliefs guide their practices in the classroom (Wellington, 2001), which impact on students' learning of science. According to Ogunniyi and Rollnick (2015), teaching science to promote students’ learning demand an active form of learning activities in classrooms, where students are involved through social interaction during the learning process. However, to implement these learning activities, teachers who are familiar with transmitting knowledge, would need to participate in professional development training and have adequate knowledge of scientific concepts to enable them guide the students through the interaction process. Allowing students to express and discuss their prior ideas of scientific phenomena, relates to socio-culturalism where scientific knowledge is constructed and shared among the students within a social space. It is proposed in this study, that such interactions would aid students’ construction of scientific knowledge in contexts where students’ culture is different from the culture of school science (Mpofu et al., 2014).

Within Africa, science education enjoys an elite status because it is seen as reducing educational poverty (Koosimile & Suping, 2015). However, students within the Sub-Saharan region are performing poorly in national examinations. With a focus on Nigeria, low funding of the educational sector has led to an inadequate provision of materials, equipment and infrastructure. Also, there is a dearth of qualified science teachers because they are not well paid, they are not given adequate in-service training and have low professional status (Okedeyi et al., 2013). Besides, the Nigerian science curriculum is content-loaded, and teachers have limited time to cover the content. Due to these reasons, teachers adopt traditional teaching strategies, which promote memorisation rather than an understanding of concepts. To promote students’ learning of science, indigenous science educators have proposed a teaching approach that will allow students to share their prior conceptions of concepts taught in classrooms (Jegede, 1995; Ogunniyi, 2007; Koosimile & Suping, 2015; Fasasi, 2017).

A review of Watkins's (2005) three views of learning and their impacts on the teaching and learning process indicated that the third view describes the co-construction and sharing of knowledge in the classroom, which relates to social constructivism. In this study, supported by my findings, I propose that making provision for students to discuss scientific concepts together in the classroom will enable them to find a place for the concepts within their reasoning and sociocultural backgrounds (Cobern, 1996). This teaching approach resonates with Vygotsky's social-cultural perspective of learning (Vygotksy, 1986), and the use of exploratory talk in classrooms (Mercer, 1996). This is because language is used as a tool within such classrooms during students' mutual interaction to construct new knowledge. On this note, the focus is on both the context of learning and on the mediating tools (Vygotsky, 1986). On this note, applying Vygotsky's sociocultural theory in the classroom would allow an understanding of the relationship between indigenous and scientific knowledge within the context of this study.

The use of language during the co-construction of knowledge within the social space of the classroom reveals the need to discuss the language issues surrounding the teaching and learning of science within a multi-lingual context. Researchers (Yore & Treagust, 2006; Yore et al., 2007; Yore, 2008; Seah & Yore, 2017) have written on how the home language of students within a non-Western context is different from the language of instruction, and the language of science, which is English. The great range in these languages poses a problem of understanding science for students within those contexts. To aid students' learning, where English is not the first language, teachers have adopted strategies to support students' understanding of concepts.

In the context of this study, Lagos, where there are multi-lingual classrooms, strategies such as code-switching, transliteration and translanguaging can be employed. Also, pidgin English can be used as a unifying language to explain some concepts to students. In this study, I propose that social interactions between students and with their teacher to relate everyday knowledge to science, and using a language familiar to students in a multi-lingual science classroom would aid students' understanding of scientific concepts considering the differences between the culture of students and that of science as already discussed in this chapter.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to discuss and describe the research methodology appropriate for this qualitative study on understanding the teaching and learning of science within a developing country and a multi-lingual context. This qualitative approach allowed for deep and explorative attention to be given to the perceptions of teachers and students in public Senior Secondary schools in Lagos, Nigeria.

At the outset of this research study, I was very open to shifting my data collection methods and my research questions once I found myself in the field, having previously drawn on my professional knowledge and the review of the literature relating to schools in the field. I conducted a pilot study where the emphasis was on uncovering students' views of their experiences of the three science subjects (biology, chemistry and physics). During the pilot study I carried out an exploratory visit, which enabled me to get acquainted with the context, and this shifted what I was interested in, where I would collect the data and even my research methods. In the main (i.e. post-pilot) research I made three sets of visits to the field; the first of these helped me to shift my research questions and these final research questions were used during the second and third sets of visits to the field. Data from all three sets of visits are analysed in this thesis using the final research questions.

The suitability of the qualitative research approach for this study is discussed in detail in Sections 3.2 and 3.3. Section 3.2 explains the rationale behind this study, the research questions and the research design that forms the basis for the study. Section 3.3 covers the methods used and includes the sampling techniques used in the main study, the sample size, the research context, the design of the research methods, ensuring data quality, the analysis of the data, ethical issues and the limitations of the study.

3.2 RATIONALE, RESEARCH QUESTIONS AND RESEARCH DESIGN

3.2.1 RATIONALE

Having taught science in Nigeria in a private secondary school for many years until 2012, I can recall the challenges of explaining scientific concepts for students to comprehend. Despite having an average class size of only twenty students, a well-equipped laboratory and access to the Internet in the private school where I taught, which enabled them to undertake practical work, students still struggled with making sense of scientific terminology. During my MA course in the UK in 2013, I was exposed to a range of teaching and learning approaches, one of which was AFL (Assessment for Learning), and this enabled me to reflect upon my teaching methods in Nigeria, which were by transmission and were different from the student-led approach supported by AFL. As a result, I decided to focus on the teacher's role in promoting students' learning within the Nigerian context in my MA dissertation. Regarding the schools that I selected for the study in 2013, I was alarmed to find large class sizes and laboratories that were not adequately equipped in public secondary schools in Lagos, Nigeria that I visited. With my background experience of teaching fewer students in a private school, I became interested in understanding how students learn science within the context of these huge multi-lingual classrooms, especially with the scientific language different from that of the language of instruction and students' home languages. In the private school where I taught, the level of diversity of home backgrounds and home languages had been considerably less.

As explained in the literature review chapter, in these days of technological development, students' understanding of science impacts positively on the economic growth of a nation, and also affects the individual, personal lives of science students (Jegede, 1997; Nwachukwu, 2012; Claussen & Osborne, 2013; Millar, 2014). Hence, this study sets out to understand the teaching and learning of science within a multi-lingual context such as public senior secondary schools in Lagos, Nigeria. This study also sets out to ascertain what the views of teachers and students are about the value of learning science. The research methodology employed is an interpretivist one and can be characterised as a multiple case study approach.

3.2.2 RESEARCH QUESTIONS

Discovering what I particularly wanted to study within my area of interest (Bryman, 2012), meant having questions to serve as lights to illuminate the research path. According to Creswell (2013), "qualitative research questions are open-ended, evolving, and nondirectional," (p. 138). As such, in my study based on qualitative data, the ['what'] questions were exploratory, and enabled an examination of the area of study. Therefore, this study sets out to address four research questions:

1. What are the views of students in Lagos state secondary schools of the value of learning science?
2. What view of learning is implicit in teachers' teaching in Lagos state secondary science classrooms?
3. What are teachers' perceptions and use of different teaching strategies within Lagos state secondary science classrooms?
4. How is science teaching and learning in Lagos state secondary science classrooms influenced by i) the language of the curriculum, ii) students' native languages, and iii) the language of science?

3.2.3 RESEARCH DESIGN

3.2.3.1 METHODOLOGY

A qualitative research should be guided by philosophical assumptions, and these need to be understood by the researcher (Creswell, 2013). These assumptions, which constitute a paradigm, are a set of beliefs that influence what should be studied, and they have helped to guide my research study (Bryman, 2012). My beliefs relate both to what is perceived as reality or truth (ontology) and to what can be classified as knowledge in terms of the relationship between the researcher and what is being researched (epistemology), (Creswell, 2013). It is impossible to carry out research without committing to an ontological and epistemological position because they guide the study (Scotland, 2002), and these are discussed below.

3.2.3.1.1 Ontology

Ontology relates to whether what is reality is external to the participants or whether it is constructed by them through their perceptions and actions (Bryman, 2012). The former will tend towards reality that is objective and does not change, while the latter shows truth as evolving depending on how the participants see things and is therefore multiple and not fixed. These two ways of understanding the nature of reality are called objectivism and constructionism (Bryman, 2012, p. 32). In this study, the different perspectives of the participants on the teaching and learning of science will be accepted and explored, and this positions it as having a constructionist ontological assumption.

This study also presumes that participants construct their views of science through social interactions within their context, and this means that these views change based on these interactions (Bryman, 2012). This belief relates both to the sociocultural theory of Vygotsky and to Watkins' description of social constructivist theory, both of which underpin this study.

3.2.3.1.2 Epistemology

Epistemology is based on two extremes of beliefs. The first is that knowledge or what is being researched can be gathered through objective methods and is external to the researcher. The second is that knowledge gathered is the subjective perceptions or views of the participants about what is being researched, and the researcher is in collaboration with participants whilst finding out these views (Creswell, 2013). The first view is termed positivism, the second interpretivism (Bryman, 2012).

To understand the meaning behind people's actions in this study, there is a need to relate to and interrogate the participants, which aligns with the interpretivist epistemological belief. Moreover, we construct meaning through the interactions between our perceptions and the world, and these meanings are communicated in a social context (Scotland, 2012). Understanding the world of human experience requires an interpretivist or constructionist approach. It is based on this notion that this study is carried out, since understanding the teaching and learning of science within Nigeria's context will require subjective evidence from teachers and students within that context of their views on science teaching and learning.

Therefore, this study adopts the interpretivist ontological and epistemological paradigm to understand the various views of the participants on the research topic, as my assumption is that experiences are relative, and are not expected to be the same for different people even if these people are describing the same set of circumstances.

3.2.3.2 THE RESEARCHER'S POSITION

The choice of position made by a researcher has an impact on the significance of the case and the issues that will be explored (Stake, 1995). By designing instruments to collect data, I myself became a key instrument, since I related directly to the cases studied and did not entirely rely on instruments designed by another researcher (Creswell, 2013). This suggests that the researcher as an instrument has a lens, which is brought to the field of study and used in order to understand the cases. Therefore, it is imperative to know the position maintained by the researcher in terms of any underlying assumptions, expectations, bias or experience that might exist and might enable him or her to conduct that research (Yin, 2011).

In this study, I took the position of a non-participant observer. This means I was seen as a researcher taking notes and audio recording the lessons, but I was not directly involved in any activity with the participants apart from when I interviewed them. Understanding how science is taught and learned within the contexts of study meant making selections of methods that could be used to explore issues with the participants. This involved deciding whether I should work with an existing theory and use the data generated to test it (deductive reasoning) or whether I would develop a new theory or understanding from the data generated and analysed (inductive reasoning), (Mason, 2002, p. 180). In deductive reasoning the researcher uses what is known about a phenomenon and the theory related to it to work out a hypothesis or hypotheses, which will be tested empirically (Bryman, 2012).

As an interpretivist and constructionist researcher, I chose inductive reasoning, in order to develop explanations or theoretical propositions out of the data during analysis (Mason, 2002). This was because having a constructionist ontological assumption and an interpretivist epistemology entailed constructing propositions from the expressed experiences of those involved in the cases studied, and making subjective interpretations of what I perceived in the field of study. My subjective interpretations were based on my previous experience of the field and my reading of the academic literature about it.

3.2.3.3 RESEARCH APPROACH

This study is concerned with rich, qualitative data. Creswell (2013) presents five qualitative approaches to inquiry: narrative research, phenomenological research, grounded theory research, ethnographic research and case study research. Narrative research entails gathering data from participants in the form of their individual experiences and stories that are chronologically ordered, and this would not have been suitable for this study, considering its research questions. Likewise, this study is not about describing any specific phenomenon that is commonly experienced by participants; therefore, the phenomenological research approach is not appropriate for it either. A grounded theory research approach would also be unsuitable, as the purpose of study has been identified from the beginning. Similarly, this study is not an ethnographic research project as it is not about fully describing “shared and learned patterns of values, behaviors, beliefs, and language of a culture-sharing group” (Creswell, 2013, p. 90). On the basis of the research questions already listed above, this study *is* about exploring real-life cases that can be described in relation to different contexts, through in-depth data collection that involves “multiple sources of information (e.g., observations, interviews, audiovisual material, and documents and reports)” (Creswell, 2013, p. 97).

3.2.3.3.1 Case study

A case is an object that is bounded by context, time and activity and has working parts that are integrated to form a system (Stake, 1995). A case can be single when one’s focus is a child, groups of children, teachers, a school or a program, and it can be collective where multiple case studies are selected (Stake, 1995; Creswell, 2013.

According to Stake (1995), the issue to be studied could be problems that are connected in a complicated manner to politics, social and/or historical factors and one's context, and therefore seeking to understand a case is associated with qualitative inquiry, which can explore details. This approach involves appreciating the complexity of the case, and spending a long stretch of time at the case, that may be one day or a year concentrating on the issue or the problems of the case. Doing this entails raising questions that are deeply connected to the issue but not too broad, to guide the researcher in observing and picking out the problems of the case in order to fully understand it (Stake, 1995).

The issue addressed in this study is a real-life one that is of interest to myself as the researcher. It has been an issue for some time, and is still an ongoing concern within Nigeria's context. This concerns the teaching and learning of science in government-funded secondary schools. To illustrate and explore the issue, multiple cases were selected and studied. Data were collected from four senior secondary schools in Lagos; each of these schools can be considered is a case, which enables an in-depth exploration of the teaching and learning of science in each of these contexts. According to Stake (1995), within a multiple case study, it is common to compare between cases, which are the different sites where data are collected, but that is not the purpose of this case study. Instead the purpose of this study is to understand the teaching and learning of science within a multi-lingual context rather than overtly to compare the four schools.

Gathering the data entailed audio recording science lessons in nine classes, and interviewing nine teachers about their views about science teaching and the values of learning science. In addition, group interviews were carried out with selected students from two classes in the first set of data collection visits, and individual interviews were carried out with students selected from seven classes visited during the second and third sets of visits to the research field. For this reason, and in order to provide a deep understanding of the distinctive features of each case and across all four cases, I used a range of methods, namely observation, interviews, group interviews and field notes, were employed (Stake, 1995; Creswell, 2013).

Additionally, since this study was carried out and analysed using Watkins' views of learning (Watkins, 2005) and Vygotsky's (1986) sociocultural theory as a background, the relationship between these theories and the data is 'inductive', meaning that firstly, I allowed themes to emerge from the data and only later, the themes generated from the data were interpreted and explained from the theoretical perspectives of Watkins and Vygotsky. This contrasts with the deductive approach, where theoretical propositions are generated in advance of the research and adjusted by the empirical research (Mason, 2002). As the inductive process relates to data analysis, details of this procedure for interpreting the data in relation to the theories will be explained in the next section. In this next section, the sampling techniques, sample size, context of research, methods, limitations of the study and ethical issues will be discussed.

3.3 RESEARCH METHODS AND ITS DESIGN, PROCESS FOR DATA QUALITY, DATA ANALYSIS, ETHICS AND LIMITATIONS

3.3.1 RESEARCH METHODS

As outlined as research questions (above), the research topic in this study is how secondary science is taught and learned, and the value of science learning that teachers and students describe within the Lagos study schools. To explore and acquire an in-depth understanding of the cases means having the research process adequately organised by the researcher, and this involves purposely sampling the participants, and using methods that will enable them to discuss the issue richly and allow myself as researcher to perform an explicative analysis of the data (Stake, 1995; Creswell, 2013). The subsequent process, analysing the data, then requires the researcher to focus on key points, looking for their common themes and subjectively, but in an informed way, interpreting their meanings in order to better understand the cases.

3.3.1.1 RESEARCH SAMPLING

Sampling is a standard feature of social research, which makes it an important part of any investigation (Bryman, 2012). Knowledge of who will give detailed answers to interview questions that would be asked in the field, and how, and where this will be achieved is of importance to a researcher, and as such should be thought of and organised before the start of any investigation. Based on the research questions, the main topic in this study is the teaching and learning of science within the context of Lagos, with a sample of four senior secondary schools. The four schools are considered cases, hence the multiple case study research approach adopted. Since these cases will be the focus of attention, this suggests that it is important to select them by purposive sampling, a strategy often used in qualitative inquiry (Bryman, 2012). Purposive sampling signifies choosing the place where those who are suitable to provide insights for answering the research questions and are willing to participate in the study can be found (Stake, 1995).

3.3.1.1.1 Research context

The criteria that were used for selecting the contexts were thought of and planned for at the start of this research, which situates this study as adopting an a priori type of purposive sampling (Bryman, 2012). The criteria used are described below in levels, from the larger scope of the state to the smaller one of the classrooms:

> Lagos State: Lagos State was chosen for this study because it is an urban area and Lagos was the capital of Nigeria from 1914 until 1991, when the capital was moved to Abuja (www.lagosstate.gov.ng, 2017). Whilst it was the capital, Lagos experienced a rapid increase in population and economic growth, because most commercial and financial businesses had their headquarters situated in this state (www.lagosstate.gov.ng, 2017). Whilst the aim of this study was not to generalise the findings, it was envisaged that carrying out the study in Lagos, which is a commercial city and more populated than any other state in Nigeria and has the various tribes in the country represented, would allow the researcher to note the dynamics of interaction. This interaction is in terms of language used (which is one of the issues of study in this research), between teachers and students within the school and classroom settings in order to understand the cases selected within the wider context of Lagos.

Another criterion that explains my choice of the state was its proximity to my own home, where my relatives still reside.

District: There are six educational districts in Lagos (www.lagosstate.gov.ng, 2017) and three of out of these were selected for the main study, due to their accessibility and convenience. For reasons of confidentiality, the pseudonyms '1st', '2nd' and '3rd' will be used for the districts.

School: Four schools were selected from districts 1st – 3rd. All four are mixed-sex schools. One of the criteria used for choosing the schools was that the schools are located in more populated areas. On this note, the expectation was that the large population and multi-tribes in these areas might enhance the linguistic diversity found within the schools. Another criterion is my familiarity with these districts from the pilot study, and this made it possible for me to select four schools from the three districts. For confidentiality reasons, the schools I selected will be given pseudonyms: W school from the 1st district, X and Y schools from the 2nd district, and Z school from the 3rd district.

Classroom: My experience of the Nigerian educational system has shown me that students have lessons in the different subjects in the one classroom, and this applies to both primary and secondary schools. Secondary schools are divided into two sections or schools: Junior Secondary schools, which have classes JS 1-3; and Senior Secondary schools, which have classes SS 1-3. At the end the junior school (JS3), students are grouped into classes based on the career pathways they choose to follow in preparation for their next three years in senior secondary schools. Because this study is about science learning, it became necessary to sample SS2 students already grouped in science classes in the four senior secondary schools. SS1 students sampled in the pilot study were not able to give in-depth answers to questions relating to science learning; hence they were not sampled in this study. Likewise, students in the final year of their schooling (SS3) were not included in the data collection so that they would not be distracted, since it was foreseen that they would be busy preparing for their West African School Certificate examination, which students normally sit in May and June of each year.

The above criteria clarify the sampling for this study. According to Stake (1995), giving descriptions of the contexts is important in a multiple case study, in order to indicate the relevance of each case for the study. Some other schools in Lagos and in other states would have matched some of these criteria, but these schools were selected because they have all the criteria of large class sizes, location in more populated areas in Lagos, and the researcher's familiarity with and accessibility to the contexts.

3.3.1.1.2 Participants and sample size

According to Stake (1995), a case study researcher should have a "connoisseur's appetite for the best persons, places, and occasions" (p. 56). For this reason, participants for this case study were also selected using a purposeful sampling method. Each case being an integrated system, having many parts, this meant selecting actors (teachers and students) who could be easily reached, are willing to participate (Stake, 1995), and are likely to provide the insights necessary for myself to answer parts of the research questions. Participants in this study were included based on the criteria of being science teachers or students intending to follow science-related careers.

Table 3.1a shows the background information of the nine teachers selected for the study.

Table 3.1a: Teachers' background information

DISTRICT AND SCHOOL	CASES	VISIT NUMBER	SUBJECT SPECIALITY	ACADEMIC QUALIFICATION	YEARS OF TEACHING EXPERIENCE
1st District: School W	W	First visit	Biology	BSc (Ed) Biology	25
			Chemistry	BSc (Ed) Chemistry	31
		Third visit	Physics	BSc (Ed) Physics; M. Ed Physics	20

2nd District: School X	X	Second visit	Chemistry	BSc Chemistry; M. Ed Chemistry	16
			Physics	BSc (Ed) Physics	22
2nd District: School Y	Y		Chemistry	BSc Chemistry	19
			Biology	BSc (Ed) Biology	17
3rd District: School Z	Z	Third visit	Physics	BSc (Ed) Physics	17
			Biology	BSc (Ed) Biology	24

In this study, I chose teachers with many years of teaching experience, as shown in Table 3.1, because I anticipated that having taught for many years, they would be familiar with, and might have adopted, various teaching methods to control large classes effectively, thus aiding their students' learning. Having these teachers participate in this study enabled me to get in-depth insights by identifying and comparing the classroom processes of teaching and learning. The teachers gave contrasting findings, which enabled me to understand the similarities and differences between their values, beliefs and practices.

The students included are already grouped in science classes in the four Senior Secondary Schools, meaning that these students are preparing to study science at university and follow science career pathways. Table 3.1b provides information about the students in the classes that were studied over the three visits to field in this study.

Table 3.1b: Information on students participating in the study

DISTRICT	VISIT NUMBER	SCHOOL, CLASS	NUMBER OF STUDENTS	AGE (Years)	SUBJECTS
1st District	First visit	School W, Class WBio1,	106	15 - 17	Chemistry, Biology

		WChm1			
		School W, Class WBio2, WChm2	90	15 - 17	Chemistry, Biology
	Third visit	School W, Class WPhy	88	15 - 17	Physics
2nd District	Second visit	School X, Class XChm	75	14 - 17	Chemistry
		School X, Class XPhy	82	14 - 17	Physics
2nd District		School Y, Class YChm	70	15 - 17	Chemistry
		School Y, Class YBio	71	15 - 17	Biology
3rd District	Third visit	School Z, Class ZPhy	69	15 - 17	Physics
		School Z, Class ZBio	74	15 - 17	Biology

3.3.1.1.3 Gaining access to the participants

Gaining access to the district and school was made possible due to my familiarity with the context (Lagos), and having known some staff in the Ministry of Education years ago whilst I was teaching in Lagos. One of the Ministry staff (who is one of the supervisory team in Lagos State) was contacted prior to the pilot study in order to help me gain access to three districts in the state. The supervisory team in Lagos State visits schools to ensure that administrative heads and teachers in schools are following policies laid down by the State Ministry of Education for adequate teaching. With the assistance of this government official, I was able to have my letter of permission (written to the Lagos State Ministry of Education) approved. The approval was also sent to the three districts I sampled for the pilot study, and each district gave me another approval letter for the principals of the three schools I selected for the pilot study.

This same process was followed in January 2016, but this time around, it took less time to get the approval from the Lagos State Ministry of Education and from the three districts. Hence, the first data collection for the first Case in school W was able to take place early in February 2016. The second visit to Lagos led to the collection of data in schools X and Y termed as Cases X and Y during November - December 2018, and third visit was to the fourth school Z, Case Z in March 2019.

Written approval given by the districts permitted me to work with teachers and students in the schools. I was very happy to have selected the four senior secondary schools and to be working with the sampled teachers and students in the main study, because they received me warmly at these schools and co-operated with me, thereby facilitating my data collection.

3.3.2 DESIGN OF RESEARCH METHODS

The logic behind this case study was to study the four schools to understand the issue of science teaching and learning within science classes in senior secondary schools in Lagos, Nigeria. As Stake (1995) explains, this posits this case study as qualitative, as the emphasis is on understanding and constructing knowledge about the issue through the researcher's personal role of interpreting the experiences of the sample (teachers and students), as observed within the contexts of the cases.

According to Stake (1995), the design of a research project requires a conceptual organisation around the issue. In this study, organising the data collection and reporting it in relation to the issue found in the cases as revealed in the research questions enabled the use of methods that allowed me as the researcher to get in-depth responses from the participants. On this note, the methods used for qualitative data collection during the three visits made to the schools were un-structured observations, semi-structured interviews, group interviews and field notes.

At an earlier stage of the research, I wanted to implement an intervention by carrying out an innovative practice where students are put in groups and can actively interact with each other to construct knowledge in the classrooms. I was able to carry out this practice in School W during my first visit to the field; however, I decided it would be inappropriate to continue with the intervention in the schools were data were collected during my second and third visits. This was because the primary focus of the research is to understand an issue by studying the cases selected, and having to organise an intervention would not allow me to have an in-depth exploration of the teaching and learning of science within the cases. A summary of the methods used for addressing each research questions is presented in Table 3.2.

Table 3.2: Outline of research questions and methods

RESEARCH QUESTION	OBSERVATIONS	INDIVIDUAL INTERVIEWS	GROUP INTERVIEWS	FIELD NOTES
What are the views of students in Lagos state secondary schools of the value of learning science?	Lesson observations in all four schools.	Interviews with teachers in all four schools. Interviews with students in all four schools.	Interviews with students in school W.	Notes taken during all the lessons and other activities of students and teachers outside the classroom.
What view of learning is implicit in teachers' instruction in the Lagos state secondary science classroom?	Lesson observations in all four schools.	Interviews with teachers in all four schools.	-	Notes taken during all the lessons.
What are teachers' perceptions and use of different teaching strategies within Lagos state secondary	Lesson observations in all four schools.	Interviews with teachers in all four schools. Interviews with students in all four schools.	Interviews with students in school W.	Notes taken during all the lessons.

science classroom?				
How do the languages of i) curriculum, ii) context, and iii) science, promote or hinder science teaching and learning in Lagos state secondary science classroom?	Lesson observations in all four schools.	Interviews with teachers. Interviews with students in all four schools.	Interviews with students in school W.	Notes taken during all the lessons.

These methods are now elaborated.

3.3.2.1 PROCEDURES FOR DATA COLLECTION

3.3.2.1.1 Observation

Observation is one of the major tools used by researchers to gather qualitative data (Creswell, 2013), and especially by case study researchers, because it directs them towards the understanding of a case (Stake, 1995). Observing a phenomenon in a field can entail the use of the five senses of sight, hearing, touch, smell and taste (Creswell, 2013). Creswell (2013) lists different ways in which researchers can carry out observations in the field of study:

a. Complete participant observation – this entails having the full participation of the observer with the people whom he or she is observing, in order to establish a rapport with them.
b. Participant as observer – here the researcher is majorly integrated into the activity at the field of study, and his/her role of participating in this activity is more important than his or her researcher role.
c. Non-participant observer– this means that the researcher is watching and taking field notes from a distance, and can record data without direct involvement with activity or people.

d. Complete observer – here the researcher is not seen or noticed by the people that are studied. (pp. 166-167)

At the start of data collection during my first visit to School W (case W), I played the role of a participant observer. During this visit, I undertook an intervention by having students interact in groups, and I audio recorded students from the groups as they stood in front of the classroom to explain the part of the topic the teacher had allocated to each group. However, I changed that approach during my second and third sets of visits and I went in to the field as a non-participant observer, watching, audio-recording the lessons and taking field notes without being involved in the teaching activities. In the last two visits I simply audio recorded the lessons using a tape recorder without carrying out an intervention or arranging students into groups. In addition to audio-recording the lessons in the science classes in W, X, Y and Z schools, I took field notes in order to help me understand the process of teaching and learning taking place within them.

Two different teachers (Biology and Chemistry teachers) had their lessons observed in case A. Table 3.3a shows how the lessons were observed during the first set of visits.

Table 3.3a: Outline of lessons observed during the first set of data collection

DISTRICT AND SCHOOL	TEACHER	CLASS: LESSONS OBSERVED	DURATION
1st District: School W	Biology	Class WBio1: Two lessons observed	One hour and twenty
		Class WBio2: Three lessons observed	Two hours
	Chemistry	Class WChm1: Four lessons observed	Two hours and forty minutes

		Class WChm2: Three lessons observed	Two hours
Total number of hours of lessons observed			**Eight hours**

During the observations of the intervention lessons, I took notes of the questions the students asked one another in relation to the topics. I did not record the discussions that took place within each group, as there were insufficient audiotapes for all the groups. Additionally, I observed that the students did not collaborate amongst themselves as I thought they would, as some of them were found reading through their notes independently. Perhaps one of the reasons could be that students found the idea too new and needed to be guided by me in order to understand what they were expected to do and how to go about that in their groups. Likewise, the number of students (ten) in each group might have hindered the chances of having extensive collaboration amongst the students. Consequently, this made me waive the idea of carrying out the intervention in my future visits to other schools.

I gained insights into some elements that played out during those lessons, such as how teachers use scientific language and how they use the local language during the lessons. These elements were not considered at the start of my study but I later realised that they are of importance if I am looking at the dynamics of interaction during the teaching and learning of science in Lagos. Hence, I changed my research questions to incorporate these elements, and I used these new questions to collect data during my second and third sets of visits to other schools.

My second visit in November - December 2018 was to the 2nd district, where I collected data from two schools in different contexts; they are referred to as case X and case Y in this study. Details of the lessons observed in these schools are shown in Table 3.3b.

Table 3.3b: Schools visited and lessons observed during the second set of data

collection

DISTRICT AND SCHOOL	TEACHER	CLASS: LESSONS OBSERVED	DURATION
2nd District: School X	Chemistry	Class XChm: One lesson observed	Forty minutes
	Physics	Class XPhy: One lesson observed	Forty minutes
2nd District: School Y	Chemistry	Class YChm: One lesson observed	Forty minutes
	Biology	Class YBio: One lesson observed	Forty minutes
Total number of hours of lessons observed			**Two hours and forty minutes**

The lessons observed in both X and Y schools took place in the science laboratories. In each of the lessons, I sat at the back of the laboratories, audio-recording the talk that took place during the lessons by using the audio tape recorder and taking notes. I focused in my notes on the types of questions asked by teachers and the students' responses. In order to gather more data to enable me answer the research questions, I planned for my third visit to Lagos in March 2019. During this visit, I went to the 3rd district, and visited Z school (referred to as Case Z), where two teachers' lessons were observed and audio-recorded. I also went back to school W in the 1st district, and I saw the physics teacher I had previously met in 2016. He participated in the research by having one of his lessons observed. Table 3.3c shows the outline of lessons observed in both schools during the third visit.

Table 3.3c: Schools visited and lessons observed during the third set of data

collection

DISTRICT AND SCHOOL	TEACHER	CLASS: LESSONS OBSERVED	DURATION
3rd District: School Z	Physics	Class ZPhy: One lesson observed	Forty minutes
	Biology	Class ZBio: One lesson observed	Forty minutes
1st District: School W	Physics	Class WPhy: One lesson observed	Forty minutes
Total number of hours of lessons observed			**Two hours**

I did not use a structured observation schedule when observing the lessons in this study for two main reasons. First, this study, **being exploratory**, requires that I record the behaviour of participants and the intentions behind them so that I can report on such, but this will not be possible if I use a structured observation schedule as the data captured would be less rich. Secondly, using structured observation would not have been appropriate in this study because I would not have been able to specify in advance appropriate categories and variables in any observation schedule that I developed (Bryman, 2012).

The data collected during lessons observation in the four schools were analysed in the light of the new research questions. Details of the analysis are discussed below.

3.3.2.1.2 Interviews

Interviewing was another method adopted in this study to gather data from teachers. According to Kvale (1996), a qualitative researcher attempts to understand the world from the participant's perspective, and this often entails having an *interview* with the participant, which is an "inter change of views between two persons conversing ...",

(p. 2). This suggests that an interview is a form of conversation between two or more people. Stake (1995) claims that interviewing is the main road to discovering and presenting the multiple views of a case. In this study, the researcher is portrayed as an interviewer who is a “traveller” (Kvale, 1996, p. 4), suggesting that s/he builds up a picture of the route as s/he accomplishes a journey. This contrasts with another metaphor of the ‘interviewer as a miner’ who unearths valuable knowledge that is uncontaminated by the participants’ experiences by using leading questions (Kvale, 1996). The metaphor of the ‘interviewer as a miner’ does not fit into the plan of this study as I do not conceive of knowledge as separate from human experience. According to Kvale (1996), the interviewer-traveller purposely seeks specific sites and follows a route that leads to the goal of answering research questions by ensuring that stories are used to describe what is heard and/or seen qualitatively. In this study, the researcher took on the role of an interviewer as a traveller in order to make meaningful interpretations of the conversations with teachers and students and to develop the knowledge that could be used to understand the teaching and learning of science within that context (Kvale, 1996).

In order to let participants express themselves freely without any form of disturbance, prior to when they were interviewed I arranged for a good private and quiet place (Bryman, 2012). Teachers were interviewed in their private offices, which are more like preparatory rooms attached to the laboratories. Suitable times to interview students and teachers were arranged before the interview took place, so that none of the participants missed out on any lesson: students were interviewed during their lunch breaks and teachers were interviewed when they had free periods between lessons.

Interviews were audio-recorded using a recording application on my laptop and (as back up) the audio recorder on my mobile phone. I carried out group interviews with some students in School W, and individual interviews with all nine teachers sampled in this study. Similarly, during the second and third visits to Lagos, I selected some students from the classes I had observed and they were interviewed individually.

3.3.2.1.2.1 Semi-structured interviews

A semi-structured interview is defined as "an interview whose purpose is to obtain descriptions of the life world of the interviewee with respect to interpreting the meaning of the described phenomena" (Kvale, 1996, p. 5). Semi-structured interviewing entails the use of listed, open-ended questions as a guide, which covers the issues addressed in a case and at the same time gives room for the researcher to further probe anything of interest that the participants might say. For this reason, this form of interview was adopted in this study, as it gave the interviewee and me a sense both of interacting formally and of having spontaneous conversations at the same time (Kvale, 1996). Details of how the teachers were interviewed in the different contexts and the durations of their interviews are summarised in Table 3.4a.

Table 3.4a: Summary of teachers' interviews

DISTRICT AND SCHOOL	VISIT NUMBER	TEACHER AND NUMBER OF INTERVIEW	DURATION (minutes)
1st District: School W	First visit	BIOLOGY: First interview	34
		Second interview	20
		CHEMISTRY: First interview	29
		Second interview	20
	Third visit	PHYSICS: One interview	32
2nd District: School X	Second visit	CHEMISTRY: One interview	19
		PHYSICS: One interview	21
2nd District: School Y	Second visit	CHEMISTRY: One interview	35
		BIOLOGY: One interview	20
3rd District: School Z	Third visit	PHYSICS: One interview	24
		BIOLOGY: One interview	22
Average duration of the 11 teacher interviews			**25**

The questions asked of the nine science teachers in the four schools are listed below:

1. Tell me about yourself, how long you have been a teacher and who/what inspired you to become a science teacher?
2. In your opinion, what is science education for? That is, why do we learn science?
3. Do you feel appropriately trained as a teacher to help students understand science? Explain.
4. Are you aware of teaching methods, which engage and involve students during lessons? If yes, give examples of the methods and instances where you have adopted them in class.
5. If you have not adopted these methods in class, can you explain why?
6. What are your views and understanding about scientific language and terms?
7. Do you think your students understand science that you teach when you use the scientific language and terms such as ____________ which you mentioned in the previous lesson?
8. Do you think not relating the meaning of scientific terms to English meanings or examples that students might be familiar with will influence how they understand those scientific terms?
9. What are your views about the use of English as a medium of instruction to teach science?
10. Which of these languages – English, students' native language or pidgin – should teachers use to teach science in order to aid students' understanding of the subject? And why?
11. Do you think students apply the scientific knowledge they are taught in schools in our society?

The use of semi-structured interviews enabled the teachers to speak at some length about their interest in science and their experiences of teaching science. Additionally, being able to interview the teachers face to face helped me to understand what they were communicating, not only in words but also by their expressions, tones and gestures (Kvale, 1996). The flexibility afforded by semi-structured interviewing enabled me to get "spontaneous, lively, and unexpected answers" (p. 129) from teachers. Probing their responses further revealed meaningful and relevant insights, which helped to shed light on the issue studied.

Selected students in Schools X, Y and Z, and few students in school W were interviewed individually. I made the decision to use semi-structured interviews with students after seeing how productive it was in gathering data from teachers. Table 3.4b shows the number of students interviewed individually in the different schools and the duration of their interviews:

Table 3.4b: Summary of students' interviews

DISTRICT AND SCHOOL	VISIT NUMBER	STUDENT, GENDER AND SUBJECT	DURATION (minutes)
1st District: School W	Third visit	Student 1 (Male), Physics	13
		Student 2 (Female), Physics	14
		Student 3 (Male), Physics	11
		Student 4 (Male), Physics	16
2nd District: School X	Second visit	Student 1 (Male), Chemistry	9
		Student 2 (Female), Chemistry	11
		Student 3 (Female), Chemistry	8
		Student 4 (Male), Chemistry	15
		Student 5 (Male), Physics	12
		Student 6 (Male), Physics	10
		Student 7 (Female), Physics	11
		Student 8 (Male), Physics	14
2nd District: School Y	Second visit	Student 1 (Male), Chemistry	13
		Student 2 (Female), Chemistry	10
		Student 3 (Female), Chemistry	15

		Student 4 (Male), Chemistry	11
		Student 5 (Male), Biology	10
		Student 6 (Male), Biology	8
		Student 7 (Female), Biology	13
		Student 8 (Male), Biology	12
3rd District: School Z	Third visit	Student 1 (Female), Physics	11
		Student 2 (Male), Physics	13
		Student 3 (Male), Physics	14
		Student 4 (Male), Biology	13
		Student 5 (Female), Biology	11
		Student 6 (Female), Biology	10
Average duration of the 26 students interviews			**12 minutes**

The questions asked of the students who were interviewed individually in the four schools are listed below:

1. Why are you learning science?
2. Do you understand science when your teachers teach you? Explain.
3. How many languages do you speak? Which of these languages do you speak most often at home?
4. Which of these languages would you prefer your teacher to use to teach you science in class? Explain.
5. How do you find the scientific language and the terms used by your science teachers? Explain.
6. What do you understand by this ____________ mentioned by your teacher in the previous biology/chemistry/physics lesson?
7. Are you able to use the scientific knowledge taught by your teachers in school elsewhere? If yes, give examples of how, where and when you have used scientific knowledge.

8. Are you supplied with books free of charge by the government in biology, chemistry and physics? If not, do you have textbooks for these three science subjects, and were they bought by your parents/guardians?

Following the example of Kvale (1996), who shows how the interview questions should be used to answer the research questions, Table 3.5 provides an overview of such in this study.

Table 3.5: Relationship of research questions to interview questions

RESEARCH QUESTION	TEACHERS' INTERVIEW QUESTION	STUDENTS' INTERVIEW QUESTION
1. What are the views of students and teachers in Lagos state secondary schools on the value of learning science?	1.Tell me about yourself, how long you have been a teacher and who/what inspired you to become a science teacher?	1. Why are you learning science?
	2. In your opinion, what is science education for? That is, why do we learn science?	7. Are you able to use the scientific knowledge taught by your teachers in school elsewhere? If yes, give examples of how, where and when you have used scientific knowledge.
	11. Do you think students apply the scientific knowledge they are taught in schools in our society?	8. Are you supplied with books free of charge by the government in biology, chemistry and physics? If not, do you have textbooks for these three science subjects, and were they bought by your

		parents/guardians?
2. What view of learning is implicit in teachers' teaching in Lagos state secondary science classrooms?	3. Do you feel appropriately trained as a teacher to help students understand science? Explain.	2. Do you understand science when your teachers teach you? Explain.
	7. Do you think your students understand science that you teach when you use the scientific language and terms such as ____________which you mentioned in the previous lesson?	6. What do you understand by this ____________ mentioned by your teacher in the previous biology/chemistry/physics lesson?
3. What are teachers' perceptions and use of different teaching strategies within Lagos state secondary science classrooms?	4. Are you aware of teaching methods, which engage and involve students during lessons? If yes, give examples of the methods and instances where you have adopted them in class.	
	5. If you have not adopted these methods in class, can you explain why?	
4. How is science teaching and learning in Lagos state secondary science classrooms influenced by i) the language of the curriculum, ii) students'	6. What are your views and understanding about scientific language and terms?	3. How many languages do you speak? Which of these languages do you speak most often at home?

native languages, and iii) the language of science?		
	8. Do you think not relating the meaning of scientific terms to English meanings or examples that students might be familiar with will influence how they understand those scientific terms?	4. Which of these languages would you prefer your teacher to use to teach you science in class? Explain.
	9. What are your views about the use of English as a medium of instruction to teach science?	5. How do you find the scientific language and the terms used by your science teachers? Explain.
	10. Which of these languages – English, students' native language or pidgin should teachers use to teach science in order to aid students' understanding of the subject? And why?	

As written earlier in this chapter, some students in school W during my first visit to the field were interviewed in groups.

3.3.2.1.2.2 Group interviews

The use of group interviews should lead to vibrant interpersonal and social interactions among the interviewees (Kvale, 1996). This should result in a wide exploration of the case if a good rapport is established between the interviewer and the interviewees and the latter are put at ease (Bryman, 2012). However, Bryman (2012) argues that the rapport should not lead to overfamiliarity, as this could affect the quality of the interview.

Four group interviews were undertaken in school W with six students in each group, except for the second group interviewed from Class WChm1, which had five students because one of them opted out for personal reasons just before the interview began. I selected students for the group interview at the end of lessons I had observed, and the criterion used for sampling them was based on their level of involvement during the lessons. I looked out for students who were active, and also students who were withdrawn during the lessons, and selected both kinds for the interview. This was a difficult task, considering the large class size, but my experience as a teacher made it easier for me to know who was attentive and interested in what was going on in the class based on their looks, gestures and focus. Table 3.6 summarises the group interviews conducted with students.

Table 3.6: Outline of group interviews with students

DISTRICT AND SCHOOL	**VISIT NUMBER**	**NUMBER OF STUDENTS AND CLASS**	**DURATION (minutes)**
1st District: School W	First visit	Six students, Class Wbio1	29
		Five students, Class WChm1	44
		Six students, class WBio2	24
		Six students, class WChm2	29
Average duration of the four student group interviews			**32**

The group interviews were audio-recorded. The questions put to the students were not as structured, but still had sufficient guiding to provide responses that would help me to answer the research questions. The group interview schedule gave room for spontaneous responses to questions (Bryman, 2012). However, this form of interview can lead to participants derailing from the main topic of discussion if they are not well-guided. To avoid this, and to make effective use of the time available with the students, I used the following questions to structure our conversations:

1. Why have you chosen to study science?
2. Do you find learning science interesting? And why?
3. Who or what motivated you to study science?
4. Is there any method you would want your teachers to adopt in this school to teach you science, apart from the ones they are using?
5. How did you find the grouping method used in the previous lesson?
6. Do you find science difficult to learn? And why?
7. Do you think science is useful and why?

During the group interviews, the students were able to speak about their experiences of science and school. Interviewing six students at once enabled me to have more students participate, despite the short time available during their lunch break to carry out the interview with each group. However, the students in their groups were not flexible enough to respond spontaneously, and were cautious in their responses, perhaps out of fear that someone in the group might reveal to their teachers what had been said during the interview. It was for this reason that I changed to individual student interviews for the following visits.

3.3.2.1.3 Field notes

Field notes are brief notes written by qualitative researchers in the field of study on what is seen or heard that is of potential value for the study (Bryman, 2012). Taking them helps the researcher to give meaning to what is observed and aids in the understanding of the case under study.

I took field notes during fieldwork [because taking field notes is part of data collection] right from the first day that I walked into the schools, including during lesson observations. In addition, I jotted down notes when I spoke informally with teachers and students during their free periods at each of the four schools, and these were later developed into full notes. The teachers and students were told that I was collecting data while talking to them, and they agreed.

3.3.3 ENSURING DATA QUALITY

3.3.3.1 TRUSTWORTHINESS

In order to evaluate a qualitative study positively, the trustworthiness of the data must be assured (Bryman, 2012). Trustworthiness of qualitative data is helped by considering its credibility, transferability, dependability and confirmability (Bryman, 2012). Ensuring the trustworthiness of qualitative inquiry is essential, due to the subjective interpretations made by qualitative researchers in order to understand a case, the high investment of time and money, the ethical issues involved and the cases' slow contributions to disciplined science (Stake, 1995, p. 45).

On arriving at the field of study, I was able to communicate fluently, most of the time in English, and sometimes in 'Yoruba', the language spoken by most people living in Lagos (a Yoruba state). Hence, teachers and students readily cooperated with me. Furthermore, as a teacher by profession, the teachers at the school trusted that I was there not to spy and report them to the higher authorities at the Ministry of Education, but to know how help students understand science better. I found this very encouraging, because I had expected a certain resistance from them, considering my younger age.

Having taught science to students in smaller class sizes in a private secondary school within Lagos, I had some idea of the challenges teachers would face with a class of sometimes over ninety students. For this reason, I came to the school looking out for some of these challenges and empathising with the teachers, which helped in making them to trust me.

In this study, having evidence of agreement across the four cases shows the credibility of the data (Bryman, 2012). Multiple accounts of the teachers on most of the issues discussed during data collection agreed, despite my having interviewed them in separate places and at different times. In addition, transferability reflects the trustworthiness of the data. As most public schools in Lagos could have some of the issues facing the four selected schools, it should be possible to transfer the results from this research to those schools within Lagos. Although a case study is less likely to be generalised (Stake, 1995), the in-depth study of the cases, should produce valuable knowledge, and this should make possible the transferability of the findings to other similar contexts (Bryman, 2012).

Dependability in qualitative research is parallel to reliability in quantitative research (Bryman, 2012). According to Kvale (1996), the question of the reliability of an interviewer is raised in interview research, due to the interpretational character of the transcription, which might give different meanings to the responses of participants. To avoid this and improve dependability in this study, I enhanced the quality of transcription by using conventions that can be easily understood and distinguished from each other in the scripts, and presenting the data in a dialogue form (Bryman, 2012). On this note, I found the transcription conventions for classroom interaction used by Harry Torrance and John Pryor in their book *Investigating Formative Assessment* (1998) very convenient and useful to use. The detail of the conventions is in Table 3.7.

Table 3.7: Transcription conventions (as used by Torrance and Pryor, 1998)

CONVENTION	MEANING OF CONVENTION
C	One unidentified participant
Cs	Many unidentified participants
> <	Many participants giving simultaneous speech in the context of classroom discussion
~	Rising intonation slowly to invite another speaker to complete sentence
-	A short pause
(**)	Inaudible phrase
…	Omitted parts
(*)	One inaudible word
C1, C2	First participant, second participant

UPPERCASE WORDS	**Words spoken loudly compared to other utterances within the context of discussion**
(***)	**Longer inaudible sentence**
Underlined words	**Words that are emphasised by the speaker**

I transcribed the data using the conventions in Table 3.7. In addition, I adopted an auditing approach (Bryman, 2012), by listening repeatedly to recorded sessions of lesson observations and interviews on audio tapes, and I cross-checked the transcriptions I had already made with what I heard on the tapes. I did this to ensure that my interpretations aligned with the participants' responses to my questions. Similarly, the confirmability of the data was improved by allowing as far as possible the data to speak for itself, without any interference in the form of the researcher's biases or personal values (Bryman, 2012).

For confidentiality reasons, I adopted pseudonyms for the participants: for example, Bayo, Olu, Andrew, Sade, Festus, Florence and Bianca, which are names common within Nigeria.

3.3.3.2 TRIANGULATION

Triangulation can be used to increase the validity of inferences made from data. A case study qualitative researcher discovers and shows the multiple views that emerge from the cases, as such work is necessary to clarify the interpretations of those views (Stake, 1995). The gaining of credence in the interpretation of data can be achieved by triangulation, and there are different ways of triangulating data**.** In this study, the triangulation of qualitative data was carried out by using the protocol of methodological triangulation (Stake, 1996). According to Stake (1995), most researchers recognise and use methodological triangulation.

Methodological triangulation was performed by using multiple methods (observations of teachers and students, individual interviews with teachers and students and group interviews with students). Doing this helped to corroborate evidence produced by the different methods and gave more foundation to my interpretations of meaning from the participants' views (Creswell, 2013).

3.3.4 DATA ANALYSIS

It is common to begin the analysis of qualitative data right from when some of the data are collected. Stake (1995) defines analysis as "taking something apart" (p. 71), and this means teasing data into their constituent components in order to make sense of them. Making a detailed description and interpretation of a case and its setting is what analysis of data in a case study entails (Creswell, 2013). Doing this involves a subjective way of making interpretations of a single instance, and also accumulating many such single instances until sense can be made of them collectively also (Stake, 1995).

To start with, a researcher should know the form of analysis that works best for him or her, and this was what I ascertained at the beginning of the main study, by reflecting on my experience during the pilot study (Stake, 1995). I devoted time to the interpretation of instances, which depends on the search for patterns that are drawn from responses to interview questions and from my observations (Stake, 1995). Therefore, the approach adopted for the analysis of data in this study was thematic analysis, which entails the search for themes or patterns not based directly on the research questions (Bryman, 2012). A theme is defined as a category picked out from data, developed from codes, and related in a broad sense to research questions, in order to relate my data to others' theoretical understanding of the data (Bryman, 2012, p. 580).

Thematic analysis was adopted because it is an approach that is flexible and can be used in different contexts of qualitative research (Bryman, 2012), especially in a case study. Although thematic analysis does not follow a set procedure (Bryman, 2012), its application in identifying topics that are repeated in the data still helps to foreground the trustworthiness of the findings. Before analysing the data, I transcribed the recorded science lessons and interview sessions verbatim and arranged them in two separate tables of teachers and students. Transcription was carried out during data collection, and this helped me to reflect and direct my focus towards topics that are important in answering the research questions. This reflection enabled me to prepare ahead for the next interview sessions I had. Afterwards, the transcribed data were studied several times for reasons of familiarisation.

After transcribing the data, I started my analysis process. During the analysis, I coded the data from the interviews, lesson observations and my field notes. I used NVivo, a qualitative computer program, during the analysis process. Using NVivo enabled me to familiarise myself more with the data and that made it possible for me to have a fuller understanding of the issues within each school and across all four. I coded the interview data (from teachers' and students' individual interviews and students' group interviews) first. The reason for this was that I found the responses of the participants important, and I wanted to begin to analyse the data while the memory of speaking with my interviewees was still fresh.

Reading through the data enabled me to develop codes, and I arranged the similar codes and the contrasting ones separately. An example of how I coded the interview data to arrive at one of the codes is shown in Table 3.8 and a table showing how each code is illustrated by data extracts is presented in Appendix 3.

Table 3.8: An example of data coding

Data Source	Data extract	My interpretation of data extract	Code
School W	Sade: When I was very young, my father normally tells me that he wants be an engineer, though he is not an engineer but my uncle is a construction engineer and he works for Lagos state government and he tells me that engineering is a useful profession. Also, I like how he is living very comfortably, getting contracts from Lagos state government to make roads.	At least some students choose to study for science-related careers. This suggests that such careers lead to well remunerated jobs within that society.	Economic reasons

School Y	Festus: I am learning science because that's what … I want to become someone big in life.	To be someone big in life means to be rich and successful.	

During the data analysis, I noticed that both similar codes and contrasting ones featured when I looked at the lesson observation data and my field notes. As I did with the interview data, I also arranged the codes I derived from the analysis of lesson observation data and field notes in tables, which are not different from the codes I obtained from the interviews. I analysed the data collected across the four schools together since the purpose of this study is not to compare the schools but to understand the teaching and learning of science within multi-lingual contexts, something common to all four of my study schools. Following Bryman's (2012) strategy, I constructed a framework – a grid-like arrangement of data – by organising similar codes into themes in tables. Themes were developed from the codes and these are discussed in Chapters 4 to 7. An example of the framework I constructed is shown in Table 3.9, which features the four main themes.

Table 3.9: An outline of the thematic analysis of data

CODE	**THEME**	**CHAPTER**
To produce scientists: • Economic reasons • Developing scientific skills and attitudes • For prestige	Value of science	Chapter 4
For scientific literacy: • For health and lifestyles • Environmental reasons • Citizenship reasons		
Students' preparation for lessons	Students' views of learning	Chapter 5
Teaching methods that aid students' learning: • Group work • Using familiar examples • Performing practical work		
Views and use of native language: • Views about the native language	View and usage of language	Chapter 6

• Use of native language in science lessons		
Views about the use of English		
Teaching scientific terms and students' responses: • Naming words • Use of exact words • Use of mathematics: words and symbols		
Teachers' views of teaching strategies: • Group work • Using familiar examples • Performing practical work • Using visual aids • Note copying • Assessing students	Teaching strategies	Chapter 7
Teachers' use of teaching strategies: • Explaining concepts • Questioning • Note copying • Preparing students for examinations		

In each of Chapters 4 to 7, I present one theme, and I use extracts from the data to explain the codes and explore the themes. In Chapter 8, I refer to the four themes to address the research questions and provide an overall understanding of the teaching and learning of science within senior secondary schools in Lagos.

3.3.5 ETHICAL ISSUES

At every phase of this study, ethical issues were considered, with respect to how the participants would be treated during data collection and subsequently (Bryman, 2012; Creswell, 2013). This aligns with the notion that attending carefully to ethical considerations during any study will contribute to its credibility (Bryman, 2012). Due to this, strategies to protect the participants were devised from the beginning of this study, and prior to getting permission to visit the contexts (Stake, 1995). Also, since the study involves children, care was taken to ensure that their welfare was protected.

In this study, ethical issues were considered in accordance with the Statement of Ethical Practice for the British Sociological Association (2002), and the guidelines followed in order to observe ethics were those that Creswell (2013) suggests, and include:

- Selecting the study contexts and seeking approval from my university (UCL) through my supervisors to proceed with the study. Likewise, I sought and gained permission and approval from the Permanent Secretary at the Lagos State Ministry of Education to carry out the pilot study in November 2014 and later in January 2016 in the other districts. The purpose of the study was disclosed in the permission letter written to the Lagos State Ministry of Education. The approval I was given enabled me to have access to the three districts for the main research in February 2016, November 2018 and March 2019 respectively. Likewise, the Head or Principal of each school I visited during the main study were informed of the purpose of the research.
- The Head or Principals gave consent on behalf of the parents of the students selected for the study. When visiting the schools sampled for the main study, I took some gifts collected from the International Office at the UCL Institute of Education, such as pens and bags, as token compensation to the Head and teachers for their valuable time. With respect to students in one of the schools I visited, I contributed towards a donation, which the year group I sampled was trying to make to the school. Doing this was advantageous to me, through helping to build trust between the students and myself. Similarly, I built trust with the students in all the schools I visited, and they agreed to give me time in their lunch breaks for them to be interviewed.
- Teachers and students at the study sites were told of the purpose of the study and were given a consent form to read through and sign before they participated. The consent forms used during the three different visits to the study sites spelt out the participants' rights to confidentiality, anonymity and withdrawal (Appendices 1 and 2). They were told of their right to refuse audio recording of interviews. They were also informed regarding how the data would be used and how their involvement would contribute towards the

understanding of science teaching and learning in Nigeria.

- While I was collecting data, the participants were not under any pressure to answer any question or talk about any issue that they did not feel wish to. I respected the participants' rights to not respond to any questions. During lesson observations, every effort was made not to disrupt the lesson.
- During data analysis, I avoided being on the side of the participants or going against them; that is, there was no bias (Bryman, 2012). Furthermore, I respected the privacy of the participants by using various methods to preserve their anonymity. The methods used include removing identifiers such as the names of schools, teachers and students, and using pseudonyms, especially during the presentation of findings.
- All data were stored securely, with the password protected for electronic instruments, and known only to me. Participants were also informed from the beginning of the study in the voluntary consent form of the likelihood of the data being shared with other researchers, in order to contribute to the wellbeing of society, which is a valuable activity of this research (British Sociological Association, 2002). The Permanent Secretary at the Lagos Ministry of Education, Heads, Principals and the teachers who participated in this study were promised copies of a summary of the findings of the study after the successful completion of my PhD.

3.3.6 LIMITATIONS OF METHODOLOGY

Critics of qualitative research make specific criticisms against it, and the primary one they give is that "qualitative inquiry is very subjective" (Stake, 1995, p. 45). Subjectivity can be a limitation. However, it is my transparent approach in giving full descriptions of my participants' views and what was observed (Bryman, 2012) that gives this study its strength. Doing this enabled me to arrange these subjective views and supporting texts under broad headings in the different chapters, in turn enabling me to present a detailed interpretation of the teaching and learning of science within Lagos senior secondary schools.

A limitation related to case studies is that findings cannot be generalised (Stake, 1995; Bryman, 2012). In this study, however, the focus is not on generalisation, but on the in-depth exploration of the cases, which helped to achieve the aim of understanding science teaching and learning within the contexts of study. Furthermore, it is possible that there are other schools that have similar characteristics to those of the schools sampled in this study, and findings from this study may apply to such schools.

Time and money were limiting factors in this study. According to Stake (1995), researchers often need a long time to understand a case, and the costs are hard to reduce. I travelled to the field on three different occasions, which was expensive. As a part-time student in paid employment I could not spend more than three weeks in the field during each visit. Meanwhile, choosing contexts that I was familiar with helped to reduce the cost that would have been incurred if I had carried out the study in an unfamiliar site. As a teacher by profession and based on my experience in Lagos, I communicated freely and easily with the teachers, which resulted in the building of trust between us. Consequently, tension that could have arisen to impede data collection was not present. Hence, time was utilised judiciously.

The biology teacher in the first school I visited (school W) was not able to have one of her lessons observed, due to her presence being needed for an impromptu official duty. This happened close to the end of the three weeks I had planned to spend on data collection in that school. As a result, the planned lesson observation for that class could not take place. Since both classes were scheduled for an equal number of observations, she kindly arranged for another teacher to use her lesson period for biology, so that I could observe that lesson and collect data.

CHAPTER FOUR

VALUE OF SCIENCE

4.1 INTRODUCTION

The previous chapter discussed the research methodology appropriate for this multiple case study with emphasis on the methods of data collection and analysis. Chapters 4 to 7 focus on data collected during lesson observations and interviews in the four schools. The data comprise teachers' and students' responses during individual interviews, students' responses during group interviews, science teachers' oral exchanges with students during lessons and information from field notes written during data collection.

The thematic analysis of the data produced codes, and these were combined to form a total of four themes. One of these themes, 'the value of science', is presented and explored in this chapter, and the remaining themes are considered in the next three chapters. Within the theme covered in this chapter, there were two main sub-themes: 'to produce scientists' (examined in Section 4.2) and 'for scientific literacy' (examined in Section 4.3).

4.2 TO PRODUCE SCIENTISTS

Teachers and students spoke about the value of producing scientists when they described why they chose to study science and the usefulness of science in society. They presented arguments that included economic reasons, developing scientific skills and attitudes, and prestige.

4.2.1 ECONOMIC REASONS

The teachers and students in this study frequently expressed the view that science offers careers that are well remunerated. One of the teachers in school Y explained why parents encouraged their children to study science:

> Most of the parents believe that a career in any sciences in the university is

> the best option for their children … as far as Nigeria is concerned, I think 80% if not 100% of parents put their children in science class for economic reason. (Individual interview with chemistry teacher, School Y)

This chemistry teacher's view that parents regard science-related careers as "the best option" suggests a presumption that jobs in science-related fields attract high remuneration – given his reference to "for economic reason". He further expressed the reason students give for studying science. He went further to explain why students choose to study science:

> If you ask the students 'why are you in the science class?', the first thing they will tell you is 'I want to be a doctor or an engineer'. I think from the students' perspective they just want to be OK and better in life … we all know that doctors are living fine. So, when you talk about the engineers, they are all living fine. (Individual interview with chemistry teacher, School Y)

To be "OK", "better in life" or "living fine", according to the chemistry teacher, points to the view that careers in science are well remunerated, which is why he stated that students choose to be in science classes. The students in this study made claims which resonate with the chemistry teacher's view of studying science for the reason of following science-related careers in order to become wealthy:

> When I was very young, my father normally tells me that he wants me to be an engineer, though he is not an engineer but my uncle is a construction engineer. I like how he is living very comfortably, getting contracts from Lagos state government to make roads. (Interview with student Sade, School W)

> I am learning science because that's what … I want to become someone big in life … being successful. (Interview with student Festus, School Y)

> My parents encouraged me to be a medical doctor. They are not educated but they are eager to see me study science and get the best in life. (Interview with student Ope, School W)

To get the best in life, to be comfortable or to become someone big in life could mean a range of things, which includes getting a job that pays well within society. The students' views seem to indicate that careers related to science are recognised for attracting benefits and rewards that would make one live comfortably. Generally, the teachers' and students' statements highlight science as leading to jobs that are well remunerated within Nigerian society. Pertinent to their views of studying science is the claim by Johnson (2012) that students from developing countries take up scientific careers due to the good salary they would have. Overall, the teachers' and students' statements tend towards the economic value of science, and according to researchers (Nwachukwu, 2012; Claussen & Osborne, 2013), science-related careers contribute to the economic growth of a nation. The emphasis on the economy seems to be ingrained within Nigerian society. This partially accords with Alex Moore's (2015) delineation of Schiro's second purpose of public schooling: to train students for socioeconomic reasons that will benefit the economy of the state. However, the teachers and students in my study seem to mention the economic value of science as a priority to individuals rather than the entire state.

Meanwhile, studying science for the development of technology in society, which could lead to economic benefits, was stated as a reason by teachers and students. The physics teacher in School X claimed that:

> Science crosses all facets of life. For example, if you go into the financial sector to start with, I believe if we can count ten successful industrialists, we will find someone like Dr Omolayole who is a physicist. As a teacher, I have always encouraged students to study science. Science will make a country to develop technologically. (Individual interview with physics teacher, School X)

The physics teacher in her example related an industrialist to a physicist (scientist), which seems to indicate a connection between science and wealth. In addition, she linked science with the development of technology within a country. Therefore, one could suggest that a nation makes technological developments as a result of scientific knowledge acquired, which could lead to economic benefits for the nation and individual scientists. Another teacher spoke of the application of scientific knowledge:

> Under science we have various fields, various careers that are very lucrative out there … Without science, the country will not be developed. As a teacher, I have always encouraged students to study science. Science will make a country to develop technologically. (Individual interview with chemistry teacher, School Y)

The word 'lucrative', as used by this chemistry teacher, indicates wealth or money-making, and according to this chemistry teacher, studying science leads to technological innovations. In addition, the teacher attested to what the physics teacher in School X expressed about the role of science in the technological advancement of a nation, and economic growth.

Students seem to agree with the views of teachers with regards to producing scientists for technology development:

> I am studying science because I want to make it in life. I wish to become like all those scientists and professors who invents stuff, and contribute to the nation's development. (Interview with student, Oyin, School W)
>
> I can say science is the study of life and technology. It enhances the level of technology. (Interview with student, Olu, School X)
>
> I am learning science because it tells us more about our environment and I want to be involved in the activities in our environment such as inventing machines. (Interview with student, Ayo, School Y)
>
> Yes, it is very useful. All these science products that we use nowadays like all these machines … were invented from science. And without science, we cannot have them. (Interview with student, Tobi, School Z)

These extracts from students' interviews in the four schools indicated the application of scientific knowledge in the manufacturing of useful technological products. The students spoke of the usefulness of science, which according to one of the students in School W contributes to the development of a nation. The students' recognition of science's contribution to the production of machines as being good for the nation appears to resonate with Furió et al. (2002)'s argument that science contributes to development within societies. When a society develops, the country is more likely to enhance its rating in the economic market (Millar, 2014).

Overall, the above statements made by these teachers and students describe the role of science in the development of technology, which would improve the lives of people and perhaps position the nation for economic development. However, are students taught science in a way that will enable them to apply the scientific knowledge introduced to them in class? This is one of the questions that this study aims to explore.

4.2.2 DEVELOPING SCIENTIFIC SKILLS AND ATTITUDES

Gauld and Hukins (1980) discussed the concept of scientific attitudes as having two dimensions: the scientific and affective. The scientific dimension, as described by Gauld and Hukins, and briefly presented in Chapter 2 of this thesis, includes: having the general attitude of curiosity, open-mindedness and creativity towards ideas; having attitudes towards evaluating ideas by being objective, intellectually honest and cautious when making decisions; and being committed to particular scientific beliefs. The affective dimension was discussed as having the will to use the abilities and skills or to use scientific methods (Gauld & Hukins, 1980). The participants in my sample mentioned that the study of science helped students to develop scientific skills and attitudes, which tended to be more associated with the scientific dimension of scientific attitudes. A biology teacher claimed that:

> I encourage them to be an engineer, be a scientist … When students work on their own, they can perform experiments, make observations, and take readings of findings as science students. They can get ahead with whatever they lay their hands on. (Individual interview with biology teacher, School W)

Scientific skills of carrying out observations and taking readings are developed when students choose to study science. According to this biology teacher, students are able to “get ahead”, which could mean that they make progress or succeed in what they do when they use the skills they have developed while studying science. One of the teachers elaborated on the skills and attitudes of scientists:

> Some of the first scholars in science were not scientists but philosophers. So they observed things around them and made notes about them. When the scientists came, they went into the laboratory to know more about these laws and some of them were disproved because laws must be scientifically proven. (Individual interview with physics teacher, School X)

The physics teacher spoke about how the scientists weighed all available evidence presented by philosophers. It could be that she felt that philosophers find out things by theoretical thinking, and scientists had to evaluate the ideas in the laboratory to prove them; doing this might have enabled them to refute the initial beliefs of philosophers. Her statement showed her belief that scientists employed the use of scientific attitudes and skills in critically weighing the ideas presented by the philosophers. The teacher’s claim resonates with the description of scientific attitudes as including being objective and cautious when making decisions, as argued by Gauld and Hukins (1980).

Students spoke about scientific attitudes that they develop when they studied science, such as that of curiosity as stated by a student in School W:

> I love science and have an attitude of wanting to know more about things. I am very curious about things around me and this broadens my knowledge. (Interview with student, Kunle, School W)

Being curious or inquisitive enhanced the scientific knowledge student gained in class, as mentioned by Kunle. Furthermore, his expression seems to indicate that he is open-minded towards ideas or things around him. To be curious and open-minded are some of the components of scientific attitude listed by Gauld and Hukins (1980). One of the students in School W expressed another component of scientific attitude and skills:

> I love science because I realise that most magician tricks are science but people don't know that. (Interview with Student, Linda, School W)

The above extract showed that some ideas that people consider as magical could be explained by science in relation to the existence of some natural causes. Therefore, this suggests that there would be no basis for students to be superstitious when they study science. Linda's view is pertinent to someone's commitment to scientific belief rather than superstition. Scientific belief is one of the components of scientific attitudes mentioned by Gauld and Hukins (1980).

In addition, through studying science, students are able to know about the work of scientists as explained by a physics teacher:

> We learn science to know basic things about theories and laws governing natures … Secondly, to be able to make scientific discovery. (Individual interview with physics teacher, School W)

Knowing basic things about theories and laws, as stated by the physics teacher, seem to align with the earlier report of the physics teacher's statement in School X about the work of scientists. The "basic things" could be ideas and pieces of evidence used to arrive at conclusions regarding the laws about nature, and "know[ing]" could be the methods employed in science. The physics teacher's explanation appears to indicate that scientific skills and attitudes developed by students inform them about how scientists come up with laws and theories about phenomena, and how to use these skills to invent things. Perhaps this might equip students to be better enlightened about what is happening around them.

Another teacher expatiated on the influence of studying science on students:

> The impact of science cannot be over-emphasised in the development of a child. Because learning science makes them see themselves as young scientists who can create things in their own respect. (Individual interview with physics teacher, School X)

According to this physics teacher, studying science motivated students to act like scientists and create things, which reinforces Holbrook and Rannikmäe (2007)'s argument that what scientists regard as important should take dominance in schools; hence students should be taught to act as little scientists. One aspect of acting like real scientists is that students develop the scientific attitudes to arrive at honest and objective reports of phenomena, which is of a direct value to students in life and at work (Gauld, 1982; Wellington, 2001).

The participants' statements presented in this section indicate that students develop scientific attitudes and skills through the study of science, which corresponds with the scientific dimensions of scientific attitudes described by Gauld and Hukin (1980). The teachers and students mentioned such scientific attitudes and skills as evaluating ideas by being objective, weighing available evidence to make decisions, and having a mind of curiosity and open-mindedness towards ideas.

4.2.3 FOR PRESTIGE

Students may also choose to study science for reasons of personal prestige, which includes social and academic status. As reported earlier in this chapter, parents within the Nigerian context influence their children to study science for economic reasons, and it appears parents do the same for additional reasons of social and academic status.

The biology teacher in School W spoke about how friends contributed towards influencing her to develop an interest in science:

> But there was someone that encouraged me when I was at the university who was a year ahead of me, but she will tell us that 'you are on a good path since you are doing science and education, now you will not know but when you get outside you will know that you are a professional'. (Individual interview with biology teacher, School W)

The phrase "get outside" suggests outside the walls of the classroom, and studying science to become a professional revealed the social status conferred on science within that context. A chemistry teacher explained why he believed that parents want their children to study science:

> Under science we have various fields compared to all the social sciences and art. So parents think that when the students are in science class they have many options or various fields. (Individual interview with chemistry teacher, School Y)

Parents think that studying science opens up opportunities for their children to explore more occupational fields than they would if they were studying social science or art. The chemistry teacher's view therefore suggests that science enjoys a social status, perhaps fuelled by economic reasons, compared to other disciplines such as the social sciences and art. Students spoke of the social status of science, which supports their decisions and shows why they choose to study science:

> Also, in the world people who dominate the world are the scientists. They dominate by contributing to the knowledge of the world, and making it a better place. (Interview with student, Bola, School W)

Using the word 'dominate' suggests the role of scientific knowledge in bringing about a radical change within the world when applied and thereby being influential. Bola's statement resonates with what the students in Osborne and Collins' (2001) study stated, namely that students gain prestige when they study science. Furthermore, making the world a better place seems to point to the relevance of science to people's lives within that society.

The participants spoke about another form of prestige that students gain when they study science. They mentioned that parents put pressure on their children to study science even when the children are reluctant to do so:

> Not everyone wants to join the science class; their parents may push some of them because parents do believe that if their child passes through science class, they will become successful due to careers developed when you study science. (Interview with student, Gregory, School W)

The word “successful” in the above extract is described in the Cambridge Dictionary as achieving a lot or becoming popular. Parents’ desire to have their children become popular may help explain why they make their children study science, so that their children can enjoy the social status conferred on science within that context. Also, in a situation like the one expressed by Gregory, the student’s experience of scientific concepts might be that of a struggle, resulting from the ‘push’ from the parents. One of the teachers reinforced Gregory’s statement by stating that:

> Sometimes the students are not interested to learn science but their parents force them. (Individual interview with physics teacher, School Z)

Forcing students to choose to study science might make them show little interest in learning the subject. Consequently, this might affect the students’ understanding of scientific concepts and performance in assessments.

Studying science seems to relate to academic status and students used the term “brilliant” commonly during the interviews to refer to those who study science. For instance, students claimed that:

> Because people say that the most brilliant students are found in the science class, I wish to be among those brilliant students. (Interview with student, Ade, School W)

> I want to be an engineer and I also want to be a role model that people would look onto and say that ‘wow, a female can do this’. (Interview with student, Kike, School W).

As mentioned in these extracts, the word “brilliant” seems to be a title of honour given to students who choose to study science. Although this study did not consider the issue of gender, Kike’s statement that people would say “wow, a female can do this” seems to indicate the existence of a gender stereotype within Nigeria’s context in relation to the choice of scientific career. On this note, some students are motivated to choose to study science, while some others are put off, feeling that they are not brilliant enough. Other students spoke about why academic status is conferred on students studying science:

> The reason most of us are offering science subject is because we want to challenge our mental reasoning and challenge ourselves that we can do more. (Interview with student, Alfred, School W)

Alfred's statement expressed the view that science is challenging and involves tough mental reasoning and that is why they are studying it. Finding the comprehension of science difficult seems to explain why science has an academic status, which is conferred on anyone associated with it. Likewise, the organisation of science competitions where students represent their schools tends to portray a society where science has an academic status. This is important because through such competitions, students are exposed to knowing more scientific terms and how these relate to the environment. Furthermore, engaging in such competitions seems to make students appear competent, and this seems to give an academic status to the students. In this respect, teachers tend to agree that science has an academic status and that explains why few students are involved in representing a school in science competitions. The biology teacher mentioned to students during one of the lessons:

> When you go out and you talk like that, they will disqualify you and you know it. The day we went to (***) if you say 'yes I will answer' and you miss it, you will lose marks, so you cannot just open your mouth. (Biology lesson observed, School WBio1)

This view of this biology teacher shows the importance of answering questions properly so that students can be able to represent the school in competitions. Another teacher mentioned another word used to show the academic status of science:

> Actually, to study science, you have to be intelligent. It's part of it. (Individual interview with chemistry teacher, School Y)

The use of the words "brilliant" and "intelligent" seems to take off the responsibility of students' learning from their teachers. It also suggests that science is not for everyone to study, which to an extent confers an academic status on science subjects. Having few students take up the study of science connects with Wellington (2001)'s first aim of science education, which is to prepare a minority for science-based careers. However, if science is regarded as being for the elites, that is, those who are brilliant or intelligent end up taking science careers, then how can the goal of 'science for all' be realised within that context? And how can all people benefit from scientific knowledge?

As already explained in this section, the participants seemed to believe that the value of science related to raising scientists for economic reasons, developing scientific skills and attitudes and enhancing prestige. According to teachers and students, developing interest to study science can be related to the value that science has within that context. Findings indicated that within Nigeria's context students are encouraged by their families, friends and the broader society to take up science-related careers. This is because science is considered to have an academic status and an economic value due to professions such as medical doctor, computer scientist, pharmacist, mechanized farmer, engineers etc. that can be pursued when students choose to study science. The teachers and students claimed these professions can enable them become entrepreneurs and be independent in the future. An entrepreneur is defined in the Cambridge Dictionary as someone who starts their own business. Gaining scientific skills and attitudes was seen as helping to prepare students for the world of work in science, where they would actively use that knowledge to develop technological products.

4.3 FOR SCIENTIFIC LITERACY

The second important aim of science education was discussed in Chapter 2 as the aim of developing scientific literacy. In this respect, teachers and students expressed their views of the usefulness of scientific knowledge in relation to their personal wellbeing, taking care of their environment, and how science contributes to making decisions involving scientific issues in society. These are presented in this section as being seen as valuable for scientific literacy.

4.3.1 FOR HEALTH AND LIFESTYLES

The teachers and students identified ways in which science contributes to the development of personal wellbeing. One biology teacher elaborated on how learning science helped in maintaining a healthy society:

> To know more about taking care of oneself. When there is an infection, you learn more about it and tell people what to do … Know how to avoid infection, the kind of food to eat; have environmental knowledge of diseases, infections, cure, diet. (Individual interview with biology teacher, School W)

According to this teacher, studying science enables students to know more about taking care of their bodies and the environment for their benefits. The biology teacher displayed her view by using examples that students could relate to during her lessons. An example was when she asked students to name the parts of the body involved in food digestion and when she mentioned how earthworms and cockroaches feed and live. Likewise, the following exchange took place:

> Teacher: These intestinal worms will absorb their food like when you put your bread inside tea. And I still remember that I said if you are tiny maybe you have so many worms, that you should go and deworm, because they are feeding on what? Digested ~
>
> Cs: Foods.
>
> Teacher: What you are supposed to eat to make you grow and robust, they will be feeding on it and you will be the host keeping a lot of them in your body. (Biology lesson observed, School WBio2)

She implied that being able to know how to keep one's body healthy is made possible when science is learnt. It seems that the teacher's approach is geared towards teaching how concepts relate to students' lives, and this appears to have ingrained the knowledge in the students. Students in School W corroborated the biology teacher's claim, for example, by stating that:

> Also, without science if someone is sick, you will not know how to take care of the person or know the type of drugs to take. (Interview with student, Andrew, School W)
>
> For me, to become a doctor is my goal. My aim is to save lives and try to help people by conducting some programmes to make them overcome problems

> that they face during their day-to-day activities such as anxiety. (Interview with student, Joke, School W)

Students reinforced their biology teacher's claim that studying science enabled the promotion of people's welfare and the saving of lives. Students in other schools expressed similar reasons for studying science:

> I want to invent new things such as vaccine, drugs and I want to bring up ways of treating ourselves, even of preventing sporadic diseases or illness among people. I want to raise a synopsis on health education. Those are the ways that I can use the science knowledge and I can be successful in it. (Interview with student, Ola, School Y)

> I am offering these science subjects because they make me to know more things about my health, and the way we should live our lives. (Interview with student, Kunbi, School X)

> The scientists have proved to us that without science we can't do anything. For instance, science has provided us with some drugs that we use when we are ill. (Interview with student, Wale, School Z)

Ola's claim of raising a synopsis on health education seems commendable because it brings an insight to students' background knowledge, which could be enhanced if explored within the classroom. Overall, the claims made for learning science related to the application of knowledge gained in the classroom to take care of their bodies and environment, and to manufacture medicines. The health and lifestyle reason given by teachers and students in this study aligns with scientific literacy because it indicates how science interacts with society. According to Millar (2014), the ability to make decisions about one's wellbeing will lead to being more likely to have good health. Therefore, this seems to relate to the humanistic argument of the purposes of teaching and learning science (DeBoer, 2000), and it highlights the value of science as being for scientific literacy.

4.3.2 ENVIRONMENTAL REASONS

Knowing how the Earth that we live in works and making sense of the world are environmental argument for learning science (Wellington, 2001; Millar, 2014; Reiss & White, 2014). Teachers and students expressed their views on the application of scientific knowledge in knowing more about their environment and how to go about their day-to-day activities.

The teachers expressed environmental reasons for learning science:

> The knowledge of science is very, very useful. It helps us to understand a lot of things about our bodies, about our environment and how to do well, how to cook well, how to avoid some things in our environment. (Individual interview with biology teacher, School Y)

> Science education is to have a scientifically literate citizen. Science is for all now either going for a science-based career or not, you must know science, it will help you to apply what you know to everyday life experiences … where we are now in biology is nutrition in plants. It is good they know what is going on in their environment, they should understand how to handle the plants around them carefully, and that plants do help us in beautifying our environment. (Individual interview with biology teacher, School Z)

All these teachers spoke about how science related to the everyday lives of people. They mentioned how using the knowledge of science helps to explain what is going on around them, and enables them to carry out their day-to-day tasks outside the classrooms. The relevance of science to social and personal lives as expressed by these teachers relates to the claim made by researchers (Furió et al., 2002; Holbrook & Rannikmäe, 2007) about scientific literacy.

Students gave examples of the environmental application of science. In one instance, Andrew (School W) claimed “most of the things we use in our homes are all science”. Talking about homes, another student mentioned:

> When I see water on the floor, I will know that there would be some microorganisms in it, so I will clean it up, make the environment hygienic and protect everyone at home. (Interview with student, Florence, School Z)

According to these students, science enables them to know more about devices they use and be aware of organisms that are not seen but exist in their environment. Similarly, Vivian (School W) stated that science enables students to “learn more about how to get clean water and what water is used for in science”. Water is commonly used and probably having the knowledge of science she was taught in school broadens Vivian’s understanding because she is able to know the ‘why’ of the use of water. In line with what we use in our environment, Bayo stated:

> I am learning science because science talks about our environment and what is going on around us. Science is useful for example, chemistry, the clothes we are wearing is all chemistry. So, it is very useful in this modern day. (Interview with student, Bayo, School X)

The student spoke about chemistry in relation to clothes, but he did not expound on this relationship or where he learned this idea. In the same way, another student explained:

> Without science there is nothing we can do. And we benefit from science in many ways. For example, through science we produce chemicals to fertilise our soil and grow food in a large quantity. Through science we have crude oil that we use in our cars to move around. So, transportation is made easier. Raw materials are also found to make cements, which we use to build our homes. (Interview with student, Gbenga, School Z)

Gbenga attributed the existence of some products around him to science. It could be suggested that students acquired their views in the science classrooms, although they did not say much about how science lessons are connected to the examples they gave.

The examples listed above illustrate that teachers and students become scientifically literate when they are able to use scientific knowledge to understand relevant issues within their environment (Laughsch, 2000; Reiss, 2014). This is on the premise that teachers guide students during classroom discourse to relate their local knowledge of phenomena to science. On this note, one could suggest that, through studying science, students believed that they are making progress socially (Hurd, 1998), and are able to live more autonomous lives (Reiss & White, 2014).

4.3.3 CITIZENSHIP REASONS

Developing an educated citizen of a country who will apply the knowledge and skills gained to make society a better place for everyone are Schiro's third and fourth purposes of public schooling (Moore, 2015). One chemistry teacher mentioned:

> But at least for a science student ... even if you don't proceed, you should be able to explain or they talk to you in a scientific word ... or the government gives an information, you will be able to explain to others that this is what

> they mean by saying this. (Individual interview with chemistry teacher, School Y)

According to this chemistry teacher, scientifically literate students are able to engage in discussions on scientific issues and therefore can enlighten other people. In addition, one of the students mentioned what scientific knowledge contributes to society:

> Science involves some knowledge about civic education too. Civic education is the study of civic rights of the citizen of a country. (Interview with Valerie, School W)

Although Valerie could not explain fully what she was trying to say when she mentioned “civic education”, her statement could be interpreted to mean that learning science helps students to appreciate their duties in relation to their communities.

Students are able to use scientific knowledge they acquired in class to understand and engage in discussions relating to scientific issues in society. Therefore, students are preparing to become active and responsible citizens (Kolstø, 2008). This can, however, only be possible if students are taught and allowed to relate scientific knowledge to their personal lives and to society (Osborne & Collins, 2001).

4.4 SUMMARY

Teachers’ and students’ interest in science appears to be related to the value of producing scientists and for scientific literacy. The participants expressed their views that jobs in science-related fields attract high remunerations. Furthermore, producing scientists would result in a boost to the economy of a country, because scientists contribute to the technological advancement within the country (Millar, 2014). In addition, students develop scientific skills and attitudes, which they can use to produce technological products and become wealthier. Due to these reasons, many parents want their children to study science and the findings further revealed that science enjoys a high social status within Nigerian society. Similarly, science enjoys a high academic status as many people believe that only brilliant or intelligent students study science. The second value of science is that it leads to scientific literacy because students are able to know how to take care of their bodies, they know more about what is in their environment and how they can take care of it, and they can make informed decisions about scientific issues within society.

The value of science as explained in this chapter aligns with the two key aims of science education discussed in Chapter 2: producing scientists; and raising scientifically literate citizens (Wellington, 2001). From the findings, it could be suggested that achieving the goals valued for science within a society depends on how students are taught science in the classrooms. This is in the context of the fact that teachers' beliefs of how students learn can influence their practice (Savasci & Berlin, 2012).

CHAPTER FIVE

STUDENTS’ VIEWS OF LEARNING

5.1 INTRODUCTION

The ‘value of science’ theme explored in Chapter 4 revealed that students may choose to study science in the hope of becoming a scientist or simply to increase their knowledge for reasons of scientific literacy. Teachers perceive that the more scientists a country has, the more technologically developed it will become. Insights from the data appear to indicate that how teachers teach science helped to determine whether students intended to pursue the subject. As discussed in Section 2.4.1, how students learn depends both on their conceptions of learning and those of their teachers (Watkins et al., 2001). Similarly, how teachers characterise assessment and learning can influence their views on both teaching and the process of learning (Watkins et al., 2002).

This chapter explores the second theme – the students’ views about what aids their learning of science in the schools. As described in Chapter 2, the views of learning refers to teachers’ and students’ ideas about learning, which shape the teaching of concepts, the curriculum, and assessment (Watkins, 2005). The focus in this chapter is on students’ views because knowing how students experience teaching and learning is of help to teachers (Reay, 2006), especially in planning science lessons. Likewise, listening to students’ voices would help practitioners and policy makers to understand the many challenges students face in schools’ contexts (Robertson, 2015). On this note, the chapter examines the findings under two sub-themes: students’ preparation for lessons in Section 5.2, and teaching methods that aid students’ learning Section 5.3.

5.2 STUDENTS’ PREPARATION FOR LESSONS

Hwang (2011) claimed that students learn more effectively when they have prepared for lessons. The narratives of students in this study of what aids their learning of science indicated that students prepare for science lessons by reading ahead of and after lessons, and they feel the need to be determined to learn science. Reading ahead means that concepts students may have read about beforehand are revisited in class rather than taught anew. This could aid students' understanding of the topic when taught in class and enhance their performance in examination. Gammerdinger and Kocher (2018) reported that pre-lecture reading in university is one of the significant indicators of performance in exams. Therefore, they recommended that students should read ahead of lectures to prepare them and enhance their exam grades.

Students appear to place importance on reading to aid their understanding of concepts:

> Because in some cases, there are some topics that you need to read, read, read, and read before you understand even though the teacher explains. You need to read on your own. (Interview with student, Kike, School W)

Emphasising the word 'read' four times reflects the importance that this student placed on reading. The emphasis on reading after being taught scientific concepts in classrooms could imply that the teaching methods adopted are not sufficient to aid students' deep understanding of science. Probably, teachers see it as the responsibility of students to read after they are taught science in order to revisit the topic and reinforce and expand their understanding. Students' views about reading seem to resonate with the view of learning as 'individual sense-making' (Watkins, 2005).

In conjunction with performing a considerable amount of reading to facilitate the learning of science, students cited having extra lessons after school. When asked to advise a person who wanted to learn science well, one student commented as follows:

> I will also advise the person to go for extra lessons to learn more and not rely only on what he or she is taught in school. This will help to improve a person's performance. (Interview with student, Titilayo, School W)

This student does not want to depend solely on what she is taught in school, which reinforces the suggestion that lessons at school are not sufficient to enable students' understanding of science. Extra lessons within the context of this study would mean paying for private tutoring. According to Titilayo, the support she received from home, such as having extra lessons, might have contributed to enhancing her performance in exams.

Another form of help students receive is tutoring by a family member who is knowledgeable about science. For instance, one of the students stated the following:

> Apart from the school lesson, my mum's sister is a medical student, and when she comes home from school, she explains any topic I have difficulties with better to me. This is motivating me to study more. (Interview with student, Zara, School W)

Zara's aunt, who is a medical student knowledgeable about science, with her explanation of concepts appears to have motivated Zara to want to learn more. Her use of the word 'better' suggests that Zara found her aunt's explanation of concepts more intelligible than that of her teachers at school. The extracts from Titilayo's and Zara's narratives seem to indicate two possible outcomes when students are given extra lessons at home: the first is an increase in motivation and the second is a boost in exam performance. Having extra lessons appears to be related to out-of-class learning when students are positioned in contexts that motivate them to learn (Wan Idros Wan Sulaiman et al., 2011). Such motivation explains why having extra private tutoring leads to these two outcomes; however, what can be said about the pedagogies of schools within this context? Perhaps tutors providing private lessons have the time to allow students to share ideas and discuss the concepts, which relates to Vygotksy's socio-cultural practice (Vygotksy, 1986; Mercer, 2008).

Furthermore, students spoke about their need to exhibit determination in order to learn science. For instance, one of the students in school W stated:

> I will tell the person to go ahead to study science if the person is determined. We know that it is only those that are determined that try to make it in science. Anyone that succeeds in a science class did so because of his or her ability and determination. (Interview with student, Valerie School W)

According to Valerie, students must be determined to learn science. Determination could be related to having a belief and confidence in one's ability to do something, which is also termed self-efficacy (Tsai et al., 2011; Lin et al., 2013; Uitto, 2014). Valerie's use of the words 'make it' appears to mean that students will understand scientific concepts and succeed in examinations if they are determined. Relating the learning of science to being determined implies that science can be challenging for students to learn. This student's view seems to rest on a performance orientation, where the belief is that students' ability leads to success (Watkins et al., 2001).

In this section, I have reported how students expressed their views on what aids their learning of science, which includes preparing ahead for lessons. Such preparation involves reading, engaging in extra tutoring at home, and being determined. In summary, the view of learning employed by students tended to be the view as being taught, as they believe that their ability and determination aids their success. However, there were also instances of the view of learning as individual sense-making when they read before and after being taught, and as building knowledge through doing things with others when they engage with extra lessons at home (Watkins, 2005).

5.3 TEACHING METHODS THAT AID STUDENTS' LEARNING

Interest can be simply defined as a positive interaction or relationship between an individual and an object or activity (Renninger et al., 1992; Logan & Skamp, 2013; Uitto, 2014). Other researchers extend this definition to encompass both a psychological state and one's preference for an activity or topic (Alexander et al., 2012), and the support experienced by a person through interaction with an object or idea (Jack & Lin, 2014). What all these definitions have in common is the positioning of interest as an experience of enjoyment or excitement that impels someone to continue to interact with the object or activity. It involves three elements: the person, the activity or object, and the context in which the interaction occurs (Renninger et al., 1992). Thus, in this respect it can be argued that the activities or teaching methods students are exposed to within the science classroom help them to develop and maintain their interest, and aid their learning in science.

Students also referred to a correlation between an interest in and learning of science:

> Because if there is no interest, you cannot learn science. (Interview with student, Andrew, School W)

Andrew's statement appears to indicate that science can only be learnt if one develops an interest in it. It is likely that he was driven by an interest in extending his knowledge by engaging in hands-on activities:

> Sometimes when I'm less busy I build a car with cardboard, wire, batteries based on my experience of science in electricity and I build the car to know more about the topic. (Interview with student, Andrew, School W)

Andrew seems to have an interest in science that reflects a personal preference for the subject, probably as a result of the enjoyment he has gained from it (cf. Taskinen et al., 2013; Jack & Lin, 2014). By building toy cars, Andrew was able to apply the knowledge he gained through his experience of physics, which further motivated him to want to learn more about science. Additionally, Andrew might have developed certain skills through learning science that he has utilised by improvising with the materials around him to build toy cars. Although he did not explain whether his experiences were gained within or outside the classroom, his statements suggest that in addition to scientific knowledge, students need motivation to learn science.

Another way in which students indicate an interest in learning science is by putting their heart into it, as can be seen in the following statement:

> … science is a course that when you put your heart in it to learn it and you say 'I am sent to the world to learn this' and you put your interest to do so, you will learn it. (Interview with student, Oscar, School W)

In the above extract, the phrase 'put your heart in it' can be interpreted as possessing a great passion for and a strong commitment to learning science. It also suggests that students' preference for science could be intrinsic. According to several researchers (Renninger et al., 1992; Morgan et al., 2001), students develop an intrinsic interest in science when it stretches their mental or cognitive capacity. Similarly, an interest in doing something implies being willing to make an effort to do so, which might require an active form of learning. However, facilitating an active interaction with science in the classroom is different from enabling rote learning and the following of instructions. Are students therefore engaged in activities in classrooms that motivate and keep them interested in learning science? It can be said that students' interest in learning science relates to the teaching strategies employed in the classrooms. In this section, students' views of group work, using familiar examples as application of knowledge, and of doing practical work will be discussed in relation to how these methods appeared to aid their learning of science.

5.3.1 GROUP WORK

During my lesson observations in School W in February 2016, I observed that students who sat in the back rows often paid little attention to the teacher and were less involved in the lesson. According to Mercer (1996) implementing a method that encourages students to talk and collaborate in groups seems effective in aiding learning. Hence, I spoke to the biology and chemistry teacher about adopting the group method during their lessons and they agreed. They were familiar with the method as they explained that educationists on a Lagos State educational initiative (the EKO Project) introduced the method to teachers a few years previously. Because of its large size, the teachers divided the class into nine groups, each of which had no fewer than ten students. They considered whether to have more than nine groups to reduce the number of students in each group; however, they felt this would result in groups being too close together and disrupting each other when engaging in noisy discussions. Nine groups therefore provided sufficient room for interaction within each group. As explained in Section 3.3.2, only students in School W were placed into groups to work together, as plans changed when the other three schools were visited.

Students in School W after the intervention, explained their views on working together in groups during science lessons:

> Grouping is good because our teacher may teach us and some will not understand, but when she places us in groups it will be like a revision class and those who don't normally participate will do so. Even those that do not

> understand the topic will do so when the person from their group is explaining. (Interview with student, Christie, School W)

According to Christie, allowing group work in classrooms enables all students to participate in the lessons. Enabling students to explain concepts to each other instead of relying on their teacher for explanations helps them to understand the topic. This implies a need for students who fully grasp the concept to help those who are still trying to master it so that the latter can acquire the requisite knowledge. Christie's view of collaborating in groups resonates with Watkins (2005)'s argument that students' sense of membership increases as they become more involved in lessons, which further enhances intrinsic motivation. The ability to learn from each other when collaborating in groups was expressed as follows by another student:

> I think it helps in a way but when you gather as a group like that, what I realize is that we children learn more from ourselves. (Interview with student, Bianca, School W)

Students' ability to learn in this way is made possible when they are allowed to discuss concepts. Bianca's statement implies that she believed that students explain topics to one another using words or language that clarify the concept for comprehension. Another student's narrative corroborates Bianca's view of group work:

> I love the method a lot because when one student came out to teach it made the lesson lively. This is because you can easily ask the student questions and he will answer you in a way that you will get it easily, unlike the teacher. (Interview with student, Valerie, School W)

Valerie's quotation demonstrated that students' perceptions towards grouping methods are positive and attest to their positive feelings about involvement during the lessons. According to Valerie, having another student explain a concept instead of the teacher made the lesson more engaging. Furthermore, Valerie's quotation indicates that the grouping method enabled students to take ownership of their knowledge, especially when explaining concepts to their fellow students, and opportunities were created for them to freely ask questions of each other. Valerie was probed further on her statement regarding teachers' explanations of concepts and she stated the following:

> They explain things well but it is not very lively like when the student is explaining. The student is like a friend; you are very close to each other, you can easily talk and interact more with them unlike the teacher. You know when you go to your teacher to explain things, they say that you were not listening in class. (Interview with student, Valerie, School W)

In the above quotation, Valerie seems to imply that the current model of teaching adopted by teachers is not as effective as it might be. Her statement seems to confirm that some students found lessons uninteresting because teachers did most of the talking during lessons and students rarely contributed as they were expected to sit and pay attention. Also, teachers do not spare time to explain concepts more when students go to meet them privately. By contrast, students' familiarity and warm relationships with each other enabled them to ask each other questions and they patiently explained concepts to each other. This was something their teachers seem not to do, which meant students were not given the opportunity to ask questions from their teachers. Students' social interaction during the group discussion of concepts, which enabled them to share ideas and facilitated their learning, illustrates Vygotsky's notion of the zone of proximal development or ZPD (Vygotksy, 1986), in that students are helped by the more capable ones to make sense of concepts.

Another student attested to Valerie's narrative regarding group work:

> I found the lesson interesting because it was somehow like a challenge between two groups. When one is explaining, another group is asking them questions. This makes students get involved and makes them bring their ideas to the lesson. (Interview with student, Donald, School W)

Donald's association of the words 'interesting' and 'challenge' suggests that the activities students performed in groups were sufficiently stimulating to have aroused their interest. It may be that this helps the student develop a 'learning orientation' (see Section 2.4.1) as, according to him, he found the lesson interesting owing to the challenging tasks involved (Watkins et al., 2001). As Donald described, placing students into groups seems to have encouraged their active participation by discussing ideas related to the concepts. Moreover, being able to bring ideas jointly to a lesson and explore them could facilitate students' cognitive performance (Mercer, 1996). The phrase "challenge between two groups" indicates competition. Students' involvement in bringing ideas to their groups to compete with others resonates with the cooperation-competitive learning approach described by Okebukola (1986a; 1986b) as a method to aid students' achievement in science. However, competition has been criticised by Watkins as encouraging a 'performance orientation' (Watkins et al., 2001).

Having students work in groups thus appears to improve students' participation within the context of a large class. According to one of the students:

> The group method is actually a good one because as we are many in the class, when only the teacher is speaking, many of us do not listen. But the group method will make them contribute because they will not want their groups to fail or fall behind, so they will want to talk and contribute to make their group better. (Interview with student, Violet, School W)

This student's narrative suggests that teachers mainly speak during lessons and students are not involved, which is pertinent to the view of learning as 'being taught' (Watkins, 2005) and accords with my observation of lessons in these schools. A lack of participation means students are less likely to be attentive during lessons, especially in a large class. As Donald stated, placing students in groups provides the opportunity for contribution during the lesson in a cooperative yet competitive way. With respect to participating in groups, students stated the following:

> Even if our apparatus is not enough, they can group us table by table and they should put apparatus on each table; at least if not all the students can use it, we can see those using it on our table, do things ourselves, and everyone will contribute on the steps to take. (Interview with student, Lanre, School W)

> And if our teachers give us projects to do in groups, it will help us to work as a team so we will be able to find out things more, and explain to each other over and over again, which will help us to learn. (Interview with student, Gbenga, School Z)

Students are motivated to participate when they are placed into groups to teach each other and clarify the concepts they did not understand after 'being taught' by their teachers. Lanre commented on students' collaboration in groups during practical activities, especially when there is not enough apparatus to go round. Furthermore, working 'as a team', as Gbenga stated, seems to demonstrate students' co-construction of knowledge. Although students were not placed into groups during the lessons observed in School Z, Gbenga underlined his support for the idea of having students participate in lessons. Watkins (2005) discussed the co-construction of knowledge as a third view of learning, which resonates with Vygotsky's socio-cultural model of learning (see Section 2.4). Both theorists laid emphasis on the discussion of ideas through social interaction between students and teachers to aid students' conceptual understanding (Vygotsky, 1986; Watkins, 2005).

Furthermore, being able to participate during the lesson motivates students to read and prepare ahead for lessons, as stated by Gregory:

> Group methods help in making us to go home and learn more about the topic. So when the teacher explains the topic in class, it looks like something I have learnt before. (Interview with student, Gregory, School W)

Reading to prepare for lessons was reported in Section 5.2.2 as one of the things students indicated they do to learn science. According to Gregory, reading ahead for lessons and revisiting the concepts in classrooms can help reinforce students' understanding. Therefore, the grouping method seems to be more effective at aiding students' comprehension of concepts than relying only on the traditional method, at least in part because it aids students' participation in lessons, which leads to discussion of ideas and construction of concepts.

Furthermore, students referred to how teachers can help to make students' participation in groups more effective:

> … if the teacher will make sure all the students that think they know the answer keep quiet and allow those who are ignorant to try and participate. (Interview with student, Oscar, School W)

Allowing all students in groups to participate during lessons suggests that Oscar does not support the idea of one student dominating a group. The above extract indicates that students in a group are likely to be at different stages of mastery with respect to any given concept and teachers should therefore ensure that all students are given opportunities to learn during lessons. Learning opportunities are also created within the classroom when students' ZPDs are identified by teachers through their speech (Mercer & Fisher, 1992). Additionally, as a result of planning by teachers, tasks can be differentiated for students based on their ZPDs. In the group context in these classrooms, teachers can allocate different aspects of topics to each group, and distribute sub-topics to individual students within each group to pre-read and explain to other students in lessons.

5.3.2 USING FAMILIAR EXAMPLES

According to Probyn (2001), students' understanding is aided when teachers explain concepts using examples that are familiar to students. Indeed, in this study, students expressed the view that learning science is aided when teachers explain concepts in this way.

One of the students in the physics class in School Z offered an example to explain the concept of acceleration:

> Oscillation and acceleration are related to everyday things around us. For instance, a moving car can be used to explain acceleration. (Interview with student, Yemi, School Z)

Yemi linked an everyday example (car) to the scientific concept of acceleration, which suggests that this student has been able to make sense of the concept. It is possible that Yemi repeated the example his teacher had used to explain the concept in the classroom. Nevertheless, the example might have helped him to know more about the concept, as he was able to relate it to a familiar example. This seems to point to Watkins' second view of learning as individual sense-making where teachers aid students' understanding of concepts (Watkins, 2005). Furthermore, it relates to one of Vygotsky's propositions of using examples that are familiar to students to make sense of the science concepts taught in classrooms (Vygotsky, 1986). For instance, Ayo was asked during his interview to explain what flame cells are; when he could not, I described flame cells using the example of a broom, commonly used within that context to sweep floors. Ayo then made the following statement, which seems to indicate that relating concepts to familiar examples could aid students' comprehension and memory of concepts:

> Ah, your explanation has made me understand very well, so I will never forget what flame cells are. Because you used a typical example that I know, which I

> see in my environment, so I can never forget it. (Interview with student, Ayo, School Y)

The explanation of the structure of the flame cell using a familiar example to Ayo resonates with one of the propositions of Vygotksy of using spontaneous concepts to make sense of non-spontaneous concepts (Vygotsky, 1986). Other students also described the use of familiar examples to explain concepts:

> If those things (concepts) are around us, they can give them to us as examples. Like when we were looking at amoeba, she told us that it is an organism that can be found in a wet environment, and she demonstrated how they look for their food and can be found where we see dirty water. So now we know that where there is water on the ground, there would be some organisms there. (Interview with student, Florence, School Z)

Florence's narrative of teachers relating scientific concepts to examples that students see around them illustrates how such examples can help students to make sense of science. Citing how her teacher illustrated what an amoeba is and its characteristics, and the impact of this on her application of knowledge, indicates the impact of such illustration on Florence's learning. Being able to apply scientific knowledge in contexts outside the classroom could reinforce such knowledge, as stated by the following students:

> I would like them (teachers) to use examples I can see around me to explain. This will help me to understand science. (Interview with student, Dorcas, School Z)

> The best way is for my teacher to use what I see everyday or do everyday to explain science topics. This is because it will be a part of me. (Interview with student, Pero, School Z)

According to these students, using familiar examples to explain topics aids their understanding of scientific concepts. Their views resonate with Sadler and Zeidler (2009)'s argument that concepts which relate to students' lives and focus on socio-scientific issues enable students to reason, socially engage, and motivate them to participate in class. Pero's use of the phrase "it will be a part of me" suggests that students are able to make sense of and construct knowledge and that this then stays with them and becomes owned by them. Knowledge that becomes part of students' lives can then be applied in other contexts outside the classrooms.

5.3.3 PERFORMING PRACTICAL WORK

Educators have used various terms to describe practical work, such as laboratory activities (Hofstein & Lunetta, 2003), scientific inquiry (Hume & Coll, 2008) and laboratory sessions (Lee et al., 2012). Despite the various use of these terms, there is agreement on its meaning as a 'doing of science' that mirrors the actual practice of scientists (Abrahams, 2011; Moeed, 2011).

Students identified a form of correlation between performing practical work and developing an interest in studying science. For example, one of the students stated:

> What actually motivated me to be in the science class is the practical, which I watch on the television and see how little children who do experiments find out things. (Interview with student, Goke, School X)

Watching how little children do practical work on the television motivated this student to study science. Perhaps the practice of scientists is of interest to the student, and this aligns with Abrahams (2011)'s argument that practical work motivates and makes students generate personal interest in science. Another student explained:

> I was inspired to study science when I was in my previous school. Any time I saw the senior students they mostly did practical work like opening up some specimens and closing them back as if they are performing surgery and this surprises me. (Interview with student, Linda, School W)

The word 'surprise' is an indication that what the student saw was novel and, for this reason, she became interested in knowing more about it; hence, her choice of science. In line with Linda's statement, being able to experience real objects could be the reason why students prefer to do practical work. For instance, one of the students stated:

> I will prefer a method based on doing project more than theory. What I mean by the project is practical work than just theory, doing writing. I like practical work because dealing with something physically makes you have the experience rather than just theory, writing. (Interview with student, Alfred, School W)

As Alfred suggests, performing practical work enables students to experience real objects. The word ‘experience’ could be explained in terms of the phrase “dealing with something physically” in Alfred’s statement. This means being able to come into contact with and work with these real objects, which might be novel and constitute an active form of learning. The word ‘experience’ also relates to Vygotksy’s socio-cultural perspective of learning, whereby students’ doing practical work with others enables them to achieve a higher level of knowledge (Howe, 1996; Powell & Kalina, 2009). Students mostly seem to prefer undertaking practical work rather than listening to teachers’ talk, which Alfred refers to as ‘theory’ in his narrative.

Students further related performing practical work to learning scientific concepts they read about in textbooks, some of which are difficult to comprehend:

> Yes; I would like to do practical work because, especially with chemistry and physics, I find them difficult, I am not able to understand. (Interview with student, Zara, School W)

> Yes, because practical work will help me in my reading. What we are reading in the textbook, we can see it when doing practical work and I’m able to understand it. (Interview with student, Thomas, School W)

> Yes; it helps us to learn more. Like for me I don’t have a chemistry textbook and if we do a practical on chlorine, that would help me to know more about it. It will help me to know more about other topics, it enhances learning. (Interview with student, Donald, School W)

The students Zara, Thomas and Donald expressed their positive view on performing practical activities to explain topics and aid their understanding. For instance, Zara refers to chemistry and physics as difficult and argues that conducting practical work helps relate scientific concepts to what she can see and touch, which relates to the view of learning as individual sense-making (Watkins, 2005). Of interest was Donald’s statement that performing practical work enhanced his learning of a topic even though he does not have a textbook in which to read and learn more about the topic. Indeed, during data collection, several students in the four schools mentioned not having a textbook and felt that undertaking practical work could therefore help them learn science. Another student explained why practical work aids learning:

> If the teacher only explains, some people might not understand but if an experiment is carried out, we will learn it and know how it works. (Interview

with student, Kehinde, School W)

The phrase "learn it and know how it works" appears to represent a view of learning as making sense of knowledge, which is discussed in Section 2.4.1 as Watkins' second view of learning (Watkins, 2005). Learning how something works indicates possessing a considerable amount of informed knowledge about that thing. According to Kehinde, students are able to make sense of scientific knowledge when they conduct practical work. The view of learning as 'making sense' as well as learning as 'building knowledge through doing with others' (which is Watkins' third view of learning) is crucial in learning science (Vygotksy, 1986; Wellington & Osborne, 2001). However, the view of learning as 'being taught' is less likely to work for the learning of science (Kruckeberg, 2006).

In addition to aiding the understanding of scientific concepts, students' preference for performing practical work also helps them to retain scientific knowledge. For instance, one of the students stated that:

> I prefer the practical method because during exams it will be very easy for you to remember what you have done during the practical. (Interview with student, Charles, School W)

Charles' statement demonstrates that students are taught in preparation for examinations and that retaining scientific knowledge would enable them to achieve good grades in this form of assessment. However, does retaining concepts simply mean memorisation? Are students able to apply the retained knowledge? Answers to these questions can be deduced from the following response by a student speaking of her preference for performing practical work:

> If I read, I will not be able to understand properly and I will just try to grasp and assimilate what I have read. But when the teacher demonstrates and explain, I will be able to capture and remember during exams the steps followed by the teacher and this will help me better. (Interview with student, Linda, School W).

In the above extract, Linda linked watching her teacher's demonstration of the concept with her ability to follow what the teacher is doing, which she felt would enable her to remember the processes followed and consequently perform well in examinations. In other words, the difference between seeing/hearing and doing is that when you see and hear it, you try to remember it, but when you do it you are more likely to grasp it and therefore remember it. In this case, retaining scientific concepts might mean memorisation, which students can then apply in examinations. It might also help students to understand concepts more deeply. In line with Linda's view, students stated the following:

> I prefer doing practical work because whatever you practise, even if they give you an oral test, your brain is going to give you the image of what you have seen and you can get everything right. (Interview with student, Oscar, School W)

> My teachers' practical work demonstrations will help me because I am the type of person that retains 70% of what I see and 30% of what I read and this will help me to remember things. (Interview with student, Valerie, School W)

Oscar's statement appears to indicate a link between the visual imagery of concepts and performance in assessments. Thus, performing practical activities enhances students' memory of concepts, which aligns with Valerie's statement. Similarly, Valerie referred to her teacher's demonstrations in class as helpful. This suggests that watching a teacher demonstrate an experiment would assist students in retaining scientific information. However, according to the learning pyramid presented by the National Training Laboratories (NTL), when students engage in practical work, they will exhibit a higher rate of learning retention than when teachers demonstrate the practical activity (Schultink, 2013). Therefore, it appears to be the case that when students see the apparatus and how it can be used in the laboratory during practical activities, it will aid their retention of scientific facts, relative to their simply being told about these facts.

5.4 SUMMARY

The students' view of learning presented in this chapter falls under two sub-themes of what aids their learning: students' preparation for lessons and teaching methods that aid their learning.

The statements given by students illustrate that, to learn science, students should be prepared to read, receive extra tutoring at home, and be determined. Students' reading enables them to revisit topics taught, which reinforced their understanding, and seems to resonate with the view of learning as 'individual sense-making' (Watkins, 2005). Students related having extra lessons in science at home to excellent performance in examinations and motivation. It is possible that during extra lessons at home, students talk with their tutors about their prior ideas in relation to science concepts, which might promote students' conceptual understanding (Vygotsky, 1986). It could be that teachers are not delivering pedagogic content in a way that aids students' understanding of concepts, which could explain why students engaged with tutors at home to learn more. Therefore, it seems that teachers' views of learning are pertinent to Watkins' (2005) view of the notion of learning as 'being taught'. The focus of this view is on having teachers teach to cover the scheme of work and prepare students for exams, with students passively receiving instructions and therefore being less likely to develop an understanding of scientific concepts (Watkins, 2005; DiBiase & McDonald, 2015).

Students' narratives indicate that they feel class activities aid their learning of science. These include allowing students to work in groups, using familiar examples to explain concepts, and conducting practical work. The students' narratives seem to relate these activities to student-centred teaching and learning methods that involve the participation of students in order to enable 'individual sense making' and 'constructing knowledge with others'. Lewin (1993) described such activities as helping students acquire an experience of science that differs from the accumulation of facts and a dependency on textbooks (see Section 2.3.2). Learning as doing things with others is pertinent to Vygotsky's socio-cultural perspective of learning (Vygotksy, 1986; Mercer, 2008). Students' participation was described by them as promoting their interest in science. Students related this to their performances in assessment, and in the understanding and retaining of concepts. The next chapter discusses another theme that can influence science teaching and learning, namely teachers' and students' views on language and its usage in science classrooms.

CHAPTER SIX

VIEWS AND USAGE OF LANGUAGE

6.1 INTRODUCTION

This Chapter presents the views of the students and teachers in the four schools about the usage of language in science classrooms. The findings were derived from the thematic analysis of data obtained from observations of lessons and from interviews conducted with teachers and students.

Vygotsky's social-cultural perspective of learning (see Section 2.4.2) positions language as a mediating tool used in learning contexts to support collaborative dialogue to aid students' thinking and construction of knowledge (Vygotsky, 1986). In a non-Western context, such as the one explored in this study, the languages employed in a science classroom are the home languages of students, the language of instruction, and the language of science (Yore & Treagust, 2006; Yore et al., 2007; Yore, 2008; Seah & Yore, 2017).

The three sub-themes regarding the range of language that will be discussed are 'views and use of native language' (explored in Section 6.2), 'views about the use of English' (explored in Section 6.3), and 'teaching scientific terms and responses' (explored in Section 6.4).

6.2 VIEWS AND USE OF NATIVE LANGUAGE

A person's native language, also known as their mother tongue or home language, is the medium through which customs are imparted to children at home (acknowledging that some children learn more than one language at home). It can also be used in some cultures as a medium of instruction in schools (Okebukola et al., 2013). In this study, the schools visited were located within Lagos, which is a multi-linguistic city primarily inhabited by members of the Yoruba ethnic group (Adeyemi, 2018). This group primarily speaks Yoruba, which is one of the native languages spoken in Nigeria (UNESCO, 1998) and is therefore the native language referred to and presented in this Chapter as spoken by teachers and students.

Teachers' and students' comments during the interviews on the use of their native language in classrooms are discussed in Section 6.2.1. The ways in which teachers used the native language during lessons I observed are examined and presented in Section 6.2.2.

6.2.1 VIEWS ABOUT THE NATIVE LANGUAGE

One of the views expressed by teachers and students regarding the use of the native language in the science classroom was that it enabled students to express themselves better. For instance, the biology teacher stated:

> You know, in most cases, students learn better in their mother language and they are able to express themselves very well in the language much more than the second language (English language). So, if a science term has a name or meaning in the students' local language and we use it in the class, then that would help them to learn better. (Individual interview with biology teacher, School Y)

This teacher might have claimed that students learn better in their home language based on his personal experience or he may have heard it from someone else. Students' ability to express themselves better in the native language could explain why they learn better. Their relative fluency in speaking the native language, as they explained compared with the English language, seems to indicate that some students struggled to communicate in the class using Standard English. This appears to resonate with Yore's (2008) argument that some students bring a well-developed home language to the classrooms rather than Standard English. Furthermore, the teacher's use of the native language to explain science terms to aid learning could constitute a form of scaffolding (Van Laere et al., 2014). This teacher's response when asked if he allowed students to use their native language in science lessons demonstrates how he provided scaffolding for students:

> At times when I ask students questions in class and they find it difficult to express themselves in English, I do allow them to speak Yoruba before interpreting it for them. This is because they are familiar with their native language. They don't think in the second or foreign language; they don't use it to think and they don't use it to express their thoughts well. (Individual

interview with biology teacher, School Y)

This teacher also believed that students within the school struggled to speak Standard English; hence, he allowed them to speak their native language to express their thoughts and then he interpreted what they said. Such interpretation can serve to relate students' expression to science concepts in English, which is a form of code switching. Code switching is when a speaker changes from one language to another (Msimanga & Lelliott, 2014). Interpreting words from the native language to English to support students' responses is similar to Probyn's (2001) findings with respect to five teachers' use of home and English languages in South African classrooms. Students' use of the native language to think about and express their personal experience of scientific phenomena is pertinent to a Vygotskian approach whereby students mentally construct concepts to aid their understanding (Vygotsky, 1986), which was discussed further in Section 2.4.2.

Other teachers reiterated a similar view to the biology teacher in School Y. For instance, the physics teacher in School X stated:

> In the previous lesson I used Yoruba to explain words like upright, inverted, and magnified under the topic 'The Refraction of Light in Lens', because I wanted them to understand the topic. And I could see on their faces that they did. (Individual interview with physics teacher, School X)

This teacher's explanation in Yoruba during an observed lesson on how different lenses focus light to form different images is presented in Section 6.2.2. The teacher might have used the native language to explain these concepts because the students were not fluent speakers of Standard English. Explaining the concept in this manner seems to be a form of scaffolding employed to support students within Vygotsky's (1986) proposed ZPD to aid their understanding. Furthermore, the teacher seems to have sought evidence of learning by looking at students' faces to determine whether they were smiling or frowning. This practice is one of several indicators described by Webb (2017) as demonstrating that learning is taking place. Students may display smiling or frowning faces because of their conceptions of learning, which might be related more to performance than learning. According to Watkins (2005), students with a performance orientation place greater emphasis on standards and public evaluation and could form negative opinions of themselves when faced with difficult tasks. On the other hand, if the students had a learning orientation, they might still look puzzled if they were trying to work something out.

Another teacher expressed the following view:

> So maybe they don't understand English enough or they can't express themselves in English enough, then someone can consider using the native language. Let's say you want to explain and make sure that the student understands by force, then you can use the native language to drive home the point. (Individual interview with physics teacher, School Z)

This physics teacher's acceptance of the use of the native language in the classroom was based on the premise that the students were not proficient in English. The phrase 'understands by force' within the context of this study may mean to understand a concept compulsorily and forcefully when words that are familiar to students are used as part of the explanation. The phrase 'to drive home the point' could mean to clarify and make something explicitly clear to students. Both phrases suggest that teachers' use of the native language helped students to understand science. The use of a word such as "force" may also indicate that teachers wanted students to mentally assimilate the contents and understand.

Students seemed to concur with the reason given by this physics teacher for using the native language in classrooms:

> Some students don't really understand English. That's why some teachers when they are explaining, they mix up English with Yoruba so that the students can understand what they are talking about. (Interview with student, Bayo, School X)

According to Bayo, teachers "mix up English with Yoruba" to ensure students understand what they are saying. Mixing up English with Yoruba in this manner is an instance of 'code switching' (Msimanga & Lelliott, 2014). Teachers also use the native language on the assumption that not all students fully understand English.

Students spoke about how using their native language in classrooms to explain concepts aids their learning, as shown in the following extracts:

> The reason is that when he (the teacher) goes further to explain in Yoruba language, I tend to digest it, absorb, and then interpret it to the normal English language so that I can get it better. (Interview with student, Sanni, School Y)
>
> Yes, I love it. Because by the time she speaks the scientific words of a scientific plant like 'Tridas' and I don't even know the name, what will I do? So, I love my teacher to speak the Yoruba version to teach me. (Interview with student, Ola, School Y)
>
> I mean using a language that I can easily understand to explain the science words. For example, using Yoruba to explain what the science words mean will make me understand the words better. (Interview with student, Pero, School Z)
>
> I speak Yoruba mostly at home with my siblings. I would prefer Yoruba because it is our father's language. Like in chemistry, when our teacher was talking about the transfer of electrons in electrovalent bonding, he said 'electron yi ma lo si oke eleyi' (meaning – this electron will be transferred to this place), and this aided my understanding. Also in physics, if our teacher says some words, she will say them again in Yoruba for better understanding. (Interview with student, Janet, School Y)

These students expressed their preference for teachers to use their native language to explain science. Sanni used words such as "digest", "absorb", and "interpret" to describe his ability to mentally process concepts when teachers use their native language to explain them. Using the native language in this capacity seems to resonate with Vygotsky's explanation of one of the two roles of speech uttered in a learning context, which is that it is transferred for inner processing within a student, thereby enabling them to make sense of the words (Vygotsky, 1986). However, the second role, whereby the speech is used for interaction with others, is not mentioned by students, probably because they had not experienced teaching methods that encouraged such interaction in class. Thus, the view of learning within this context appears to be one of individual sense-making rather than the social process of interaction in the classroom (Watkins, 2005). Ola's statement seemed to indicate that she was knowledgeable in the use of her native language, hence her preference for teachers to use it to give meanings to certain scientific names. Similarly, Janet acknowledged Yoruba was her first language, and she mentioned speaking the native language at home. Therefore, Janet might also be knowledgeable in the use of the native language and can understand what is said when teachers utilise it to explain concepts. Furthermore, the examples given by Janet seem to indicate teachers' use of code switching.

In addition to stating the advantages of using the native language in classrooms to aid students' understanding of concepts, the participants also spoke about the limitations of the native language. One of the teachers mentioned the following:

> If I want to teach science in Yoruba, that means someone still has to write the physics textbook in Yoruba. And as the physics teacher I will now have to study it because to interpret into Yoruba will be very difficult. This is because, even as a Yoruba man, I don't know the names of the scientific terms in Yoruba. (Individual interview with physics teacher, School W)

According to this teacher, to teach science in Yoruba would be difficult for teachers because it means they have to give Yoruba terms for scientific words. This would require teachers to know the elements, customs, and traditions of both the native language and of science (Seah & Yore, 2017). However, as mentioned by the physics teacher, it seems that the Yoruba language does not have the vocabulary used in modern science. Thus, it could be a difficult task for him as a teacher to invent such words to enable him to use these to give meaning to scientific terms. Consequently, teachers might not want to teach science using the native language. But why couldn't they use the scientific terms but say other things in Yoruba?

It also seems that, despite their support for its use in classrooms, students might also lack competence in the use of their native language. For instance, one of the students expressed the following:

> Teachers can use Yoruba at times but the words should be ones I can easily understand. This is because I speak English more at home and I don't really know how to speak Yoruba but I understand it. My parents speak Yoruba at home once in a while. Although my dad is from Edo state and my mum is from Kwara state, I was born and brought up in Lagos. (Interview with student, Yemi, School Z)

Yemi was one of the few participants whose narratives indicated a support for the use of Yoruba as a native language in classrooms, though she stated that the words used should be ones that she can easily understand. As stated by Yemi, her parents had an intertribal marriage; her mother is from Kwara, where Yoruba is spoken, and her father is from another ethnic tribe, and speaks another native language (cf. Adoti, 2018). Yemi further stated during her interview that her parents were educated up to university level. An intertribal marriage is also known in Nigeria as an inter-ethnic marriage, this is when people from one tribe marry into another (Chukwuebuka et al., 2018). This means there are differences in social norms and culture such as language, mode of dressing, climate, food, and music. According to Chukwuebuka et al. (2018), a mother teaches her children to speak her language because she is always at home with them, which the father might not approve of. Therefore, it can be the case that the English language, which is the official language, is used for communication in the homes of intertribal couples to avoid conflicts. This perhaps explains why Yemi speaks more English, and Yoruba only 'once in a while' at home.

Another student reiterated Yemi's comments about the use of Yoruba in classrooms:

> But that would be Yoruba words that I can easily understand. There are some Yoruba words that I don't understand. But using some simple ones that I know will help me to understand the science topics well. (Interview with student, Bisi, School Z)

Bisi was not fluent in the use of Yoruba. She further stated during her interview that her parents studied up to university level and, although she is from Oyo state, a Yoruba-speaking state in Nigeria (Ojo & Awokola, 2012), she speaks mostly English at home. Hence, her occasional use of Yoruba could explain her limited understanding and her request for the use of simple Yoruba words to explain science in the classroom.

In summary, the participants' narratives during interviews indicated that teachers' use of the Yoruba language to teach while giving students the opportunity to speak the same language to express their ideas could aid students' understanding.

However, a limited understanding of the elements of the native language might make it difficult for some teachers to use the language. Similarly, students who are not well versed in speaking the native language at home might not know the meaning of numerous words, even when teachers use the language in class. Aside from participants' narratives, some of the talk in the lessons that were observed illustrated the use of the native language, and these are presented in the next Section.

6.2.2 USE OF NATIVE LANGUAGE IN SCIENCE LESSONS

In all the lessons observed in this study, it was common for teachers to interject the native language into class discourses to give instructions, to clarify concepts and terms, or to emphasise strong feelings.

For instance, teachers gave instructions using Yoruba, to emphasise what they wanted students to do. The chemistry teacher in School W told her students the following:

> Teacher: Now we talk of the laboratory preparation of oxygen. Mo fe ki e ya aworan yi. Se e ti gbo? (I want you to draw this diagram. Can you hear me?). This is the diagram (She pointed to a diagram on a chart).
> Cs: YES MA. (Chemistry lesson observed, School WChm1)

The chemistry teacher spoke the native language to instruct the students to copy the diagram she had drawn on a chart, which she had hung on the wall in the laboratory. The teacher could have conveyed her message using the formal language of instruction (English) but she did not. Therefore, it appears that she wanted to strongly emphasise to the students the importance of drawing the diagram. Similarly, a teacher in another school stated the following during a lesson:

> C: Ma, ehm do we write the rule in our jotter?
> Teacher: Jotter wo? E ko rule yi sile si inu iwe yin (Which jotter? Write down this rule in your notebooks). And you should all remember it. (Physics lesson observed, School XPhy)

This physics teacher wrote a rule on the white board that shows how an image is formed in a mirror. One of the students asked a question on behalf of other students. The teacher's response using the native language appears to show that she was not in support of writing down the rule in their jotters. This is pertinent to Probyn's (2001) findings that teachers switched to the home language to emphasise certain points. As shown in the above extract, the teacher appears to believe students learn when they are told forcefully and when they memorise concepts. Another teacher in School X said the following to his students:

> Teacher: Hello o E DAKE! (BE QUIET!) You are making noise. This is where we consider to be zero. Are you with me?
> Cs: Yes sir. (Chemistry lesson observed, School XChm)

Before this chemistry teacher spoke using the native language, someone rang the bell in the school compound to signal the end of the lesson and the students began to make some noise. The chemistry lesson had not ended because it was scheduled for two periods; hence, it seems the teacher spoke the native language (loudly) to manage students' behaviour in the classroom. By speaking out loud using Yoruba, he was able to settle the students down within a short space of time and immediately carry on with his teaching.

Aside from speaking Yoruba to instruct students and manage their behaviour in the classroom, teachers also clarified concepts using the same native language. During one of the observations of the biology teacher's lessons in school W, the following exchange took place:

> Teacher: What are the bones that make up the ribs?
> C: We have the bone ribs; we have the sternum, and the pectoral girdle.
> Teacher: THE PECTORAL GIRDLE? The pectoral girdle is not part of it. Ko kin nse ara e (it is not part of it). Se o mo wipe awon egungun meji ti owa ni ejika e ni won npe ni pectoral girdle? (Don't you know that the two bones on your shoulder are the ones called the pectoral girdle?) You tried by mentioning some of the bones. (Biology lesson observed, School WBio1)

The words 'pectoral girdle' mentioned by the student was not accurate according to the teacher's feedback. The teacher not only spoke Yoruba to denounce the student's answer, she went further by clarifying what the pectoral girdle is and where it is located in the body. This clarification of concepts seems pertinent to Vygotsky's Zone of Proximal Development, where the teacher as a more capable adult tells students so that they can move from their current level to the expected level (Vygotksy, 1986).

The teacher's use of the native language in this way manifests code switching, and the teacher seems to have done this to support the student's response and aid the understanding of all students (Probe, 2001; Msimanga & Lelliot, 2014).

One physics teacher in School X spoke Yoruba during her observed lesson to explain concepts to students and aid their understanding:

> Teacher: The rule ni wipe a ti mo ibi ti image yi ti ma form (The rule is that we know where the image will be formed); near the centre of curvature. Is that understood?
> Cs: Yes ma.
> Teacher: Ti ori nkan ba wa ni saale, ti idi wa ni oke, a je wipe o wa inverted. (If the upper part of something is facing down and the lower part is facing up, then it is inverted.) Ti image ba to bi ju object lo, a ma so wipe o wa magnified. (If the image is bigger than the object, we say it is magnified.) To ba je wipe object to bi ju image lo, a je wipe o diminish ni yen. (If the object is bigger than the image, that means it is diminished.) (Physics lesson observed, School XPhy)

Although this physics teacher did not use Yoruba names for 'inverted', 'magnified' and 'diminished', she explained the meaning of the words using the native language. These are words that have the same meaning in science as well as in English. During this lesson, it was observed that while the teacher was explaining the concepts using the Yoruba, most of the students listened with rapt attention and responded by saying "OK, now I understand". Afterwards, several students were observed to be conversing amongst themselves in a low tone and pointing to the diagram the teacher was drawing on the board. It is possible that the teacher's explanation aided their conceptual understanding, which enabled them to talk more about the concepts amongst themselves. Thus, this teacher's explanation of concepts using Yoruba appears to provide a form of scaffolding that aided students' comprehension of concepts (Van Laere et al., 2014).

The teachers also used the native language in classrooms to emphasise strong feelings:

> Teacher: Tell me the similarities between man and rabbit. I've already explained this, what are the similarities?
> Cs: murmurings (***)
> Teacher: Se eri pe e kawe (you can see that you did not read). You are not

ready to learn; ko si nkan ti anybody le se (there is nothing anybody can do about that). (Biology lesson observed, School WBio1)

This biology teacher expresses her feelings of displeasure at the students' inability to answer her questions. Although Probyn (2001) reported several reasons why teachers switch to the native language in the classroom (see Section 2.4.3.2), these did not include the expression of strong feelings. Similarly, the biology teacher in School Y spoke the native language in class to emphasise the point he had made:

Teacher: Eni to ba si, ti ko gba yen later on a je egba o, tori gbogbo igba la nso bayi pe (whoever continues to repeat this error will be flogged later on by cane because I keep on repeating that). Faeces is not what?~
Cs: A metabolic waste product. (Biology lesson observed, School YBio)

Although this teacher had repeatedly told the students that faeces is not a metabolic waste product, the students kept on giving the wrong answer. The teacher therefore used the native language to emphasise a warning and show his displeasure. In School Z, the Physics teacher said the following to the students:

Teacher: Mi o mo maths te mo (I don't know the maths you all claim to know).
Cs: Ah!
Teacher: Oya! (Common on!) Look up everybody! (Physics lesson observed, School ZPhy)

In this physics lesson, it was observed that the students were not able to use a scientific formula to calculate a problem the teacher had written on the white board. The teacher used the native language to mock the students for failing to answer the question. The teacher's assessment of students by asking them to solve the mathematical problem using the formula written on the white board appears to resonate with the view of learning as being taught (Watkins, 2005). The students' appeared to acknowledge that their response was laughable because they all kept quiet until the teacher told them to focus on what he was about to write on the white board.

This Section has shown how teachers used Yoruba in classrooms to instruct students during the lessons and manage their behaviour, primarily to ensure they did what they were told. This use of Yoruba appears to align with Watkins' (2005) view of learning as being taught. Moreover, teachers' use of this native language to clarify concepts, whereby they scaffold students within their ZPD to aid their learning, appears to align with Vygotsky's sociocultural theory (Vygotsky, 1986). Finally, teachers used Yoruba in the classroom to emphasise their feelings when students failed to give answers to their questions. Overall, the teachers switched code by moving from Yoruba to English to help students understand science and to grab their attention (Probyn, 2001; Msimanga & Lelliott, 2014). This suggests that one language might not be enough to help these students learn science because one language might not be suited to represent the culture of science (Schulzke, 2014). The next Section presents teachers' and students' views on using another language, English, in science lessons.

6.3 VIEWS ABOUT THE USE OF ENGLISH

The literature reviewed in Chapter 2 revealed that the English language spoken by the colonial masters was adopted in Nigeria as a second language and became the language of education, politics, businesses, law, and administration (Danladi, 2013). The findings in this study indicate that the English language appears to have primacy over the use of native languages in schools. Teachers and students often expressed a preference for using English in school because it is a language generally spoken within society. For instance, the physics teacher in School Z expressed the following view:

> English is a universal language spoken in the country and I believe it is a means of communication for effective learning. Since we are in school, we are in a formal setting, so it should be English. (Individual interview with physics teacher, School Z)

This teacher referred to English as a "universal language", probably because it is the country's official language and is authorised for instruction in schools by the Nigerian government. The teacher's reference to the use of English as a "means of communication" in a "formal setting" appears to place more value on the status conferred on the language within that society. Proclaiming that "it should be English" suggests that teachers prefer to use English to teach, even when students might be struggling to understand the language.

Students also expressed their support for the use of English in school:

> I would prefer English because English is a general language that everyone speaks in school. (Interview with student, Bayo, School X)
>
> I prefer them to use English because we are in a school. When Yoruba language is used in the class, it causes disorderliness. Students will take that as a reason to make the class noisy. (Interview with student, Olu, School X)

Bayo's description of English as a "general" language corroborated the physics teacher's narrative. The use of English appears to be associated with structure and organisation, which Olu described as lacking in the native language, Yoruba. This could explain why the teacher disapproved of the use of the native language in a "formal setting", and appears to render English superior to native languages within that context (Lodge, 2017). Indeed, as reported by Olu, the native language is used in classrooms in a way that permits jest, which might lead to disorderliness in classrooms. Other students also endorse the primacy of English within the Nigerian context:

> I like our teachers to use Yoruba sometimes and not all the time so that Yoruba will not affect my speaking of English. (Interview with student, Bola, School X)
>
> I want them to use English language because most people understand English more than Yoruba. Since our childhood days, we have been hearing our parents speak English. Some parents do not teach their children Yoruba or any other native languages. (Interview with student, Dorcas, School Z)

The students' emphasis on being fluent in spoken English suggests their choice of wanting to communicate in English. Bola's desire to speak English fluently has led her to disapprove of the idea of being taught using Yoruba all the time, which aligns with the claim made by Probyn (2009) and reported in Section 2.4.3.2. In homes where students speak English more often than their native languages, they might lack an in-depth knowledge of the native languages and not understand all the native language words spoken by their teachers. This seems to resonate with Okebukola et al.'s (2013) argument that parents prefer their children to be taught and gain competence in English. This is because parents believe their children will secure well-paid jobs and be respected in society if they speak the language of the British colonialists (Okebukola et al., 2013). Another teacher stated:

> To me, English is what we can use. I believe that English is still the best language that can be used to teach science. It will be English because that was what my teacher used to teach me. You cannot give what you don't have. So we need to use the language that we are taught to enable us cope with our tasks. (Individual interview with physics teacher, School W)

This physics teacher's narrative seems to show that his preference for English as the best language of instruction is because he was taught using that language. The phrase "you cannot give what you don't have" seems to suggest that scientific knowledge is owned by the teacher and will be transmitted (Wellington & Osborne, 2001).

Students reported that using English in classrooms within a multilingual context such as Lagos will help teachers and students with different native languages to understand one another:

> I prefer our teachers to use English. Because not all the teachers understand all the languages spoken by the students. (Interview with student, Shade, School X)

> I prefer English because it is a general language that everybody understands whatever the students' background since our school comprises Ibo, Yoruba and Hausa ethnic groups. And English is the general language that everybody understands, so I will prefer English. (Interview with student, Florence, School Z)

According to Danladi (2013), English probably became a contact language between Nigerians from different ethnic groups to ease tensions and rivalry between them. This perhaps explains the preference of these students for the use of English. However, as the physics teacher in School W stated, "most of our students in science are not that competent in the use of English". As such, students' use of English in classrooms might be for communication purposes rather than to aid their learning. One of the teachers corroborates this view in his narrative:

> I don't believe that the differences in the English and science meaning of some common words such as cells or gravity will make science difficult for the students to understand. What I actually feel concerning the understanding of students is that most of them are not well grounded in English. (Individual interview with biology teacher, School Y)

This biology teacher referred to several words that are used in science and in everyday life with distinct meanings. Song and Carheden (2014) described such words as a ‘dual meaning vocabulary’ (DMV) (see Section 2.4.3.1). The teacher seems to relate the difficulties students faced in science to their non-proficient use of English rather than to how the words are introduced to them in classrooms. Students’ difficulty in using the English language could lead to a difficulty in thinking about and making sense of concepts (Wellington & Osborne, 2001). Teachers also seem to have this difficulty as the physics teacher in School W stated that “many of us (teachers) have problems with English”. The language issue within classrooms in this context seems to resonate with the findings of Song and Carheden (2014); adopting one of their recommendations within this context may therefore help. For instance, they recommended that DMV words should first be explained in plain, everyday language to students before they are told the scientific meanings (Song & Carheden, 2014). Moreover, the everyday language might not be Standard English as they are not well versed in it. In relation to this, one of the students mentioned:

> The school should allow teachers to teach using pidgin language since all of us understand pidgin. (Interview with student, Wale, School Z)

Pidgin language is an altered form of English that is commonly employed as a shared language among speakers of different native languages in Nigeria (Danladi, 2013). Wale was the only student who mentioned that teachers could use pidgin language to teach, which may indicate that this is not a popular preference amongst students. The reason for this could be that the pidgin language is understood as substandard and is not approved for official use in classrooms (Balogun, 2013).

Teachers and students both related science teaching and learning to the use of English in classrooms. For example, one teacher expressed the following view:

> There is no other way to teach students such (science) words other than using English. For example, you can’t interpret the scientific words in the Yoruba language; it will be very difficult. (Individual interview with chemistry teacher, School X)

According to this teacher, scientific words are best interpreted or explained in English. This could be because scientific English, although unique, is still a form of English (Halliday & Martin, 1993). In line with this chemistry teacher’s comments, students also expressed the following views:

> I prefer English to Yoruba because the teachers will be able to express themselves in English so that we may understand the scientific terms. There are some terms in science which if the teachers try to express them in Yoruba, it will be very difficult for students to understand, such as tetraoxosulphate (VI) acid. (Interview with student, Ayo, School Y)

> I would prefer my teachers to use English to teach me science. Because in most cases we have some topics that deal with English in particular, the definitions. They can't just use Yoruba to explain those topics. (Interview with student, Kike, School W)

The scientific term 'tetraoxosulphate (VI) acid' could be termed a 'naming word', which Wellington and Osborne (2001) describe as a name given to a familiar or unfamiliar real object in science. This scientific term has a meaning that is different from other names; it was coined from a number of languages – Latin, Greek, and English (cf. Nwadinigwe, 1985). This indicates the difficulty of translating and expressing such terms in another language. Kike's statement that the scientific definitions of topics "deal with English" seems similar to the expressed view of the chemistry teacher in School X reported above. Science contents are written in English because scientists use English as a language of discourse (Halliday & Martin, 1993). Meanwhile, most scientific terms were drawn from languages such as Latin, Greek, German, and French (Nwadinigwe, 1985; IUPAC, 2020). Furthermore, the views of students reflect the fact that Yoruba does not have a contemporary scientific vocabulary, which makes it difficult to explain concepts. This view is pertinent to one of the findings in Probyn's (2001) study in South Africa of teachers' perceptions and attitudes regarding teaching and learning science through the medium of English as a second language.

The support and reasoning for the use of English as a language of instruction was also mentioned by one of the teachers:

> If you are not knowledgeable in English, there are some questions in science that definitely you will not be able to answer. I do tell my students that they should be able to dissect questions, to split it so that they will be able to know what the question is about and how they will answer it. So English is very important. (Individual interview with physics teacher, School Z)

This physics teacher appears to have exposed some of the difficulties facing students while learning science. As stated in the above extract, teachers' views of learning concern students' ability "to answer" questions in examinations, where the competent use of English is required to 'dissect' and 'split' questions. The delivery of science content, and the writing of examination questions in English within that context, explain the need for mastery in the use of English. However, if students are not competent in the use of English, how can they be expected to understand the science taught in classrooms, and how can they give correct answers to questions?

In this Section, participants' views regarding their preference for using English as a medium of instruction have been presented and discussed. English appears to have primacy within the context of this study, in part because it is the language of the former colonial masters (Danladi, 2013) and in part because of its role in the language of Western science. The primacy of English has led to its preferred use in society and in schools as a common language that is spoken by everyone (Danladi, 2013). Parents also want their children to speak English fluently in order to enjoy the status conferred on the use of the language (Okebukola et al., 2013). Furthermore, in line with the primacy of English, the findings seem to indicate that, despite some students' lack of competence in the use of English, teachers and students expressed a strong preference for science to be taught using the language. In this study, having students prefer the use of English in science classrooms seem novel, but teachers' preference seems to be in line with Probyn's (2005) findings in research carried out in South Africa. Probyn reported that teachers still preferred English as a language of instruction despite the challenges of teaching science in that language (Probyn, 2005).

The use of pidgin English to explain concepts was also suggested by one student. It could be that using pidgin English would aid students' understanding of concepts, which explains why that suggestion was made. However, it does not seem popular and pidgin English is not authorised for use in 'formal' settings. Similarly, the use of Yoruba seems to be partially preferred by some and not preferred by others. The latter group indicated their non-preference because, according to them, the Yoruba language lacks a scientific vocabulary that could be referred to while explaining scientific concepts. Teachers stated that students must be proficient in the use of English to answer examination questions. In this respect, teachers' assessment of students' knowledge through questions appears to be in line with the view of learning as 'being taught' (Watkins et al., 2007). According to Halliday and Martin (1993), scientists adopted the English language as a language of discourse within the science community. The teaching of scientific terms and students' responses to this will be explored in the next Section.

6.4 TEACHING SCIENTIFIC TERMS AND STUDENTS' RESPONSES

Wellington and Osborne (2001) argued that learning science is similar to learning a new language (p. 5). As discussed in Section 2.4.3.1, scientific language contains features such as precision, a vast specialist vocabulary, the use of analogy, and the use of mathematical symbols (Sutton, 1992; Warren et al., 2001; Halliday & Martin, 2003; Ahmad, 2012; Seah et al., 2014; Song & Carheden, 2014; Seah & Yore, 2017).

In this Section, classroom discourses between teachers and students, and extracts from teachers' and students' narratives during interviews, will be presented and discussed in relation to features of the language of science. Such features include naming words, the use of exact words, and mathematical words and symbols. The findings indicated that students were taught science by their teachers in order to enable them to learn the language used within the scientific community, and be able to communicate with them (cf. Wellington & Osborne, 2001).

6.4.1 NAMING WORDS

Naming words signify real objects or entities that are identifiable or observable (Wellington & Osborne, 2001). Teachers were observed to mention and clarify the names of entities in their science lessons:

> Teacher: I want you to know that enzymes end up with 'ase'. Just few of them end up with 'nin'. Are you with me?
> Cs: Yes ma. (Biology lesson observed, School WBio1)

The biology teacher clarified the scientific names of enzymes, including amylase, maltase, and renin, to facilitate easy identification when students encounter such names. For example, although 'enzyme' might be a familiar word that students have used in sentences outside the classrooms, they might not be familiar with the different types of enzymes and their names. Therefore, the teacher might hope that teaching students about the different types of enzymes and ways of identifying them would enhance students' ability to know their names. Similarly, in a chemistry lesson in School W, the chemistry teacher showed students some equipment in the lesson:

> Teacher: Now we talk of the laboratory preparation of oxygen; you have drawn the diagram. What is the name of this?
> C: Measuring cylinder.
> Teacher: This is not a measuring cylinder. This is a gas jar. What did I call it?
> Cs: GAS JAR.
> Teacher: What is this? (Students started to guess) This is a pneumatic trough.
> Cs: Ah! (Students started to laugh)
> Teacher: The word is P-N-E-U-M-A-T-I-C (Teacher spelt the word). (Chemistry lesson observed, School WChm1)

It was observed during the lesson that students were not familiar with the apparatus when it was shown to them by the teacher. This could explain why one of the students called it something else and was corrected by the teacher. Telling the students the name of the apparatus appears to reflect a level of naming words, where names are given to *unfamiliar* objects (Wellington & Osborne, 2001, p. 20). The chemistry teacher's act of spelling the word 'pneumatic' was possibly done to aid students' ability to use the name the object.

In another lesson, the teacher spoke about the names of different types of bacteria:

> Teacher: You can also classify bacteria based on their shape. The second way to classify bacteria is based on their ~
> Cs: Shapes.
> Teacher: Who can tell us the different types of shapes that bacteria can take?
> Cs: Streptococci.
> Teacher: Yes. Another one~
> C: Bacillus anthrax.
> Teacher: Yes. The third type?
> Cs: (Chorus answering, with many of them making fun of the names)
> Teacher: Which other ones do we have? We have streptococci, we have *Bacillus anthracis*, and *Leptospira* that are spiral in shape. Now let's look at examples of bacteria that are cocci in shape, that is they are ~
> Cs: Circular in shape. (Biology lesson Observed, School ZBio)

The teacher's use of scientific names during the lesson seems to indicate that she had taught them the topic before the lesson was observed and audio recorded. Students made fun of the names when the teacher mentioned them, which indicates that they might be fascinated by the sounds and the pronunciation of those names. The teacher asked the students to name the different 'shapes' of bacteria; instead, the students gave examples of bacteria with different shapes and the teacher did not try to stop them. Citing examples of bacteria rather than mentioning the types of shapes suggests that students might have memorised the names of different types of bacteria without knowing their meaning and how these relate to their shapes. This may indicate that students view learning as being taught, where the form of teaching is curriculum-driven and students memorise what they are told by their teachers (Watkins, 2005). Similarly, the following discourse took place in the biology lesson observed in School Y:

> Teacher: Who can tell me the name of the excretory organ of, let's say, a tapeworm?
> C: Flame cells.
> Teacher: Flame cells. Good. (Biology lesson Observed, School YBio)

The word "flame" could be a verb with synonyms such as 'glow', 'kindle' or 'shine brightly' or it could be a noun with synonyms such as 'passion' or 'excited' (see Merriam Webster Dictionary). In the above extract, "flame cell" as a noun phrase seems to be a naming word that was used in the science classroom to indicate the excretory organ in tapeworms. Ayo, who gave the answer, was asked during my interview with her to describe a flame cell and explain why scientists use this name for the excretory organ. In response, Ayo gave facts about flatworms (which include tapeworms) and how they can only be seen with the aid of a microscope. When probed further on why the excretory organ has the name 'flame cell', he replied, "Our teacher just mentioned the name briefly; he did not tell us". In line with Ayo's contribution in the classroom, it appears he knew the term 'flame cell', probably by memorising it when it was mentioned, without understanding its meaning. Thus, it is reasonable to suggest that teaching science through language to aid students' understanding could be productive if teachers use names to explain the appearance of entities and their functions.

One of the teachers spoke about the relevance of using naming words in developing knowledge of the entities, including chemicals, referred to in the science classrooms. He stated:

> I think, sulphuric acid and from its IUPAC name which is tetraoxosulphate (VI) acid, you will know that you have H_2SO_4, that the compound contains hydrogen, oxo-you will know that compound contains oxygen. Truly the IUPAC names really express those compounds very well and it makes it easy for students to grasp it compared to the former old names. (Individual interview with chemistry teacher, School Y)

The acronym 'IUPAC' stands for the 'International Union of Pure and Applied Chemistry'. The organisation comprises members such as industrial and academic chemists who ensure that a common system is in place for naming chemicals and that there is consistency in the terminologies of chemical compounds (IUPAC, 2020). The teacher in his narrative mentioned two names that are used for a particular chemical compound: sulphuric acid and tetraoxosulphate (VI) acid, the latter of which is the IUPAC name. Thus, names given by the IUPAC could help students to make sense of scientific compounds.

As discussed in this Section, the names given by scientists help to clarify the names of objects, concepts, equipment and entities. The IUPAC name informs teachers and students about the structures of chemical compounds, which can also convey information about their composition. Furthermore, in my study, students found the scientific names funny and were fascinated by the way these names are pronounced. In the lessons observed, it was common to see teachers tell students the naming words and occasionally explain them; however, it was rare for teachers to allow students to discuss and explain the meaning of these names. This seems to align with Wellington and Osborne's (2001) claim that students are given few chances to explore their views and those of others. Being able to discuss concepts in classrooms is an essential component in developing an understanding of the meaning of scientific language, which aligns with Vygotsky's theory of learning (Vygotsky, 1986). Therefore, utilising the naming words of entities in classrooms seems to promote students' memorisation, which aligns more with the view of learning by being taught (Watkins, 2005).

6.4.2 USE OF EXACT WORDS

In the science lessons that were observed, teachers made students speak the science words exactly as they heard them and probably as they were written in the science textbooks. In one of the chemistry lessons in School W, the following oral exchanges took place between the chemistry teacher and one of her students:

> C: The second method is the decomposition of peroxide
> Chemistry teacher: Is it just peroxide?
> C: Hydrogen peroxide.
> Teacher: Manufacturing of Vaseline? It's not how it was used
> C: It is used in the hydrogenation of oil
> Teacher: Hydrogenation of oil? ~
> C: Of vegetable oil. (Chemistry lesson observed, School WChm1)

In these two examples, the teacher expected students to use the exact name of the chemical she had taught them in class. It is possible that the words 'peroxide' and ‘oil’ could be referring to something else, which is why the teacher stopped the students and made them say their complete names. The teacher may also have been teaching the students the exact term; hydrogen peroxide, to make them conform to how the word is used within the science community (Moje, 1995), or in examinations.

In another lesson, the following exchange took place:

> Biology teacher: Repeat after me: Excretion can simply be defined as the removal of ~
> Cs: (students repeated the words)
> Biology teacher: waste products of metabolism from the body of ~
> Cs: (students repeated the words)
> Biology teacher: an organism to avoid its toxic effect.
> Cs: (student repeated the words)
> Biology teacher: That’s it. From that definition, you will see that we mentioned waste product of metabolism, not just ordinary waste products. (Biology lesson observed, School YBio)

Here, the students repeated the definition of excretion word for word after their teacher. By stating the exact words, the teacher appeared to want them to learn the meaning of excretion. Repeating the words might also help to foreground the concepts. Furthermore, the biology teacher emphasised the word ‘metabolism’ to highlight its definition as written in the scheme of work or syllabus. This would also serve to make students aware of the term while answering questions relating to excretion in examinations. The implication is that using the exact words as taught could enable students to get high marks in exams. However, is passing examinations the same as learning? Teaching students to pass examination could entail teachers trying to cover a high workload of science content in syllabuses (Ogunniyi, 1996). Teachers could adopt a transmission method to teach all the content (Watkins, 2005), while students who are passive recipients forget a large proportion of what they have been taught (Hurd, 1998).

Following an observation of a lesson in School Y, one of the students in the class was interviewed. During the interview, the student explained the excretory system as follows:

> The excretory system tells us about the removal of waste products of metabolism from our bodies. (Interview with student, Collins, School Y)

Although the student was asked to explain the excretory system, Collins used the precise phrase “removal of waste products of metabolism” that the biology teacher had emphasised earlier during the lesson. Using expressions similar to those of the teacher to describe the concept suggests this student has passively received the information transmitted. Students using scientific language in the exact manner they are told by their teachers aligns with a view of learning as being taught, which could be curriculum-driven (Watkins, 2005).

Similarly, during a physics lesson in another school, the following exchange took place:

> Physics teacher: Note these two points; one is that in an elastic collision momentum is conserved. Momentum is what?
> Cs: Conserved
> Physics teacher: That is, momentum before the collision is the same after the collision. The second point is that kinetic energy is equally conserved. You must try to remember these two points as much as possible. (Physics lesson observed, School WPhy)

The physics teacher emphasised two points about the concept of momentum. The words “must try to remember” indicates that students are required to recall those words as they have been taught, perhaps in exams, as this would mean they have mastered or learned the topic. When interviewed, one of the students from that class was asked to use real-life examples to explain the meaning of the word ‘momentum’. He said:

> Momentum before a collision is equal to momentum after the collision. (Interview with student, Junior, School W)

Junior simply repeated the words the teacher had used during the lesson to define momentum instead of explaining the meaning of the word using one or more real-life examples. Another student, Kike, from the same class, defined momentum as “the ability of an object to move or to rotate, and the momentum before a collision of objects is the same after the collision”. Junior and Kike's repetition of the exact words used by their teacher demonstrates that those terms are ingrained in their minds. Moreover, as discussed earlier in this Section, using the exact science words resonates with Watkins’ view of learning as ‘being taught’, which involves teachers transmitting content and students repeating and memorising the words (Watkins, 2005). The question is: does students’ repetition of concepts denote their learning of these concepts?

Students’ use of exact science words seems to be an act of pride for them according to one of the teachers in School W:

> A lot of my students are always happy when they hear those terms. And because of the way we pronounce these terms, they are always happy to know them and they easily grab them. They see themselves as more knowledgeable when they speak those scientific words and they see that their ability to speak those terms is what differentiates them from other students in other departments. (Individual interview with physics teacher, School W)

Students’ excitement at speaking the scientific words seems to be due to the academic status bestowed on them and this seems to evince the status conferred on science within the context of this study (see Chapter 4). This teacher’s narrative appeared to show that students conformed to these norms and are identified with the scientific community when they spoke the exact language of science (Moje, 1995). In addition, students appeared to gain academic status or pride when they spoke the language of science outside the classroom in the presence of peers in other disciplinary fields. Nevertheless, it was not clear if speaking these terms aided students' understanding of the scientific concepts as such words can also present a barrier to learning (Wellington & Osborne, 2001).

6.4.3 USE OF MATHEMATICS: WORDS AND SYMBOLS

Wellington and Osborne (2001, p. 21) placed mathematical words and symbols at the "highest level of abstraction in a hierarchy of scientific words". This is because the meanings seem disconnected from what is physically present around the students. One of the teachers talked about the relevance of symbols in science:

> The language is part of science. I believe that understanding the concepts associated with a symbol matters. When we talk about temperature, it can be theta (θ) and can be T; these are symbols. So, I believe it should not be confusing for them, it is common knowledge to them as science students. (Individual interview with physics teacher, School Z)

This teacher implied that symbols are a part of science that all science students should be familiar with. Although the symbol theta might not be connected to what students see around them, using it in relation to a concept in science (temperature) endows it with meaning. Therefore, symbols could be said to be entities to which scientific concepts (such as temperature) relate in order to give meanings to those concepts (Wellington & Osborne, 2001).

The participants seemed to hold the view that to learn science, one must be knowledgeable in mathematics. For instance, some of the teachers mentioned the following:

> Since my elementary days I have been good at calculations, mathematics and this gave me the confidence to study science. (Individual interview with chemistry teacher, School W)

> Apart from that it is because of the calculations compared to other departments like the social sciences and arts, which don't have many calculations. Most of these scientific words are normal words that students can learn like learning English or any other subject. So, some students who find mathematics challenging might find science difficult. (Individual interview with chemistry teacher, School Y)

In the views of both these teachers, learning science is linked with having mathematical skills. Both suggest that students might find science challenging if they are struggling to learn mathematics. The chemistry teacher in School Y also stated that scientific language should be learned in the same way one learns any other language, which resonates with Wellington and Osborne's (2001) argument that learning science is like learning a new language (p. 5). Furthermore, the chemistry teacher states that science differs from other subjects because of the calculations involved. Students appeared to share the views of teachers regarding the link between science and mathematics:

> I believe science is a challenging class unlike other departments. So, science is mostly based on calculations. (Interview with student, Alfred, School W)

> Yes, a lot has changed. In senior secondary class 1 the calculation aspect in science was very easy to understand but when I got to senior secondary class 2 (S.S2), this aspect got more difficult. (Interview with student, Valerie, School W)

These students corroborated the teachers' view of linking science with mathematics, and of finding science challenging due to the calculations they encountered. Valerie's statement implies that mathematical concepts in science get more difficult as one ascends one's schooling; she found the calculations she had to do in S.S2 more difficult than the ones she did in S.S1. In some of the lessons observed, the topics taught involved calculations and the use of formulae, equations, and units. In School W, the chemistry teacher told the students the following exchange took place:

> Teacher: Can someone give me the equation on the board?
> C1: Is it the equation of carbon (IV) oxide??
> Teacher: NO, I mean the equation for the bonding of hydrocarbon with oxygen to give us carbon (IV) oxide and water. We are still on properties; you must have crammed it to understand. (Chemistry lesson observed, School WChm2)

According to this teacher, students are expected to 'cram' equations to understand. The word 'cram' is defined in the Merriam Webster Dictionary as to 'overfill' or 'jam-pack' or 'forcefully pack things together'. In the context of this study, the word could be suggested to mean filling the students' brains with equations for them to memorise, which might not denote understanding. Another teacher in School W appears to express the same view:

> Teacher: Lets convert this to kinetic energy. We are going to have
> $\frac{1}{2} M_1U_1^2 + \frac{1}{2} M_2U_2^2 = \frac{1}{2} ((M_1 + M_2) V_2^2)$
> Let us read this equation together
> Cs: (students read out loud the equation written on the board by teacher)
> Teacher: So, we are to note that in an inelastic collision, the momentum is conserved, the kinetic energy after collision decreases. Is that clear?
> Cs: Yes sir. (Physics lesson observed, School WPhy)

Asking students to read the equation out loud seems to indicate that this physics teacher wanted them to memorise what they have said (Ferro, 2017). The above extract also shows that the teacher gave students the equation along with its meaning, which indicates that equations were expressed as shortened forms of words for scientific concepts.

The chemistry teacher in School Y also spoke about the use of units in science:

> Teacher: Your average titre value would be 20.3 + 20.1 + 20.2 over 3. Who has a calculator?
> Cs: 20.2
> T: 20.2. PLEASE don't forget that unit cm^3. If you don't put the unit there you won't get it. They will just tell you it is wrong. In physics and in chemistry, units are very important. (Chemistry lesson observed, School YChm)

This teacher's expressed reason for ensuring students include units in calculations suggests that students are taught science in line with the curriculum to prepare them for external examinations. The phrase 'they will just tell you' refers to the external examiners who will mark the students' examination scripts. In this respect, teaching students to include units in calculations in chemistry and physics appears to be examination-driven. The unit could be said to be a form of mathematical symbol because of its use in calculations and how it relates to a concept. For example, cm^3 relates to volume.

The use of formulae in science also seems to relate to concepts:

> So, a student that does not know the chemical formula of sodium chloride, which is NaCl, but knows how to calculate the molar mass, might get confused. What I am trying to tell the students is that if they know the chemical formula, when they see such questions they will get them right. (Individual interview with chemistry teacher, School Y)

According to this chemistry teacher, students' knowledge of the chemical formula of a compound makes it easier for them to calculate its molar mass. The teacher's narrative indicates that teaching scientific formulae aids students' performances in examinations. This chemistry teacher spoke extensively about formulae during his interview, stating:

> Formulas are used in science to help students and teachers. When you have a formula it will direct when somebody has to give a definition. From formulas you can definitely express yourself. And when you have a question, instead of wasting time, formulas will give you what to deal with, especially students in exams. (Individual interview with chemistry teacher, School Y)

This chemistry teacher extended his initial statement about chemical formulae by stating that, through the use of chemical formulae, students are directed and informed on how to answer questions in examinations. Furthermore, chemical formulae can direct students when asked to define concepts. This teacher's narrative about formulae resonates with the explanations of researchers (Yore et al., 2007) on the use of formulae to show relationships between concepts. When interviewed, one of the students in this study applied a formula to define a concept:

> Momentum is the product of force and its velocity. That is, momentum is force multiplied by velocity. And momentum before collision is equal to momentum after collision. (Interview with student, Junior, School W)

Junior's attempt to define momentum using a formula suggests that formulae are one of the language tools used in science and can aid students in remembering remember concepts. However, if students get a formula wrong, as Junior did in this case, they may get other facts about that concept wrong. Junior was not able to explain the meaning of the word 'momentum' during the interview, which suggests that students' ability to define concepts does not necessarily denote an understanding of their meaning.

Wellington and Osborne (2001) expounded that teaching science entails the use of 'modes of communication', which include mathematical symbols (p. 7). As shown and discussed in this Section through classroom dialogues and interview extracts, mathematical symbols, which include equations, units, and formulae, are useful in aiding students' memorisation of concepts. Moreover, the ability to memorise the definitions of concepts and equations will aid students' performance in examinations. In relation to the use of mathematical words and symbols in the observed classrooms, the view of learning evident is that of ' being taught' as students are told by their teachers to store information about units, equations, and formulas.

From this Section, teaching scientific terms seems to be carried out to ensure students know the language used within the science community. Naming entities using the exact words of science and using mathematical symbols seems to be used to aid students' memorisation of concepts. Also, teachers emphasise that students mentally store these words and mathematical symbols to retrieve them for use in examinations.

6.5 SUMMARY

The emphasis of this Chapter has been on the three forms of language: native language, language of instruction, and language of science, that are present in science classrooms in a non-Western context. Teachers exhibited code switching by mixing Yoruba with English, which is the language of instruction, to manage students' behaviour in class (so that students do as they are told by teachers), and to emphasise their feelings towards students. Furthermore, few teachers used Yoruba to expound on concepts to promote students' understanding, which showed a missed opportunity to align with Vygotksy's proposition of scaffolding students within their ZPDs (Vygotsky, 1986).

The participants' preference for the use of English in class demonstrates the primacy of this language over native languages. Within their society, competent speakers of English seem to enjoy the status it confers, probably because it is the language of their previous colonial masters. The use of English in classrooms seem to aid the rote learning of concepts as a large number of students are non-fluent speakers of English; hence, few opportunities are created by teachers for them to socially collaborate and learn science more deeply.

When teaching science, teachers emphasised features of the language of science which, as discussed in this Chapter, are naming words, the use of exact words, and the use of mathematical words and symbols. According to Wellington and Osborne (2001), teaching science entails teaching a language that students should learn in the same way that they learn a new language. Teachers tell students scientific concepts that they seem to memorise without necessarily having any understanding as to their meaning. Furthermore, the language of science is actively engaged in bringing conceptual structures into existence rather than passively reflecting pre-existing concepts (Halliday & Martins, 1993). This suggests that students in this study might not be appropriating the language of science for the effective learning of concepts. In the lessons observed, students were given few chances to discuss scientific terms and get to know their meaning, whereas this could have aided their conceptual understanding (Wellington & Osborne, 2001).

CHAPTER SEVEN

TEACHING STRATEGIES

7.1 INTRODUCTION

The focus of this Chapter is on the fourth theme, which is concerned with the teaching strategies employed by teachers. Again, this theme is derived from the thematic analysis of data collected from the same four schools in Lagos state, Nigeria. Insights from teachers' narratives during individual interviews and from observed lessons are presented to elucidate how teachers' beliefs about teaching and learning science guide their classroom practices (Wellington, 2001).

The discussion in this chapter centres around teachers' views of certain teaching methods and how these are enacted (or not) in classrooms. Teachers' views on strategies that aid students' learning of science are presented in Section 7.2, while the strategies they were observed to actually practice in their lessons are described in Section 7.3.

7.2 TEACHERS' VIEWS ON TEACHING STRATEGIES

Teachers' views on how science can be learned appear to stem from their experiences of learning science themselves. During the interviews, teachers drew on their learning experiences as they discussed the strategies they believe would aid students' learning of science. They talked about group collaboration, citing familiar examples, performing practical work, using visual aids to explain concepts, providing notes for students to copy, and assessing students. Each strategy is now addressed in turn.

7.2.1 GROUP WORK

Teachers expressed their views on asking students to collaborate in groups. For instance, the chemistry teacher in School W stated:

> I am a product of Alfred Grammar School; during our time we didn't have a chemistry teacher ... but we trained ourselves by doing group study together. This is the best strategy to use in class in the sense that we will move faster during lessons because it is supposed to encourage the students and the teacher; the teacher will talk less, students will learn more, they will be able to derive things for themselves. Even teachers will have peace; they will not be stressed at all as they will talk less. (Individual interview with chemistry teacher, School W)

This teacher's view is that the grouping method is the best strategy to adopt in the class. The reasons she gave included the fact that students are allowed to interact with each other, lessons go at a faster pace, students are motivated because of their involvement, and teaching is student-centred as teachers do not transmit knowledge. She implies that transmitting knowledge makes teachers 'stressed', which suggests that teachers themselves might not enjoy talking a great deal in classrooms. Students' ability to train each other, as mentioned by this chemistry teacher, demonstrates how students can assist each other when they interact in groups. Although this teacher did not emphasise the language students use when interacting within their groups, it could be suggested that using a language they all speak fluently and can understand enhances their ability to help one another to learn. Students' social interaction when discussing concepts thus enables them to share ideas and facilitates their learning. This accords strongly with Vygotsky's notion of the zone of proximal development and learners' need to experiment with concepts through talk (Vygotksy, 1986). Such interaction could lead to a mutual construction of knowledge (Watkins, 2005). Similarly, another teacher in School W expressed the following:

> That is how we are supposed to teach them, group work, because when students are together and you give them work to do, they do it, they interact with each other in the process. (Individual interview with biology teacher, School W)

According to this biology teacher, students are more likely to focus on and complete tasks when they interact with one another. This teacher's views are again in line with the Vygotskian emphasis on the value of interaction for developing understanding which, as Watkins (2005) suggested, could lead to a mutually-enhanced understanding. Furthermore, students may complete tasks in groups because this joint activity promotes and enhances their reasoning ability (Mercer, 2008). Several teachers shed light on why they believe that interaction in groups aids students' cognition:

> On their own the students carry out research. They then discuss the project together in groups. And if any student is not able to solve the questions on his or her own, this student will ask his or her fellow student. (Individual interview with physics teacher, School W)
>
> You will allow the students to do more of the work; you will just be like a catalyst, facilitating them to do more. Those struggling can even be in groups to read and explain things to one another. If there are any concepts they don't understand, others will help them and they will continue with their work. (Individual interview with chemistry teacher, School X)

Helping one another within the group could explain how students reason together to construct knowledge, so long as they are not simply 'solving' a problem for each other without full understanding. This is pertinent to the discussion on Vygotsky's socio-cultural approach to learning and Mercer's view of students' dialoguing to construct knowledge in Section 2.4.2. Both of these authors suggest that encouraging students to share their experiences by communicating with one another with a more proficient person (in this case the teacher or other peers) facilitates the discussion and enables them to develop their knowledge (Vygotksy, 1986; Mercer & Howe, 2012). Using the word 'catalyst' accords with Vygotsky's proposition that teachers scaffold students within their zone of proximal development to aid their logical reasoning and the formation of concepts (Vygotsky, 1986).

Teachers spoke about the way in which group work facilitates students' involvement during lessons:

> At times we use group discussion; give out the topic for them to discuss and brainstorm, which is how to reach all of them. Let everybody talk and participate, that's how to get the attention of all of them. It is a big class, even moving around is difficult. (Individual interview with biology teacher, School Z)
>
> You can give them projects to do and to explain. Give them a topic to build on in groups and allow them to present the topic. (Individual interview with physics teacher, School Z)

The teachers seemed to believe that adopting a group method in classrooms allowed students to participate in classroom discussion and explanation of concepts. If comprehending a new concept necessitates being given a chance to talk about the concept using the exact words and thinking about its meaning (Wellington & Osborne, 2001, p. 83), then the group method indeed aids students' comprehension of knowledge. According to the biology teacher in School Z, putting a large class of students into groups could aid their participation in classrooms. The phrase "to build on" in the physics teacher's narrative in School Z suggests that students might be required to read in advance topics that are yet to have been fully covered by the teacher. In line with this, another teacher expressed the following:

> That is where this group method will help because not all of them might read but, if they are in groups, the ones that read will help those that didn't. I also tell them that whatever you read and can stand in front of your mates to explain will sink into the brain better. (Individual interview with chemistry teacher, School W)

This chemistry teacher mentioned that adopting the group method prompts students to read so that they are able to explain a concept to others in their groups and to the whole class. This seems to resonate with Okedeyi et al.'s (2013) argument that students read when inquiry-based approaches, which promote their participation, are practised by teachers in classrooms. Furthermore, the notion that concepts that are read and explained to others 'will sink into the brain better' suggests that students make sense of concepts, which accords with the research on learning indicating that by teaching others, students learn themselves (Watkins, 2005). It also resonates with Webb's (2017) argument that the discourse of science, which includes reading, talking, writing, and listening to science, will aid students' understanding of concepts. I was curious to find out, however, whether teachers within this study actually practised group work in classrooms.

Teachers highlighted several issues that could hinder the practice of group work in classrooms. One of these issues was explained as follows by one of the teachers:

> We can give them topics to read ahead for the next lesson, and what we expect is for students to sit, read, and work together during the prep time in

> school, but they don't do it because they are tired. Also, they get home late after coming home from school late. Some of them have house chores to do at home, some will leave here and go to sell goods for their parents. So, they might not read. (Individual interview with chemistry teacher, School W)

As expressed in the above quotation, students may not be able to sit to read together in groups while in school or later on their own at home. During the interview, this chemistry teacher spoke further about the structuring of the school timetable by the government, which allows students to stay behind for prep after school closes at 2 pm. She stated that students play till 2.30 pm when prep starts. However, because they are tired, they do not maximise their time to adequately read either independently or together in groups. Students may encounter a lack of support at home if they are not given time to study because, as this teacher suggested, some secondary school students in Lagos sell goods and carry out house chores after school for their parents or guardians. Thus, if students do not read collaboratively in groups ahead of lessons, they might not be able to critically engage with the concepts written in textbooks (Wellington & Osborne, 2001), thereby defeating some of the purpose of adopting the group method.

Aside from students' lack of reading, teachers highlighted another issue that appears to hinder them from adopting the group method:

> Time is an issue. If one adopts that teaching method (group work), not much of the scheme of work will be covered at the end of each term. (Individual interview with chemistry teacher, School X)

Time allocated for lessons seems inadequate and might not allow teachers to adopt the group method in classrooms. This view aligns with the claim made by Pimentel and McNeill (2013) that teachers work under pressure to cover the curriculum and prepare students for tests. Another chemistry teacher in School W corroborated this chemistry teacher's claim, stating that "I stopped that method because we were unable to move faster with the syllabus". These extracts indicate that teachers struggle to cover all the science content stipulated in the syllabus or scheme of work. As discussed in Chapter 1, there are two evaluation agencies in Nigeria; WAEC and

NECO, which organise the external examinations. One of the teachers referred to one of these agencies in order to shed more light on the science curriculum:

> It's the government who are part of education; they are involved in writing the curriculum. And it's 'OK', we have been using it. And in our school we do align our scheme with WAEC because that is the external examination that we prepare our students to sit for at the end of their completion of secondary school. (Individual interview with physics teacher, School W)

This teacher's narrative confirms that the government oversees the development and assessment of the curriculum by external examination bodies. This explains why teachers expressed their worries about covering topics in the curriculum. Another teacher spoke about the volume of content included in the scheme of work:

> I will not lie to you; we are not using the group method 100% during lessons. This is because the scheme of work is cumbersome, it is loaded with many things. (Individual interview with physics teacher, School W)

The terms 'scheme of work', 'syllabus' or 'curriculum' are described as policies laid down within any level of an educational system to support effective teaching (Musingafi et al., 2015). Such words are used in connection with one another in this study because the scheme of work is derived from the syllabuses and the syllabuses from the curriculum (Musingafi et al., 2015). The word 'cumbersome' suggests that the curriculum is overloaded, which corroborates Ogunmade's (2005) argument that the science curriculum in Nigeria is content-laden. This appears to explain why teachers transmit content to students so that they can cover everything within the short instruction time available (Ogunmade, 2005; Lyons, 2006). Nevertheless, teachers' narratives seem to indicate their support for the use of the group method. In addition, it seems the government also supports this method as one of the teachers described how they have adopted this method in in-service training:

> All physics teachers in Lagos state meet for training. We normally have workshops where we train ourselves in groups. It is a good forum put in place by Lagos state. There is another thing that we do, which is called Team Teaching. Like if I have difficulty in a particular topic, I can ask another teacher within my group to come and teach the topic. (Individual interview with physics teacher, School W)

Training teachers in groups indicates the benefits of group learning and suggests that teachers might adopt the group method in classrooms. However, as teachers have already expressed and discussed in this Section, using the group method in classrooms might not, in their opinion, be feasible.

7.2.2 USING FAMILIAR EXAMPLES

Teachers described how the use of familiar examples helped students to understand science concepts. For instance, the chemistry teacher in school W stated:

> I want students to understand rather than cramming. This makes it possible for them to relate to what is happening around them. I usually use examples from the environment to teach them. For example, oxygen is used by welders for combustion. Relating such concepts to day-to-day activities will enable students to understand science and retain knowledge. (Individual interview with chemistry teacher, School W)

Relating science concepts to examples students can find around them aids their understanding and retention of concepts. Cramming could mean having a cognitive overload, which seems likely to make it difficult for students to develop an understanding of scientific concepts (Kruckeberg, 2006). According to Wellington and Osborne (2001), science is full of words that are unfamiliar to students because they are not part of their everyday lives. Students' comprehension of concepts is facilitated by an ability to visualise and connect these to everyday examples, thereby rendering them less foreign. In such a case, students do not 'cram' excessive content.

Another chemistry teacher also highlighted the importance of using familiar examples in science classrooms:

> When you are teaching chemistry or physics you try to relate it to their immediate environment; that is, when you talk about acceleration, an increase in velocity, you try to apply it to a car. And when you talk about chemistry you try to apply it to what they are familiar with like sodium chloride to normal salt at home. They will be able to understand better all the chemical words. (Individual interview with chemistry teacher, School Y)

This chemistry teacher's narrative described how chemistry and physics teachers needed to use familiar examples to help students create meaning out of scientific terms (Wellington & Osborne, 2001). When teachers use familiar examples, they help students use these (spontaneous) examples to make sense of science (non-spontaneous) concepts (Vygotsky, 1986). This chemistry teacher further explained that:

> At times when you explain as a teacher, instead of you giving them a common example first, you can ask them. As a teacher, by allowing that, you are also teaching yourself. So that when you are in another class, you will remember the examples that the students are more familiar with; that will make it easier for students to understand the topic better. (Individual interview with chemistry teacher, School Y)

Asking students to mention familiar examples seems to be a way to involve them and encourages them to contribute towards their learning. This form of practice contrasts with a teacher-centred approach where students passively receive scientific content (Savasci & Berlin, 2012). Asking students to give familiar examples in a social setting so that they understand the concept better illustrates Vygotksy's concept of socio-cultural practice, in that they are able to interact and relate the examples to scientific concepts (Vygotksy, 1986). According to this chemistry teacher, the involvement of students in his lessons means he is able to acquire knowledge of examples that could aid students' learning, thereby improving his practice (cf. Lotter et al., 2007). It seems that teachers believed that when they used familiar examples to explain science concepts in classrooms, and allowed students to contribute by citing examples, students' understanding was enhanced. At the same time, teachers acquired more knowledge on how to teach their students in order to aid their learning.

7.2.3 PERFORMING PRACTICAL WORK

Abrahams and Millar (2008) describe practical work as one of the features of science education and an activity that involves the manipulation and observation of real objects and materials by students. Teachers expressed their views on the importance of performing practical work to enhance students' learning of science. One of the teachers stated:

> If one is not good with practical activities, one would not be able to study science. Doing practical work really helps. My experience of doing practical work at the evening classes helped me learn the subject better. I was able to

> learn how to handle apparatus with confidence during practical activities. (Individual interview with chemistry teacher, School W)

In the above extract, this chemistry teacher indicated that being 'good with practical activities' depends on students' capabilities, not on how teachers plan activities in classrooms. In addition, she appeared to hinge the learning of science on performing practical activity. The reason for this could be that it allows students to link scientific ideas to real life situations (Abraham & Millar, 2008). On this note, doing practical work conforms to Vygotsky's explanation of using real life experiences (spontaneous) to understand science (non-spontaneous) ideas (Vygotksy, 1986). This teacher's reference to her confident use of apparatus when carrying out practical work aligns with Darlington's (2015) suggestion that students should have autonomy in the laboratory whilst using and manipulating equipment. This might increase their interest and motivate them to study science (Morgan et al., 2001). Furthermore, Hofstein and Lunetta (2003) reported that practical activities could provide learning opportunities for students if teachers designed the activities to engage students and allow them to focus on inquiry. However, in all the four schools, there were no practical activities in all of the lessons observed; instead, one of the teachers showed some apparatus to students to explain the laboratory preparation of oxygen.

Another teacher related practical activities to activity-based learning where students were involved in lessons:

> Activity-based learning, where we do more experiments, can make them feel involved. When the students participate they gain better knowledge, they remember what they have been taught. (Individual interview with biology teacher, School Z)

According to this biology teacher, carrying out experiments keeps students involved in lessons, which leads to increased retention of concepts. Having students work together to carry out the practical activities planned by teachers could also enhance their cognitive performance (Mercer, 1996), which aligns with Vygotksy's socio-cultural perspective on learning in that they collaborate and work with apparatus and real objects to understand the scientific concepts (Vygotky, 1986). Furthermore, they seemed to believe that students' appreciation of science increased when they performed practical work:

> Science is a part of philosophy that we call realism. Realism we talk about, you have to lay your hands on parts and not the idea alone. So, when you see things, you appreciate it better. (Individual interview with physics teacher, School X)

Philosophy is the study of questions about existence and knowledge, which could explain why this teacher related it to science. She used the word "realism" to refer to the empirical and testable nature of science, where students are given the opportunity to model "scientific inquiry processes" to construct their knowledge of science (Meichtry, 1999, p. 284). This physics teacher's view of learning was that of seeing and handling things in order to make sense of concepts, which is pertinent to the view of learning as individual sense-making as well as Vygotsky's emphasis on cultural tools as mediators of meaning (Vygotsky, 1986; Watkins, 2005). In line with this view, another teacher spoke about the use of equipment to demonstrate concepts in classrooms:

> I used a methodology that has to do with a seeing and believing method. The main reason why I brought the pendulum is to make them know that when an object is moving round they can see how the motion is taking place. (Individual interview with physics teacher, School Z)

This teacher's demonstration of circular motion using a pendulum suggests that students would see and thereby learn science. This is in line with one of the ways of explaining concepts: 'see it my way', outlined by Wellington and Osborne (2001). Being able to explain concepts in this way appears to conform to the modelling phase described by Hodson (2014) as part of the three-phase approach to doing science, where the teacher explains and demonstrates the strategies for conducting scientific investigation to students. The other two phases are: the guided practice, where students perform the task with the help and support of their teachers; and, the application phase where students independently take the responsibility for planning, conducting and reporting their inquiries (p. 14).

However, there seemed to be several factors that could impede the performance of practical activities in the case study schools. According to the biology teacher in School Z:

> Due to the large class size, doing practical work is really hindered. We should not have more than five students in a group, at most six, and we are having like ten, so some of the students will just be looking and not concentrating. (Individual interview with biology teacher, School Z)

The average number of students in the classrooms observed for this study was eighty, which corroborates the findings of an earlier study carried out in Lagos state (Mohammed, 2013) regarding excessively large class sizes in secondary schools. The hindrance to doing practical work resonates with DiBiase and McDonald 's (2015) report that the issue of class size is not encouraging the implementation of inquiry-based practice. The reason for this could be that having a large number of students does not give sufficient room for all of them to be involved in discussions about the activities they are performing. In addition to large class size, teachers also mentioned another impediment:

> We are not well equipped as you can see. If you go to a school such as BAC school, they have a well-equipped laboratory. You don't need to caution the students there because they know they are in for serious work and not a roadside one. This enhances how they behave themselves and their commitment. (Individual interview with physics teacher, School X)

This physics teacher's narrative resonates with the argument of Hardman et al. (2008) that inadequate resources pose challenges for teachers wishing to implement teaching strategies that involve interactions among students. Students' interests will be stimulated and their curiosity aroused in a well-equipped laboratory. Stating that they are "in for serious work" seems to indicate that students' attention is captivated and they are able to relate science concepts to real objects (Abrahams & Millar, 2008), which leads them to behave well. In this respect, a well-equipped laboratory can contribute to a classroom comprising a community of learners, which Watkins (2005) described as a context where students are highly involved, engaged, and intentionally learn science (see Section 2.4.1). Therefore, the effectiveness of performing practical activities to enhance students' knowledge and understanding

(Abrahams & Millar, 2008) might be hindered by large class sizes and inadequately equipped laboratories.

7.2.4 USING VISUAL AIDS

Another view expressed by teachers with respect to teaching strategies concerns the use of visual aids to enhance students' understanding of concepts. For instance, one of the teachers described the following:

> So making use of the projector will help when you have a more compact and concise package with more illustrations, diagrams, it should be 'OK'. Because some of the apparatus we have might not be enough but once they can see clips of different materials in diagrams, they are able to appreciate it. (Individual interview with physics teacher, School X)

Using the projector to present pictures and illustrations of items and concepts could aid students' understanding as they would be able to see what they would physically use were they able to carry out practical work. As discussed in the previous Section, students were impeded from performing practical work due to inadequately equipped laboratories. Another teacher described the effect of using visual aids in class on students:

> A teacher should be able to establish or drive home his or her points so that students will be able to understand. This can come with making it visual, with students seeing some of those things. Because sometimes when you see, it goes a long way, it even reduces the stress in explaining concepts that are abstract to students. (Individual interview with physics teacher, School Z)

According to this physics teacher, using visual aids enabled teachers to explain concepts to help students understand science. The phrase "to establish or drive home" appeared to mean to go all the way in ensuring students understand. Wellington and Osborne (2001) expounded on the different types 'of explaining', one of which is teachers getting pupils to 'see it my way', which might entail the use of illustrations, analogies, and metaphors to explain concepts (p. 35). Teachers' use of visual aids appeared to accord with the 'see it my way' style of explanation, which aligns with the phrase "when you see" in the teacher's narrative. Furthermore, teachers' stress when explaining concepts seems to corroborate Wellington and Osborne's (2001) argument that to explain is an art because it entails putting difficult concepts into terms students can understand. The abstractness of concepts could be why students find them difficult to understand. The physics teacher in School Z went further by giving a name to the use of visual aids:

> I believe it should be teacher-student-centred, it should not be the teacher talking. My knowledge about being teacher-student-centred is that it should be the opposite of a lecture method. This can come with making it visual, with students seeing some of those things. (Individual interview with physics teacher, School Z)

The use of visual aids to explain concepts was given the name “teacher-student-centered” by this teacher who contrasted it with an approach where teachers are talking. It seems likely that the teacher actually meant ‘student-centred’ because it does not involve teachers transmitting knowledge; rather, students are actively engaged in class (Okedeyi et al., 2013). However, it is unclear from this teacher’s words how showing diagrams, pictures, or illustrations of concepts related to the active engagement of students. It could be that when students see the diagrams that are projected in classrooms they are allowed to discuss them, which could explain why he described the method as the opposite of a lecture method. In this sense, using visual aids and allowing the discussion of concepts appears to constitute a method of teaching that supports Vygotsky’s socio-cultural perspective on learning in that students’ talk about concepts taught in class, which is shown to them, could aid enable them to make sense of those concepts (Vygotsky, 1986; Mercer, 2008).

Teachers also spoke about hindrances to the use of visual aids in classrooms, which suggests they may not be using this method much. For instance, they stated:

> If we have a projector, we can use it to show them what we are teaching them. But if we have a generator and projector, we can set it up in the laboratory and use it to teach. (Individual interview with biology teacher, School W)
>
> You can show them video clips of different materials. But electricity is a fundamental challenge that we are facing. (Individual interview with physics teacher, School X)

A generator is a machine that produces electrical energy, and as mentioned by the biology teacher in School W, this will be needed when there is a lack of electrical supply. Lack of electricity when there is no generator does impede the use of visual aids by the teachers in this study when it referred to use of projector. This conforms to the claim made by Agbowuro et al. (2015) that a lack of resources has led to students depending on memorisation of science concepts transmitted to them by the teachers. It seems likely that the use of visual aids had not been widely adopted by teachers within the schools visited, despite their knowledge of it.

7.2.5 NOTE COPYING

It was observed during data collection that towards the end of some of the lessons, students copied notes from the board. Teachers gave students notes to copy either for the topic taught during the lesson or for the topic selected for the next lesson. In addition, teachers made references to the content in the notes given mostly at the start of the lesson.

Regarding note taking, teachers described teaching topics in line and pace with the scheme of work. For instance, a chemistry teacher stated:

> Another reason is that the government expects us to give them notes because they believe that students will learn the same thing if teachers give the same notes to all students. If they take their own notes they will not learn the same thing, giving them notes will also serve as evidence that students have been taught the topic because there are different topics for each week. (Individual interview with chemistry teacher, School W)

The findings indicated that teachers conformed to directives from the government by giving notes to students and questioning them during lessons to determine whether they had read and learnt the notes they were given. Teaching to cover the topics stipulated in the scheme of work by giving notes to students resonates with the view of learning as being taught rather than learning as building knowledge when students do things together (Watkins, 2005). Ensuring that all students have the same contents written in their notebooks also indicates the level of control the government has over what and how teachers teach within the context of this study.

In response to the question of why students copied notes, the biology teacher in School W commented:

> I was giving them notes because I realised that some are lazy and cannot take their own notes. In this present SS2, what I did for them last term that yielded good results is that when I took notes for the week, they took their own for the following week. (Individual interview with biology teacher, School W)

Laziness was one of the reasons cited by the biology teacher to explain why she provided notes to students to copy during lessons rather than allowing them to write their own after each session. But what does the word 'lazy' mean here? Does it mean that the biology teacher views students as deliberately not taking notes or as not having the capacity to produce accurate notes? With respect to the latter, another teacher opined that:

> It is good for them to take their notes but the ability to do so is not there. (Individual interview with chemistry teacher, School W)

This teacher asserted that students were not capable of taking notes. However, could students' inability to take notes be related to a lack of conceptual understanding? It appears teachers held the view that students could not take notes themselves, as it was observed in the four schools visited that teachers gave notes to students to copy and referred to these during lessons.

Another claim made by one of the teachers is that students took notes by copying directly from textbooks:

> They will not take notes and few of them will copy from the textbook whereas some will not go to that extent but will copy from those that copy from the textbook and their notes will be voluminous. (Individual interview with chemistry teacher, School W).

According to this chemistry teacher, copying directly from textbooks led to copious notes. This implies that students could not take notes using their own words due to a lack of comprehension of the content in textbooks. Hence, they copy directly from the textbook which leads to an excessive volume of notes being taken. Overall, the teachers' view is that the availability of notes on the topics taught helped students to cover the topics in the scheme of work at a quicker pace:

> So, if you give them notes on the topic taught per week, they can go over the notes to read and it will enable us to move along with the scheme of work weekly and not fall behind. (Individual interview with chemistry teacher,

> School W)

To corroborate this claim, in one of the lessons I observed, this chemistry teacher asked questions based on a new topic she had earlier given students notes on. Consequently, she had more time to show the students the apparatus she had brought with her to class to explain the topic. The above quotation also indicates that note taking is a teaching method that is curriculum-driven rather than student-centered (Watkins, 2005; Lyons, 2006). Watkins (2005) further suggested that this teaching method aligned with a view of learning as 'being taught' as teachers are transmitting knowledge rather than involving students to collaborate and construct knowledge. However, despite giving notes to students, teachers indicated that not all students read them:

> Write notes for them, they will not even go over it. They are not eager to read on their own no matter how much you encourage them. (Individual interview with chemistry teacher, School X)

It could be that students have difficulty understanding what they read in the notes they are given; hence, they do not read them. It is possible that the scientific language, which is also referred to as 'jargon', is a barrier that could prevent students from understanding what they read (Halliday & Martin, 1993). This could lead students to regard science as difficult (Archer et al., 2015). Therefore, for deep understanding among students, teachers should not just try to communicate scientific ideas by giving notes to students, they should give them opportunities to talk about the ideas using appropriate words to make sense of concepts, and allow them to take their own notes (Wellington & Osborne, 2005).

7.2.6 ASSESSING STUDENTS

Students' conceptions of learning may depend on their experiences of different styles of teaching and how they are assessed (Watkins et al., 2002). Some extracts from the data illustrate the assessment strategy used by teachers in class and their views on assessing students. It seems teachers used this strategy to determine whether students were learning what they had been taught, identify the prior ideas students have of concepts, and involve students in lessons.

One of the teachers expressed the following view during the interview:

> Before the end of the lesson, some were not too sure because I discovered that once I asked questions, I knew when a student was not coping and that is why I had to revise it with them. (Individual interview with physics teacher, School X)

The physics teacher mentioned that she assessed students by asking questions to ascertain whether they have understood the concepts she taught them. Asking questions to find out about students' misconceptions is one of the strategies of assessment for learning and it is necessary for students' learning (Hodgson & Pyle, 2010). This form of questioning aligns with the formative form of assessment that takes place during the lessons, where teachers use questions to enhance students' learning (Vlachou, 2018). Similarly, another teacher stated:

> I'm using questioning when the need arises, to enquire, to ask them, to try to probe into their minds, to know what they know or understand. I ask them questions to try to understand how well they know or the knowledge they have about the particular topic. (Individual interview with biology teacher, School Y)

In addition to finding out whether students understand the concepts taught in classrooms, this biology teacher stated that questions were used to assess students' prior knowledge of the science concepts taught in class. Assessing students in this manner would help the students because, as indicated by Vygotsky, the teacher as a more knowledgeable adult would be able to identify the assistance to render to the students to aid their understanding of concept (Vygotsky, 1986). Acquiring knowledge of students' prior ideas of concepts might help teachers aid their understanding of these concepts (Stears, 2009).

Teachers also cited another reason for assessing students:

> I do involve them (students) by asking some of them to solve questions on the board. And after the student has finished explaining and even if he or she can't explain it very well, I will just cover it to explain the concepts to the whole class. (Individual interview with physics teacher, School Z)

This quotation suggests that students become involved in lessons when they are asked questions. In the above extract, this physics teacher's view was that asking questions should be aimed at encouraging students to interact to influence their thinking. In this respect, students' involvement in lessons when they are asked questions appears to have focused on finding out what students know about topics but also played the dual role of making the lessons more participatory.

Teachers' views on methods of teaching that could aid students' learning of science have been presented and discussed in this section. The views of teachers who participated in this study were discussed in relation to teaching strategies, which they believed could aid students' learning of science. Such views guided their practice (Wellington, 2001), hence the need to understand the teaching strategies adopted by these teachers in classrooms. The next section presents the strategies teachers were observed to use in classrooms within the context of this study.

7.3 TEACHERS' USE OF TEACHING STRATEGIES

As discussed in Section 2.2.2, teachers' beliefs on students' learning ability and about teaching, learning, and the nature of science could influence their practices in class. This section presents the teaching strategies teachers adopted in the lessons observed in the four schools I visited. The science teachers taught students by explaining concepts in different ways, questioning students, giving them notes to copy, and preparing them for external examinations. These teaching strategies are discussed in turn in the following four Sections.

7.3.1 EXPLANINING CONCEPTS

Explaining a science concept to aid students' understanding is complicated because care must be taken to ensure that the meanings of the ideas conveyed are not misrepresented (Wellington & Osborne, 2001). Wellington and Osborne described several 'styles of explaining' science concepts, one of which was referred to in Section 7.2.4: 'see it my way' which entailed using illustrations, analogies, diagrams drawn on cardboards and metaphors to explain concepts. Other styles include 'say it my way', 'let's think it through together', and 'the teller of tales'. 'Say it my way' involved teachers' style of making students repeat exactly what they have mentioned, while 'let's think it through together' is interactive and teachers draw out, reshape and rephrase students' ideas of concepts. The 'teller of tales' involved teachers' telling of story from history about science topics (Wellington & Osborne, 2001, p. 35). Most of the strategies teachers were observed to use were of a 'see it my way' and 'say it my way' style, indicating that teachers wanted to introduce students to the language of science (Wellington & Osborne, 2001).

Students sometimes filled in the blanks in what teachers had said in order to complete sentences. For instance, in School W, the biology teacher said:

> Teacher: So, if you look at *Planaria*, you will see that it is a flatworm. What are invertebrates? Animals ~
> Cs: Without backbones (chorus answering) (Biology lesson observed, School WBio2)

This biology teacher encouraged students to complete her sentence about invertebrates, which resonates with the oral cloze procedure reported by Wellington and Osborne (2001, p. 28) as one way in which teachers initiate students into the language of science. In relation to the style adopted, this teacher appeared to want students to 'say it my way'. In so doing, students seem to be learning the language of science while making minimal contributions, which was common in most of the classrooms observed. For instance, in another classroom the following exchange took place which illustrates how little role students played in the class:

> Teacher: Now to proceed, considering that they're in the same location, the only difference you are bringing out is length. Is that clear?
> Cs: Yes sir. (Many of the students are yawning)
> Teacher: Your T is directly proportional to square root L, which by implication means that T is equal to KL. Like T over L is equal to a constant. (Physics lesson observed, School ZPhy)

In this classroom, it was observed that the teacher spoke for close to ten minutes during the lesson without involving students, either by asking them questions or making them carry out some activities. This may explain why some of the students were yawning during the lesson. The teacher was transmitting content to the students, so that students appeared to be 'being taught' rather than making sense for themselves (Watkins, 2005).

Teachers also used diagrams on charts to explain concepts to students:

> Teacher: Look at the diagram. Assuming we have two bodies; the first body and the second body coming together (shows students a chart with a diagram). This is before collision. Look up! After their impact, we are going to have this (points to the diagram). As you can see from the diagram, the first object is the one pushing the second what?
> Cs: The second object.
> Teacher: The implication of this is that in an inelastic collision, energy is lost, the kinetic energy decreases in an inelastic collision, unlike in an elastic collision, there is no energy loss, energy is conserved. Is that clear?
> Cs: Yes sir. (Physics lesson observed, School WPhy)

One of the suggestions proffered by Wellington and Osborne (2001) to help students overcome the language barrier in science is for teachers to use diagrams, drawings, and pictures as “support for the spoken word” (p. 122). It seems this physics teacher’s style of explanation is that of ‘see it my way’ because the students’ contribution was minimal with only occasional responses being made, as the teacher referred to pictures/diagrams. Similarly, in another class a chemistry teacher drew a graph on the board to explain the concept of absolute temperature and then asked one of the students to recall what he had been taught:

> Teacher: I defined absolute temperature for us. Ibikunle, do you have any idea what I said about this?
> Ibikunle: Sir?
> Teacher: What is absolute temperature?
> Ibikunle: Ah … (silence)
> Teacher: I said absolute temperature is the point at which the volume of a gas is theoretically zero and I drew the graph on the board; we still have it here. (Chemistry lesson observed, School XChm)

The student, Ibikunle, could not define the term absolute temperature and this teacher repeated what he had previously used the diagram to teach. This suggests that students might not have comprehended the meaning of the term despite the teacher’s use of the diagram. Using the diagram could have supported what was said if the teacher had used it to help students talk about ideas around the term or relate it to an example that is familiar to them. This would align with Vygotsky’s socio-cultural perspective on learning as it would involve students discussing scientific terms using examples around them and thinking about why the word 'absolute' is used (Vygotsky, 1986).

Teachers probably recalled previous topics to help students make sense of knowledge. For instance, one of the teachers in School Y mentioned:

> Teacher: When you were in S.S1, you had done the separation technique right?
> Cs: Yes sir.
> Teacher: So, now you can recover your solvent from a solution. So, the last question states 'list two methods that can be used to recover the potassium sulphate from the solution'. (Chemistry lesson observed, School YChm)

Ideas previously taught and recalled in class could be prior ideas held by students that they can then talk about, if allowed, to make sense of new concepts. This chemistry teacher did not give students the space to explain what they remembered about the concepts before he asked a question about the topic. This may be because he is having to teach at a faster pace to cover the scheme of work, as discussed in Section 7.2.5. Teachers also referred to textbooks in classrooms. For instance, in one of the lessons in School W, the chemistry teacher read from the textbook:

> Teacher: It says oxygen may be prepared industrially by the electrolysis of acidified water; however, it is also prepared by the fractional distillation of natural gas. (Chemistry lesson observed, School WChm2)

It is possible that the teacher read directly from the chemistry textbook to refresh her knowledge on that topic. This would indicate a reliance on the textbook. In the same lesson, the following exchange took place between the chemistry teacher and students:

> Teacher: I said you should read about the chemical properties of oxygen, uses of oxygen, classification of oxides? How many of you read it, raise your hand.
> C: I don't have a textbook.
> Teacher: There is what? No textbook?
> Cs: Yes ma (some students responded).
> Teacher: Which textbook did I recommend for you? Is it essential or Ababio?
> Cs: Ababio.
> Teacher: I said *New School Chemistry*, which is Ababio. (Chemistry lesson observed, School WChm2)

In addition to instructing students to read a particular chemistry textbook, this chemistry teacher also specified this textbook as the one students should buy. Teachers have to cover topics in the curriculum, which is controlled by the government (as discussed in Section 7.2), and based on my anecdotal experience the government also recommends the textbooks to be used by teachers and students. On this note, students who do not have a textbook could be disadvantaged when it comes to understanding science and might perform poorly in examinations. However, students who have textbooks might also perform poorly in examinations for at least one of the reasons that affects them all: scientific language. The scientific language used in textbooks, which includes words that are an important part of science, are words students are likely to meet in examination papers (Wellington & Osborne, 2001). Furthermore, teachers' use of textbooks to explain concepts suggests that students will also have to depend on textbooks, which aligns with the view of learning as 'being taught' unless if they study the textbook in order to make sense of what is written (Watkins, 2005; Watters & Watters, 2007).

Another way in which teachers explained concepts to students was to use familiar examples:

> Teacher: Just imagine your own organs in your digestive system. I want someone to name the organs in the body that are parts of the digestive system starting from the beginning to the end. (Biology lesson observed, School WBio2)

The above extract suggests that making a link with an example students are familiar with could motivate them to learn more about the topic. Students might have used the names of parts of their digestive system in sentences prior to the lesson, which means they were less foreign to them and this could help them to understand the topic (Vygotksy, 1986). In another lesson, this same biology teacher used an analogy to explain a concept:

> Teacher: Is it possible for organisms to eat the same type of food? Is it possible for us to give our babies solid food as early as three months, to start giving him pounded yam, amala, yam (native Nigerian foods)?
> Cs: (Students started to murmur silently) Ah! It is not possible. (Biology lesson observed, School WBio2)

When the teacher mentioned local Nigerian foods, which are familiar to the students, it seemed by the look on their faces that they were able to make a connection between these foods and the digestive systems of babies. This could have helped them to picture how impossible it is for babies to eat such foods. In other words, in accordance with Wellington and Osborne's (2001) argument, teachers used of a range of different ways to describe and teach science to aid students' comprehension of concepts. Furthermore, using familiar examples relates to using prior ideas familiar to students, which Vygotksy (1986) referred to as spontaneous concepts, to help them understand new non-spontaneous (science) concepts.

The following extract presents what another told students in one of the lessons:

> Teacher: And when you want to culture a particular microorganism, you need a sterile medium. For example, if somebody is sick, you can be asked to go and do a test in the hospital. And when you are asked to go for such a test, where do you go? You go to the laboratory. And when you get there, what do they do? They take your blood sample and that blood sample will be tested to know whether you have malaria or typhoid fever. (Biology lesson observed, School ZBio)

This biology teacher's use of a story to explain the concept of culturing in biology reflects a 'teller of tales' style of explaining (Wellington & Osborne, 2001). My anecdotal experience suggests that having malaria or typhoid fever is a common phenomenon in Nigeria. Using the 'tale' of getting tested and treated in hospital when sick to explain what 'culturing' means would therefore make the idea less foreign and more comprehensible to students. Using familiar examples could therefore be one way in which complex science ideas are made simpler to facilitate comprehension.

7.3.2 QUESTIONING

Questioning forms an important rationale for interaction in class, is a major part of the learning process, and is one of a number of ways in which a deep approach learner is differentiated from a surface approach learner because such knowledge would inform teachers about how students learn (Chin & Brown, 2000). At best, questioning constitutes a way of making students engage with their present understanding, consider other ways of explaining a concept, and ascertain why some explanations are better than others at making concepts clear (Chin & Osborne, 2010). Likewise, teachers' questions dictate the course a classroom talk will take and influences the type of thinking students will adopt in the class regarding a scientific concept (Chin, 2007; Chin & Osborne, 2010). On this note, teachers could use open questions to engage students' ideas in dialogue or use closed questions to narrow students' responses to what they want to teach (Harris & Williams, 2012). Wellington and Osborne (2001) reported two types of questions used by teachers in science classrooms: pseudo-questions and cued-elicitation (pp. 32-33). These were both used by the teachers in this study.

For instance, in School W, the following discourse took place between the biology teacher and students:

> Teacher: What is present in the cockroach?
> C: Cockroach has a salivary gland
> Teacher: Not only that
> C: and it has -
> Teacher: HOW MANY MOUTH PARTS? (Teacher raised her voice) (Biology lesson observed, School WBio1)

It appears this teacher wanted the students to mention the exact word she 'had in her head' which characterises her question as a closed question (Harris & Williams, 2012). She probably raised her voice because the student did not give the correct answer. Prior to her question of "what is present in the cockroach?", she made reference to the mouthparts of a cockroach and earthworm, and wanted the students to identify the differences between the two. However, her question did not appear to be explicit enough and that could be why the students gave different answers. In another school, the following communication took place between one of the teachers and students:

> Teacher: What term is used to describe the stage indicated by a change in colour of a methyl orange? What term? End what?
> Cs: End point (Chemistry lesson observed, School YChm)

The question asked by this chemistry teacher seems to be a 'closed one' requiring students to give short answers (Chin, 2007). It is also a pseudo-question because he steered students towards mentioning the exact word he wanted (Wellington & Osborne, 2001). In another classroom, the following dialogue ensued:

> Teacher: So these are the five groups of microorganisms. So we are going to be taking them one by one. Who can define what viruses are?
> Cs: (silence)
> Teacher: Or what is a virus? Who can give us examples of a virus?
> Cs: Ebola virus, HIV, Lassa fever. (Biology lesson observed, School ZBio)

This biology teacher rephrased the question when the students were not able to define a virus. It is possible that students found it easier to give examples of viruses than to define them, which might require the use of knowledge of concepts and vocabulary students did not possess (Wellington & Osborne, 2001); hence, they remained quiet.

Teachers also used cued-elicitation in classrooms:

> Teacher: When we were treating physical properties in SS1, there was something we mentioned concerning physical properties. What do we mean by physical properties?
> Cs: They are ... (guesses from students)
> Teacher: Like colour, touch, smell, and at times we talk about the temperature, boiling point *(teacher was looking at the students and beating on the table)*.
> C: And the melting point (Chemistry lesson observed, School WChm2)

In addition to asking students to recall what they were taught in their previous class, this chemistry teacher looked at the students and was beating on the table while giving examples of physical properties. The students could not give immediate answers to the question, although it seems the cues given by this teacher enabled one of the students to recall one of the meanings of the term. The teaching strategy adopted by this chemistry teacher seems to be that of 'cued elicitation' where a teacher asks a question and displays non-verbal tactics while waiting for students to respond (Wellington & Osborne, 2001, p. 33).

The questioning strategies adopted by teachers in this study allowed students to give short answers and did not give students the room to discuss science concepts. Using pseudo-questioning and cued elicitation might not help students know the meaning of scientific terms as, according to Wellington and Osborne (2001), learning science is a 'minds-on' activity, which entails practising the language of science through discourse (p. 83).

7.3.3 NOTE COPYING

Teachers made references in their lessons to the notes they gave to students to copy, probably to make them 'say it my way' or 'see it my way'. In one school, the biology teacher told the students the following in one of the observed lessons:

> Teacher: I want to give you just what we have in our notes. Group five, where are you? Differences and similarities between a (*) and part of a bird; it is in your book, look at it. (Biology lesson observed, School WBio1)

By asking the students to look at the notes, the expectation appears to be that once they looked at the notes and saw the words, they might understand and remember what they had been taught. In another lesson, the biology teacher directed the students to the notes they had copied earlier:

> Teacher: 'OK' let's go on, number three of our objectives. What is a canal? There are three of them in my notes. (Biology lesson observed, School WBio2)

The phrase "in my notes" in the above extract appears to confirm that this teacher gave her notes to the students to copy, perhaps before the lesson. The extract also suggests that the teacher followed the scheme of work and made notes based on this. However, giving notes to students to copy from the board will not make them independent note-takers who are able to improve their primary skills in taking notes on what teachers have said nor will it aid their understanding (Wellington & Osborne, 2001).

Teachers referred students to notes to make them learn scientific facts:

> Teacher: How do we use it in the production of margarine? (SILENCE) Ah ah, that was not how it was put in your notes. (Chemistry lesson observed, School WChm1)

It seems that students were expected to refer to notes and repeat the scientific content these contained word for word. Thus, teachers expected students to 'say it my way', which relates to the transmission method and means students were less likely to construct scientific concepts (Kruckeberg, 2006). Furthermore, giving notes to students appears to be a way to ensure that all students have the same scientific content to study:

> Teacher: Laboratory preparation of oxygen; you have copied it?
> Cs: Yes ma
> Teacher: Industrial preparation; you have copied it?
> Cs: Yes ma
> Teacher: 'OK', now I have explained this, the diagram that you don't know, will you please close your notes, CLOSE YOUR NOTES, I want to know how far you have got on the notes that you have copied. (Chemistry lesson observed, School WChm1)

Giving notes to students to copy appeared to the teacher to show that students had been taught a topic. Moreover, this teacher assumed they could be assessed to determine whether they had learned the scientific ideas. However, despite having notes to copy, students might still find science difficult because the words and language it uses are unfamiliar to them (Osborne & Collins, 2001) and they have received scientific ideas in a largely passive manner.

7.3.4 PREPARING STUDENTS FOR EXAMINATIONS

As discussed in Section 7.2.5, teachers taught to cover the scheme of work developed by external examination bodies in accordance with the government's directives. Thus, teachers followed the scheme of work in their classes in order to prepare students for examinations. For instance, the following discourse took place in one of the teachers' lessons in School Y:

> Teacher: I want to remember some animals that are always asked about in questions, let's say an earthworm. If they ask you for the excretory organ of an earthworm, what would you say?
> Cs: Silence
> Teacher: Now what if they mention maybe flowering plants?
> Cs: Stomata
> Teacher: Okay. What about if they mention man?
> Cs: Kidney, lungs, liver
> T: Eh hh, so, for man now you know we have more than one excretory organ? (Biology lesson observed, School YBio)

By asking students these questions, this teacher appeared to be trying to make them aware of the type of questions they will be asked, and to know how to answer these questions in an examination. Furthermore, these appeared to be closed questions which only required short answers from students. In another lesson, a chemistry teacher told the students the following:

> Teacher: The volume of a base is the one you used the pipette for. The normal ml they use is 25. If you use 20 ml in WAEC, you will indicate it so that it would be much easier for the marker to know. So, in the question, you will be asked to indicate the volume of the pipette you used, but most people use 25 ml. It is a general one. (Chemistry lesson observed, School YChm)

This teacher taught students in his class how to answer questions relating to the topic, titration, in WAEC. Thus, when teachers referred to examination questions, they were teaching students the language of examinations in addition to the language of science. In line with this, when students answered questions as they were taught in class and performed well, did this necessarily mean that they understood the scientific ideas they had been taught? As shown in this Section, teaching students to prepare them for examinations indicates that teachers aimed to cover the scheme of work or syllabus; hence, they adopted a transmission strategy in class (Watkins, 2005).

7.4 SUMMARY

Teachers expressed their preference for the use of group methods in classrooms as they believed that students were able to discuss concepts amongst themselves and could explain concepts well to one another. Furthermore, teachers were placed in groups during in-service training, which suggests that the government supported the use of group work methods in classrooms. However, teachers mentioned several issues that were preventing the use of groupwork such as large class size, a lack of extra reading by students, and inadequate time allocated for lessons. The use of familiar examples to explain concepts in classrooms appeared to enable students to make sense of concepts, which resonates with Vygotksy's idea of using known concepts to explain unknown or non-spontaneous concepts (Vygotksy, 1986). Doing practical work can also increase student interest, promoting their involvement in lessons and possibly enabling them to retain the concepts they are taught. However, the issue of large class size and inadequate resources in schools appeared to impede engagement in practical activities.

The use of visual aids to illustrate concepts could aid learning if students were allowed to discuss these concepts. However, a lack of electricity hindered teachers' use of such aids. Note taking was another method mentioned by teachers that they believed enabled them to cover the content in the scheme of work, suggesting that this method was curriculum-driven (Watkins, 2005; Lyons, 2006). Teachers assessed students' knowledge to determine whether they had understood the concepts they were taught in class, to assess students' prior ideas of concepts, and to involve them in lessons.

Teachers were observed to use different strategies in classrooms, such as explaining concepts, questioning students, making students copy notes, and teaching to prepare students for examinations. Teachers explained concepts by introducing students to the language of science. They expected students to fill in the blanks in sentences and to listen passively and make only minimal contributions. In addition, teachers' use of graphs and diagrams in class appeared to be designed to make students see things their way, which suggests teachers were engaged in transmitting concepts. Teachers recalled concepts taught in the previous year without allowing students to talk about these ideas to demonstrate they have understood them. They also referred to textbooks in class, which indicated their reliance on these to explain concepts. Using familiar examples could aid students' understanding of concepts if students were allowed to discuss them and relate them to newly taught concepts (Vygotsky, 1986). However, it was mainly the teachers who were observed to use these examples in classrooms. In general, the style of explaining concepts employed by teachers in this context tended more towards the transmission of concepts as teachers expected students to 'see it my way' and 'say it my way'.

Questioning students using closed, pseudo-questions and cued elicitation to draw out the knowledge they possessed might not enable students to understand the meaning of scientific terms (Wellington & Osborne, 2001). It seems that at least some teachers gave notes to students to copy because they viewed students as lazy, as discussed in Section 7.2.5. However, if they allowed and encouraged students to make their own notes, they could improve students' essential skills in making sense of science concepts and using their own words to create meaning (Wellington & Osborne, 2001). Preparing students for examinations suggests that teachers were largely driven by what was written in the curriculum.

In conclusion, teachers' views of strategies that could aid students' understanding of concepts were not fully enacted in the classrooms observed in this study. The reasons given in teachers' narratives and extracts of classroom discourses corroborate the argument of Ogunniyi and Rollnick (2015), discussed in Section 2.3.1.1.1. These authors maintained that due to large class size and a shortage of resources, teachers in developing countries continue to choose the transmission method over other methods that could promote the active participation of students. Active discussion of concepts in classrooms among teachers and students would enable students to understand the correct meaning of scientific vocabulary and language when trying to make sense of science concepts. Adopting teaching strategies that promote such classroom activities would resonate with Vygotksy's socio-cultural perspective on learning and Watkins' third view of learning as discussed in Section 2.4 (Vygotsky, 1986; Watkin, 2005; Mercer, 2008). However, such strategies were only encountered when teachers referred to familiar examples to explain concepts, and when students in some of the classrooms in School W were given topics in groups to explain to one another and later to the whole class.

CHAPTER EIGHT

DISCUSSION AND CONCLUSION

8.1 INTRODUCTION

The aim of this study was to explore the perceptions of teachers and students regarding the teaching and learning of science in Public Senior Secondary schools in Lagos, Nigeria. In pursuit of this aim, the research findings presented and analysed in Chapters 4, 5, 6, and 7 produced numerous valuable insights. In this final chapter, these are discussed in relation to the four research questions:

1. What are the views of students and teachers in Lagos state secondary schools on the value of learning science?
2. What view of learning is implicit in teaching in Lagos state secondary science classrooms?
3. What are teachers' perceptions and use of different teaching strategies within Lagos state secondary science classrooms?
4. How is science teaching and learning in Lagos state secondary science classrooms influenced by i) the language of the curriculum, ii) students' native languages, and iii) the language of science?

The answers to these research questions are discussed in Sections 8.2, 8.3, 8.4 and 8.5. Additionally, limitations in the study are discussed in Section 8.6, recommendations in Section 8.7, possibilities for further research are provided in Section 8.8, and a conclusion is presented in Section 8.9.

8.2 DISCUSSION OF RQ1: What are the views of students and teachers in Lagos state secondary schools on the value of learning science?

In Chapter 4, the theme 'the value of science' was explored in relation to students' and teachers' views on why they chose to learn science. The findings indicate that students' and teachers' interest in learning science are in accordance with their views on the scientific value of producing scientists and the need for scientific literacy. The value of taking up careers in science is discussed in Section 8.2.1 while Section 8.2.2 discusses the value of being scientifically literate.

8.2.1 VALUE OF PRODUCING SCIENTISTS

One of the aims of science education discussed in Section 2.2.1 is that of preparing a minority for science-based careers (Wellington, 2001; Reiss, 2014). Reiss's (2014) presentation of the five possible aims of science education (see Section 2.2.1) expounded on what learning science should achieve in a society and incorporates Wellington's (2001) key aims of science education. In this study, the findings presented and described in Chapter 4 indicate that students and teachers believed that learning science produces scientists who take up science-based careers that are well remunerated and attract social and academic status. In addition, these scientists acquire scientific skills and attitudes that can be put to use later in life. These findings align with Wellington's (2001) and Reiss's (2014) aims of science education in that they show how learning science helps one to live a flourishing life, although the views of students and teachers in this study place particular emphasis on preparing students for the world of work, which Wellington (2001) referred to as deferred vocationalism.

The analysis generally highlights the economic value of learning science whereby students study science to acquire skills and knowledge that enable them to gain employment. The economic value of science in this study agrees partially with Alex Moore's (2015) delineation of Schiro's second purpose of public schooling, which is to train students for socioeconomic reasons that will benefit the national economy. However, the economic value of science mentioned in this study appears to benefit the individual more than the state because science-related careers are highly remunerated and, on this basis, students choose to study science to become wealthy. To buttress this view, the findings show that a high number of students want to become engineers and medical doctors due to the good salary on offer, which corroborates Johnson's (2012) report on students within developing countries who pursue science-related careers due to the good remuneration (see Section 2.2.1). In addition, my findings suggest that students and teachers believe that scientists influence the world by making a change through the application of scientific knowledge and the generation of technological products. However, students' and teachers' emphasis is on the economic gains accrued from using such scientific knowledge to run private businesses rather than the overall economic development of the nation.

In addition to economic enhancement, individuals who choose science-related career pathways believe they will gain prestige due to the social and academic status conferred on anyone studying science. This prestige may be partly fuelled by the economic reasons explained in the previous paragraph, or it could be driven by the demand to reduce educational poverty in Africa (Koosimile & Suping, 2015). Regarding the status enjoyed by scientists, the findings suggest that students are encouraged by their families to study science because it gives the impression they are intelligent and are likely to live a comfortable life in the future. In addition, science competitions organised among schools within Lagos state enable students to learn more about scientific terms and the usefulness of science, which contributes to the academic status enjoyed by science students. The finding that students acquire academic status by studying science supports findings from Osborne and Collins' (2001) study on students' views on the value of learning science when they claim that learning science indicates that one is intelligent.

Notably, students and teachers expressed the view that some students who make their way into science classes actually struggle to learn science. As described in Section 4.2.3, such students may hold the view that science is challenging because it requires them to reason about concepts. In addition, teachers ascribe the responsibility to learn to students rather than focus on how they teach the students.

The findings also indicate that students hope to develop scientific skills and knowledge when they learn science, which includes carrying out observations and being curious, open-minded, creative, objective, honest, and committed to scientific beliefs. As described in Section 4.2.2, these attributes conform to the scientific dimension of scientific attitudes listed by Gauld and Hukins (1980) and corroborate Gauld's (1982) and Wellington's (2001) reports of the direct value of developing scientific skills and attitudes for life and in work. Of particular interest is the students' claim that part of a commitment to scientific beliefs is to be able to explain natural occurrences that other people consider to be magical or superstitious. In Section 2.3.3, an indigenous knowledge or worldview was explained as the ideas possessed by people within a cultural context, in this case Africa, to explain natural phenomena (Aikenhead, 1996; Mpofu et al., 2014; Fasasi, 2017). The students' view that science can be used to explain how the world works indicates they are taught to believe that scientific knowledge is superior to indigenous knowledge (Jegede, 1995). In this respect, students may lose some aspect of their identity when they neglect their indigenous worldview (Ogunniyi, 2007). This could be due to teachers' failure to discuss with students how their cultural beliefs relate to scientific ideas, a phenomenon I observed during the lessons taking place in the four schools. Incorporating students' culture into science lessons could help make science concepts less foreign to students and motivate them to learn science. Adopting this style of teaching science conforms to Vygotsky's (1986) socio-cultural perspective on learning science in that students are able to use the spontaneous concepts or their everyday knowledge of phenomena to explain the non-spontaneous or scientific concepts taught in classrooms.

8.2.2 VALUE OF PRODUCING SCIENTIFICALLY LITERATE CITIZENS

To develop scientifically literate citizens is the second key aim of science education stated by Wellington (2001) and relates to the ability of students to understand scientific issues that are relevant to their lives (Reiss, 2014). Both students and teachers in this study indicated that possessing scientific knowledge enables individuals to know how to take care of their bodies, which enhances wellbeing and promotes good health. Furthermore, students and teachers value science for its relevance to their social lives because they are able to use their scientific knowledge outside the classrooms to learn about their environment and the organisms within it, and to know more about the appliances used in their homes. They also expressed the view that citizens are empowered by scientific knowledge to engage in discussions on scientific issues. All of these views relate to scientific literacy because they show how science is connected to human lives and enables people to live effectively in the world (DeBoer, 2000).

Applying a knowledge of science to take care of one's health resonates with Millar's (2014) utilitarian argument and Schiro's third purpose of public schooling, which is focused on the humanistic view of using scientific knowledge to live flourishing lives (Moore, 2015). The findings presented in Section 4.3.1 indicate that it was mainly the biology teachers who used examples connected to students' lives to teach scientific concepts. This is probably because the topics taught in biology lessons focus on the health and physiology of organisms. Teaching biology in a way that connects with students' lives could help them comprehend science concepts better, and this might explain why students' performance in biology is better than chemistry and physics in national examinations (WAEC and NECO), as discussed in Section 2.3.1 (cf. Agboghoroma & Oyovwi, 2015).

Students' and teachers' emphasis on the usefulness of scientific knowledge outside the classroom supports other researchers' claims regarding the relevance of science to social and personal lives (Furió et al., 2002; Holbrook & Rannikmäe, 2007). Although students gave examples of products within their environment that exist due to science, they did not explain how these examples are connected to the science concepts they were taught in classrooms. Moreover, as observed in lessons, students were not asked to apply scientific knowledge to relevant issues within their environment. Thus, it could be that students acquired these examples from outside the classroom, most likely from their friends or parents or, in some cases, home tutors (see Section 5.2). As advocated by other researchers (Koosimile & Suping, 2015; Fasasi, 2017) and discussed in Chapter 2, encouraging students during science lessons to talk about some of the ideas they expressed during their interviews would help them make sense of scientific concepts. It would also enable them to apply their knowledge outside the classroom, as illustrated by the women in the Wangari Maaithai's *Green Belt Movement* where a combination of scientific knowledge with local indigenous knowledge enabled them to engage in tree-planting and other activities (Maathai, 2003).

According to Kolstø (2008), the citizenship value of science is that it prepares students to become active citizens who are informed and responsible. The students and teachers in this study did not say much about the citizenship value of science, although a few mentioned that scientific knowledge could be used to engage in discussions on scientific issues and contribute to the welfare of other people in society. This view corroborates Millar's (2014) democratic argument on the value of learning science and resonates with Schiro's fourth purpose of schooling, which proposes that students become educated citizens who apply knowledge gained from schools to make positive and profound changes in society. One possible explanation for the minimal reference to the citizenship value of science could be that the content of the curriculum or scheme of work does not make reference to this; instead, the focus is more on examination results.

Overall, students' and teachers' views on the value of learning science lean towards the economic and prestigious benefits of being a scientist. The scientific literacy aim of science education is not popular within the context of this study, which aligns with Furió et al.'s (2002) study described in Chapter 2, in which they showed the unpopularity of the aim of scientific literacy in some schools in Spain. On this note, the call by Reiss (2014) to teach science that is relevant to students' lives seems to be neglected in Lagos senior secondary schools. It seems that the teaching of science content that relates to people's lives, which allows students to engage socially and to reason, and empowers them to contribute towards their learning (Sadler & Zeidler, 2009), is not much in operation in classrooms within these schools.

8.3 DISCUSSION OF RQ2: What view of learning is implicit in teaching in Lagos state secondary science classrooms?

Watkins' theories of learning and Vygotsky's socio-cultural theory together serve as the theoretical framework for this study. As discussed in Section 2.4.1, Watkins (2005) described three views of learning: learning as being taught, learning as individual sense-making, and learning as building knowledge through doing things with others. Each of these views of learning has specific implications for teaching, for the curriculum, for assessment, and for guiding the learning of students. The findings from the lesson observations indicate that, overall, the implicit view of learning held by teachers is that of learning by being taught. This was played out in classrooms in the way students passively received instructions, which conveyed teachers' commitment to accuracy in science, class management through the projection of their voices, and their precise use of scientific language.

It thus appears that teachers' expectations of how students should answer questions in classrooms, in external examinations, and in science competitions reflected their commitment towards scientific accuracy. In six of the lessons, teachers were observed to tell students how to respond to questions accurately in ways that would enable them to achieve the maximum mark and perform well in competitions and in examinations. Telling students specific ways to answer questions relates strongly to Watkins' view of learning as being taught, whereby students receive instructions and passively take information on board verbatim with few or no contributions of their own (Watkins, 2005). As discussed in Section 8.2.1, the disposition towards science competitions within the context of this study conveys an academic status, and the findings show that teachers prepare students for these and for examinations by transmitting knowledge that covers the curriculum. It is possible that teachers might have passed on this focus on competitions as students' narratives indicated teachers' preference for placing students in groups in order to compete (see Chapter 5). Those students whose foci are on competition and demonstrating learning are described as having a conception of learning that is performance-oriented (Watkins et al., 2001). Therefore, this study reveals a connection between teachers' style of teaching and students' conception of learning, which corroborates the claim of Watkins et al. (2002) (see Chapter 2).

Teachers' emphases on the articulation of certain scientific concepts in classrooms, which they asked students to memorise, was another way in which they demonstrated their support for scientific accuracy. As presented in Chapters 6 and 7, teachers transmitted knowledge and expected students to recall the words they have been taught verbatim, which conforms to the view of learning as being taught. Similarly, the findings indicate that teachers make students learn the definitions of concepts that are written in the notes they give them to copy and in textbooks.

Although giving notes to students to copy was explained by teachers in Chapter 7 as compliance with government directives, it seems teachers also do this to enable them to cover topics listed in the content-loaded curriculum and to ensure students have access to the same content. Furthermore, teachers' instructions to use specific units, equations, and formulae to represent certain concepts appear to be curriculum-driven. Teachers' reliance on the use of textbooks when instructing students is also indicative of an attempt to convey accurate scientific content to students as found in the curriculum.

As presented in Chapter 7, teachers taught with minimal contributions from students other than a few interjections of 'yes ma' or 'yes sir' when responding to teachers' questions, which reflects teachers' view of learning as being taught. It is possible that teachers have tuned their style of teaching to their view of learning; hence, they transmit knowledge to cover content in the curriculum and prepare students for examinations which corroborates Watkins' (2005) claim, as discussed in Chapter 2, that teachers with a view of learning as being taught transmit content to students in classrooms. Furthermore, teachers' style of class management, which involves shouting to control students' behaviour, reflects a focus on monitoring students to ensure they comply with rules rather than inspiring their learning (Watkins, 2011). Students' compliance with rules will likely make them to become passive recipient of contents and will develop a performance-orientated conception of learning.

Teachers' use of scientific language by telling students the precise meaning of terms along with the minimal involvement of students also supports the view of learning as being taught. In Chapter 6, the analysis indicated that teachers spelt out the names of organisms and apparatus and gave the exact terms of chemicals for students to know and memorise. Students passively received instructions from teachers and often completed teachers' sentences using the exact words teachers had written on the board or in notes given to them to copy before their lessons.

In summary, insights from teachers' instruction during lessons strongly indicate their implicit view of learning as learning by being taught. Teachers' support for scientific accuracy, their control of students' behaviours in classrooms, and the precise use of scientific terms and formulae indicate a view of learners as passive recipients of knowledge. As discussed in Section 2.4.1, the view of learning as being taught does not involve interactions with students and they are not able to discuss concepts (Kaptan & Timurlenk, 2012). Teachers' transmission of knowledge could be likened to bright rays of light emanating from a lamp that are expected to illuminate where they land. However, students' learning is not the same as being lit by bright light; it is all about their agency and how they are motivated to learn. As such, students who are told what to do are less likely to develop a good understanding of science concepts (Osborne & Freyberg, 1985; Harrison et al., 1998; Kruckeberg, 2006), and scientific terms or words memorised might be quickly forgotten.

A science education that took seriously students' comprehension of science concepts, in addition to their getting good grades in examinations, would consider students' engagement in the form of their social interactions in classrooms, which conforms to Watkins' third of view of learning as building knowledge with others. Similarly, actualising this view of learning in the classroom requires what Vygotsky teaches us about the importance of language as a mediating tool when students collaboratively discuss concepts. However, the teachers' view of learning as being taught, which is practised in classrooms as discussed in this Section, will not enable students' understanding of science concepts.

8.4 DISCUSSION OF RQ3: What are teachers' perceptions and use of different teaching strategies within Lagos state secondary science classrooms?

8.4.1 TEACHERS' PERCEPTIONS OF TEACHING STRATEGIES

In Chapter 7, teachers' views on strategies that could aid students' learning and the factors that could hinder the adoption of these in classrooms were presented. As stated in Section 8.3, Watkins' theories of learning and Vygotsky's socio-cultural theory were utilised as a theoretical framework to understand the teaching and learning of science in Nigeria. In line with this framework, this section discusses teachers' perceptions of teaching strategies, including placing students in groups to work together, conducting practical work, explaining concepts by citing familiar examples and using visual aids, and asking questions to assess students' learning.

Some of the teaching strategies mentioned by the teachers in this study as aiding students' learning and listed above are similar to the teaching methods proposed by Okedeyi et al. (2013) as effective inquiry-based methods that involve students and capture their attention in classrooms (see Chapter 2). These strategies also align with Vygotsky's socio-cultural perspective on learning and Watkins' third view of learning, both of which lay emphasis on students' social collaboration to construct knowledge. Despite the emphasis of teachers on involving students in some of these strategies, such as doing group work and practical activities in lessons, the findings revealed several factors that could hinder them from adopting some of these strategies in classrooms.

Putting students in groups to cooperate or collaborate has been found to have a positive impact on students' performance and/or learning in science (Ayodele & Fatoba, 2017). Although teachers in School W mainly spoke about the group method because it was adopted as an intervention in some of the biology and chemistry lessons, it appeared teachers in all four schools were aware of the method. Teachers' perceptions of adopting the group method in class indicate that they believed that students' involvement in lessons is facilitated by allowing them to teach each other in groups. In this scenario, teachers act as a 'catalyst' to scaffold students, who are prompted to read in preparation for lessons. These perceptions of group work accord strongly with Vygotsky's notion of the zone of proximal development, where a more knowledgeable person scaffolds students to think logically and converse in order to construct more advanced concepts (Vygotsky, 1986).

Contrary to Stears' (2009) view that allowing students to socially interact in classrooms to promote learning might place excessive demands on teachers, the teachers in this study indicated that the group method makes them less stressed because they talk less. This indicates that teachers prefer to adopt this strategy rather than transmit knowledge in classrooms, which was discussed in Section 8.3 in relation to teachers' implicit view of learning. Although teachers talked about undergoing team teaching in groups during their in-service training (see Chapter 7), their narratives did not explain whether they collaborated in groups, other than by helping one another to teach difficult concepts to students. This suggests that teachers might not know how to use this method to its full capacity to facilitate interaction and the co-construction of knowledge among students, and as such they do not employ this strategy in classrooms. Aside from this possibility, teachers also gave other reasons for why adopting this method is not feasible in classrooms (see Chapter 7).

In agreement with teachers' perceptions of what supports the group method, students' views on this method (see Chapter 5) indicate that reading is a major determinant of their participation in groups. This supports Okedeyi et al. (2013)'s claim that adopting inquiry-based methods in classrooms encourages students to read their notes. However, playing games during the time allocated in the timetable for them to read after school hours, and their engagement in chores at home, often makes students tired and unable to read sufficiently. Other reasons, such as a lack of time in which to allow students to interact to discuss concepts and the need to cover an overloaded curriculum, result in teachers choosing to transmit concepts, a finding reiterated by other researchers (Okedeyi et al., 2013; Pimentel & McNeill, 2013; Lyons, 2016). Taking into consideration Vygotsky's second proposition that students use language to think and verbally construct their thoughts about concepts, teachers did not talk about the language students use to collaborate in groups. Further discussion on the use of language in science classrooms is presented in Section 8.5.

Performing practical work is another strategy teachers claim aids students' learning in classrooms because it requires them to work together using equipment to make sense of abstract concepts, which enhances their cognitive performance. Students' narratives indicate their support for practical work for the same reasons given by teachers. Indeed, the advantages of adopting practical work presented by students and teachers in Chapters 5 and 7 is in alignment with the findings of other researchers (Mercer, 1996; Abrahams & Millar, 2008; Hodson, 2014; Darlington, 2015). Furthermore, adopting this method is in line with Vygotsky's socio-cultural perspective on learning and Watkins' view of learning as co-constructing knowledge in that students are able to collaborate and make sense of concepts experientially

(Vygotsky, 1986; Watkins, 2005; Mercer, 2008). However, this assumes teachers plan the lessons to engage students and allow them to take responsibility for conducting and reporting their inquiries (Logan & Skamp, 2013; Hodson, 2014). The findings highlight the issues of large class size and inadequate equipment in laboratories as factors that hinder the inclusion of practical work, and this also reiterates the findings of previous studies (Mohammed, 2013; Ogunniyi & Rollnick, 2015). These issues result partially from the low funding of the educational sector in Nigeria (Okedeyi et al., 2013), which was discussed extensively in Chapter 2. As a result of inadequate funding and a lack of opportunity to carry out practical activities, it could be suggested that the scientific knowledge of students in this study was not enhanced because they were not able to link scientific concepts and underlying theories with how science works in practice (Abrahams, 2011).

Teachers' perceptions of explaining concepts using visual aids and referring to familiar examples to aid students' comprehension of concepts share the findings of other researchers (Logan & Skamp, 2013; Msimanga & Lelliot, 2014). The use of such strategies aligns with Vygotsky's (1986) proposition that one uses spontaneous concepts to make sense of non-spontaneous (science) concepts (Vygotsky, 1986). In addition, teachers might refrain from explaining concepts using familiar examples because these examples exist within their own socio-cultural milieu and may mean little to students.

Finally, teachers' perceptions about the use of questions to assess students conform to a formative style of assessment that is claimed to enhance students' comprehension of concepts (Vlachou, 2018). An appropriate use of formative questions in classrooms reveals to teachers any prior ideas and misconceptions students might have about concepts (Hodgson & Pyle, 2010). But questions can only be considered 'formative' if they engage the student in meaningful inquiry and thought, rather than just repeating correct answers. Truly formative questioning strongly aligns with Vygotsky's (1986) idea of allowing students within their socio-cultural milieu to talk about their prior ideas of new science concepts in order to understand them (Vygotsky, 1986, Stears, 2009). However, using questions to draw out students' pre-existing ideas and reconcile these with new science concepts

(Watters & Watters, 2007) seems to demand a level of expertise among teachers that they might not have developed during their teacher training.

8.4.2 TEACHING STRATEGIES USED IN CLASSROOMS

The discussion of teaching methods and their impact on learning in Nigeria in Chapter 2 indicates that, despite present-day students' desire for an activity-based style of teaching in classrooms, teachers continue to rely on knowledge transmission (Okebukola, 1985; 1986a; 1986b; Aina, 2017). As discussed in Section 8.4.1, teachers' perceptions of the strategies that aid students' learning are those that involve and engage students in lessons, which aligns with Vygotsky's socio-cultural perspective on learning and Watkins's view of learning as building knowledge by doing things with others. However, evidence from the observed lessons shows that teachers used methods that conform to the view of learning as being taught (Watkins, 2005).

As presented in Chapter 7, teachers' explanation of concepts in a 'say it my way' style, their use of questioning styles such as cued-elicitation along with closed and pseudo-questions, and their emphasis on students copying notes all reflect a traditional style of transmitting knowledge to students and use of summative rather than formative assessment (Watkins, 2005). The minimal contributions from students during lessons is a far cry from the active form of learning that researchers (Lemke, 2001; Watkins, 2005; Watters & Watters, 2007) have proposed will ignite students' interest and enhance the value of science education to produce engaged scientists and science-literate citizens. Teaching students how to answer questions in external examinations, referring to the exact type of textbook to buy for the science subject, and reading out content from textbooks in lessons all indicate that teachers' style of instruction is curriculum-driven and that the curriculum is examination-driven. The issues highlighted in Section 8.4.1 as hindrances to the adoption of methods teachers perceive will aid students' learning appears to have compelled teachers to adopt traditional styles of teaching, which accords with several previous studies (Ogunniyi, 1996; Mohammed, 2013; Ogunniyi & Rollnick, 2015; Onyia et al., 2016). In addition, teachers' implicit view of learning, discussed in Section 8.3 as learning by being taught, aligns closely with a traditional style of teaching (Watkins, 2005). Therefore, in this study, it seems that what teachers perceive as effective strategies for learning science is not commensurate with what they practise in classrooms.

Various studies that describe reasons for the mismatch between teachers' perceptions and what they practise in classrooms were discussed in Chapter 2. These reasons include limitations in teachers' professional and content-area knowledge, students' lack of knowledge and experience of science concepts and their resistance to learn in new ways, non-alignment of teachers' beliefs and practices with students' personal goals, and the influence of teachers' knowledge of students' capabilities, their conception of science, their ideas of effective teaching, and the purpose of education (DeBoer, 2000; King et al., 2001; Lotter et al., 2007; Schroeder et al., 2011; Logan & Skamp, 2013; Pimentel & McNeill, 2013). Such reasons appear to hinge on two factors: teachers' implicit views of learning discussed in Section 8.3 and summarised as learning as being taught; and difficulties facing the educational system in Nigeria, some of which have been discussed in this section and are to do with large class sizes and a shortage of equipment for teaching science.

The discussion in this section has focused on teachers' perceptions of inquiry-based strategies that aid students' learning of science, and the strategies they were observed to use in lessons. Teachers' perceptions of strategies such as putting students in groups to collaborate and discuss concepts, carrying out practical work, explaining concepts using visual aids and examples familiar to students, and using formative questions to assess students' knowledge all conform to Vygotsky's socio-cultural perspective on learning and Watkins' third view of learning. Furthermore, difficulties facing the educational sector may hinder teachers from using inquiry-based strategies in classrooms. These include teachers' limited knowledge of these methods, students' lack of reading to prepare for lessons or reinforce what they have been taught in class, inadequate time for lessons, an overloaded curriculum, inadequate equipment, and large class sizes. In classrooms, teachers were observed to adopt traditional teaching methods whereby they transmit knowledge to cover the topics written in the curriculum, which contrasts with their own perceptions of effective teaching methods. This mismatch appears to be due to two factors: teachers' implicit view of learning and the difficulties facing the educational sector in

Nigeria. Given Vygotsky's proposition regarding the mediating role of language in learning, it is possible that the language used in classrooms could be another factor influencing the methods teachers adopt, which will be explored with respect to the final research question.

8.5 DISCUSSION OF RQ4: How is science teaching and learning in Lagos state secondary science classrooms influenced by i) the language of the curriculum, ii) students' native languages, and iii) the language of science?

Vygotsky's socio-cultural theory identifies language as a tool employed to make sense of science concepts during social interactions in classrooms (Yore et al., 2003, 2004; Seah et al., 2014). As discussed in Chapter 2, researchers within non-Western contexts have argued that students face language difficulties because they encounter languages that differ in grammatical structures and the use of words (Jegede, 1995; Ogunniyi, 1996; Aikenhead & Jegede, 1999). Studies have explored the role of language in the learning of science in South Africa and have found that the difficulties students face indicate they struggle to learn and that teachers code-switch, transliterate, use translanguaging, and cite examples to explain science concepts (Qhobela & Rollnick, 2010; Brock-Utne, 2012; Msimanga & Lelliott, 2014; Probyn, 2001, 2006, 2009, 2015; Webb, 2017). The dearth of studies on the role of language within multi-lingual classrooms in Lagos, Nigeria indicates that language might not be perceived to have an influence on how students learn science. However, given the aims of science education as producing scientists and scientifically literate citizens (Wellington, 2001), it seems pertinent to explore whether students taught using traditional methods (see Section 8.4.2) within multi-lingual classrooms in Lagos are influenced by the language of the curriculum, their native languages, and the language of science. The influence of these three dimensions of language is discussed in the following sections.

8.5.1 THE LANGUAGE OF THE CURRICULUM

As indicated in Sections 8.4.1 and 8.4.2, teachers' attempts to cover a science curriculum overloaded with content, which appears to be focused on producing high marks in science examinations, drives them to adopt the traditional method of teaching in classrooms. Researchers in Nigeria have examined students' failures in science subjects in national examinations, and have called for the science curriculum to be reformed so that it is less loaded with content and incorporates material relevant to students' needs and aspirations (Ogunmade, 2005; Ojimba, 2013; Okedeyi et al., 2013; Aina, 2017). In addition, there has been an emphasis on increasing teachers' capacity through their training and re-training to continue with curriculum reform and provide adequate learning resources (Omorogbe & Ewansiha, 2013; Onyia et al., 2016). Moreover, the language in which the curriculum is written, which teachers use in class to transmit knowledge, has not been examined in relation to students' failure of science subjects.

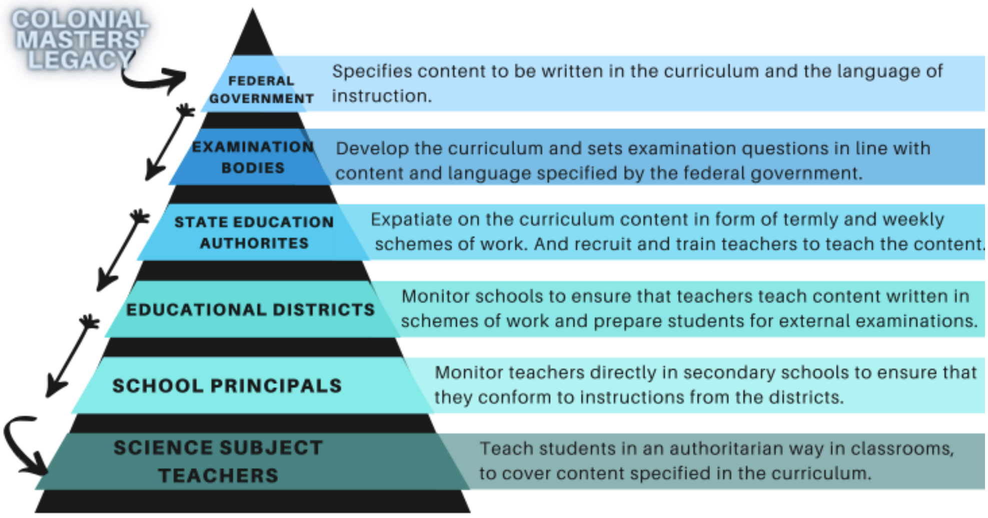
The English language spoken by the colonial masters was transmitted to Nigeria to serve as a contact language between Nigerians from different ethnic groups and between Nigerians and Europeans (Danladi, 2013). As discussed in Chapter 2, the English language is the language of instruction in schools and in the curriculum (Danladi, 2013). Teachers' and students' views on the use of English language in schools presented in Section 6.3 indicate that they perceive that English is still the official spoken language in that society, even after the exit of the colonial masters. The findings also show that English language is perceived to have primacy over the use of native languages because: English has a structure and organisation that native languages do not have; it is used in formal settings; teachers prefer to teach in English as they were taught in English; parents want their children to gain competence in speaking English in order to acquire social status; and science curriculum content and examination questions are written in English. However, as narrated and presented in Section 6.3, teachers and students are typically not competent in the use of English, as a consequence of which teachers might not allow students to discuss, think through, and make sufficient sense of scientific concepts in classrooms.

Teachers' and students' preference for teaching using English language in classrooms appears to be at a surface level, as they are not competent in its use. This could explain why teachers transmit what is written in the science textbooks and the curriculum. The Vygotskian approach to learning requires using language as a cultural tool to shape students' prior ideas, integrate learning with culture, and construct knowledge through social interaction in classrooms (Vygotsky, 1986; Howe, 1996; Mercer, 2008). However, the teaching methods observed in classrooms and discussed in Section 8.4.2 are in stark contrast to methods that involve students socially interacting and developing together cognitively. Because a proficient use of language will facilitate the communication and discussion of concepts amongst students, using another language that is commonly understood among the multi-ethnic groups in this study might be more appropriate.

The literature reviewed and discussed in Chapter 2 suggests that pidgin, which is a shared language, is now being recognised and is regarded as important by the Nigerian government (Danladi, 2013), even though it is considered commonly to be substandard (Balogun, 2013). The findings of this study agree with Balogun (2013) in that the use of pidgin in schools is not deemed universally appropriate as only one student referred to its use in explaining concepts in classrooms.

The use of the English language in formal settings in the context of this study appears to be enforced, and probably reflects the legacy of the former colonial masters as shown in its use as the language of instruction and the writing of science content in the curriculum. Although Jegede (1997) reported that Nigerian leaders reformed the curriculum away from the system instituted by the colonial masters after independence in 1960, it seems that the legacy of the colonial masters remains in place at the level of authority. Moreover, the federal government appears to use this legacy to control the teaching and learning of science. Figure 8.1 illustrates how this authority is passed down from one level to another to ensure compliance in the educational sector in Nigeria.

Figure 8.1: Authorities at different levels within Nigeria's educational sector



As shown, the federal government passes on directives to external examination bodies; the examination bodies then pass on directives in the form of the science curriculum they have developed to all 36 state education authorities; each state education authority passes the directives on to the education districts within the state which then pass them on to school principals; each school principal ensures that the science subject teachers receive the directives; finally, the science teachers pass on the content to students in classrooms. Students are at the bottom of the pyramid as the passive recipients of the scheme of work, which is overloaded with science content as discussed in Section 8.4.1. Students' views portrayed in Chapter 5 of preparing for lessons by doing extra reading, having extra tutoring at home and being determined appear to indicate students' ways of coping with the overloaded and largely foreign science curriculum. It appears that English and science, both of which entered school systems in Nigeria through British colonisation (Jegede, 1997; Danladi, 2013), continue to enjoy dominance and status within the country. Thus, the delivery of science content and the writing of examination questions in English means that students need to master the use of English to enable them to perform well in examinations.

With teachers and students both attesting to the problematic use of English, which is the language of instruction (see Section 6.3), it seems very difficult for students to engage in an active form of learning that conforms to Vygotsky's approach (Mercer, 2008). As Mercer and Howe (2012) argued, the quality and use of language during social interactions transforms into a form of talk that promotes the development of collective and cognitive reasoning. Adopting the transmission strategy in classrooms in an unfamiliar language will result in students memorising concepts (as discussed in Section 8.4.2) rather than understanding science (Ogunmade, 2005).

Furthermore, teachers continue to adopt the traditional style of teaching science through English as this is what they themselves experienced in schools. For instance, the physics teacher in School W stated: “To me, English is what we can use. I believe that English is still the best language that can be used to teach science. It will be English because that was what my teacher used to teach me …” (see Chapter 6).

8.5.2 STUDENTS’ NATIVE LANGUAGES

Students’ and teachers’ narratives presented in Section 6.2 indicate that although the classrooms in Lagos schools are multi-lingual, the majority of students and teachers speak Yoruba, the native language spoken by members of the dominant Yoruba ethnic group living in Lagos (Adeyemi, 2018). The findings indicate that teachers’ and students’ views on the use of Yoruba in classrooms relate to students’ inadequate proficiency in the use of English. Four of the nine teachers and 14 of the 26 students interviewed during the second and third visits to the field of study believed that using Yoruba to explain concepts helped students to process this information. This view resonates with Vygotsky’s view on the first role of speech, as students were able to think through and express themselves better when they spoke Yoruba. However, the students did not mention Vygotsky’s second role of speech, which is the use of speech to interact, possibly because they had not experienced that style of teaching in classrooms. One of the reasons given by those who did not support the use of Yoruba in classrooms was that the language does not contain the vocabulary used in modern science, which could make it challenging for teachers to give meaning to scientific terms.

Two of the teachers were observed to occasionally code switch in classrooms by switching to Yoruba to explain concepts, which aligns with studies on the practice of South African teachers (Probyn, 2001, 2006, 2009, 2015; Msimanga & Lelliott, 2014).

Explaining concepts by mixing English with Yoruba is an instance of code switching, and this seemed to aid students' understanding as many were observed to respond by saying "OK, now I understand". For example, the physics teacher in School X was observed to speak Yoruba as a form of scaffolding to explain the concept of the refraction of light in a lens, which accords with Vygotsky's (1986) proposed ZPD. Furthermore, as presented in Chapter 6, teachers code switch to emphasise points they want students to memorise, and to emphasise their displeasure, especially when students fail to answer their questions correctly. Teachers use the language to exercise their authority (see Figure 8.1) and control students' behaviour and engage their attention in classrooms. However, teachers control students' behaviour in classrooms, could shift their focus away from managing students' learning (Watkins, 2011).

Although English is the only language allowed in formal settings such as secondary schools (see Section 8.5.1), teachers' use of Yoruba to explain concepts by code switching with English appears to enhance students' understanding. Therefore, teachers' use of Yoruba to explain or describe what they would have explained using English, and using 'scientific terms' is one way to aid students' comprehension. An alternative that would conform more to Vygotsky's socio-cultural perspective on learning and Watkins' third view of learning as constructing knowledge with others, would be to allow students to use Yoruba to share their prior ideas of concepts and then discuss how these relate to the science concepts they are taught.

8.5.3 THE LANGUAGE OF SCIENCE

Several studies examining the language of science have reported that it has a lexicon and grammar with features that distinguish it from other languages (see Section 2.4.3.1). Teachers' implicit view of learning by being taught was discussed in Section 8.3 in relation to how teachers conveyed their commitment to accuracy in science and the precise use of scientific language. The findings presented in Chapter 6 elucidate the features (naming words, the use of exact words, and mathematical words and symbols) of the language of science taught in class to introduce students to the way in which this language is used within the scientific community. Science education is seen as an aspect of Western culture, and its entrance into the Nigerian school system through the colonisation of the British (Cobern, 1996; Jegede, 1997) may explain why science has both a high social and an academic status in this study (see Section 8.2).

In line with previous research (Wellington & Osborne, 2001; Seah et al., 2014; Song & Carheden, 2014) on 'Dual meaning vocabulary', the findings highlight several scientific words taught in lessons such as 'collision', 'conserved', and 'force' that are used both in science and in everyday language. Teachers did not ask the students if they knew the differences in the use of these words at the start of their lessons, probably because their concern was to ensure students memorised the precise scientific meaning of these words as stated in the science curriculum. Because teachers are not asking students to discuss their prior ideas of such words, which resonates with Vygotsky's proposition of using spontaneous ideas to understand non-spontaneous concepts (Vygotsky, 1986), what they teach might not make scientific sense to students.

Likewise, words such as 'decomposition', 'excretion', 'hydrogenation', and 'preparation' were also used in lessons. Seah et al. (2014) described such words as used by scientists to convey ideas and called this nominalisation (see Section 2.4.3.1). For example, the word 'decomposition' is a noun remodelled from the verb 'decompose', a technique scientists employ to present ideas in an "economic and efficient manner" (Wellington & Osborne, p. 66). To aid students' comprehension of science words would entail knowing the meaning of such words and then using them to form sentences and describe concepts. This involves helping students to explain concepts in their own words before they are introduced to different keywords and how they are used in science. Teaching students in this way aligns with Vygotsky's proposition of the ZPD because students are involved in the lesson, guided by a More Knowledgeable Other. Talking about concepts in a language they can speak comfortably before the teacher translates it into English and scientific terms could aid students' learning of concepts and help them become proficient in the use of scientific English, which nevertheless remains a form of English (Halliday & Martin, 1993).

Some scientific terms mentioned in lessons are official names given to objects, entities, and chemical compounds that have meanings peculiar to science, probably because they are coined from languages such as Latin, Greek, French, and English (Nwadinigwe, 1985; IUPAC, 2020). Words such as *Bacillus anthracis, Leptospira,* and certain names coined by the International Union of Pure and Applied Chemistry (IUPAC) organisation, such as tetraoxosulphate (VI) acid, were used emphatically in lessons, with teachers encouraging students to memorise them. Although students joked about these names during lessons, they were not able to define these words when teachers asked them, nor could they explain how scientists formed those names when asked during interviews, other than to cite examples (see Section 6.4). In this respect, memorising these words reflects the view of learning as being taught and a traditional style of teaching that is curriculum-driven (Watkins, 2005). Teachers' narratives also suggest that students are excited when they speak these scientific terms, which appears to relate to the academic status science enjoys (see Section 8.2). Furthermore, teachers argued that it is not the scientific terms that students find difficult but the English words used to explain these terms, and this could be why teachers code switch. To aid students' learning, teachers could simplify these terms by telling students the history underlying the use of these names or terms (Wellington & Osborne, 2001). Telling students such tales and explaining how these relate to their personal lives could incite students' interest and motivate them to learn science (Logan & Skamp, 2013; Okedeyi et al., 2013).

Teachers' use of mathematical words, symbols, units and formulae during lessons corroborates Wellington and Osborne's (2001) argument that teaching science involves the use of mathematical symbols. Moreover, teachers' instruction that students should memorise these mathematical words, units and symbols also aligns with the view of learning as being taught rather than individual sense-making or constructing knowledge together (see Section 6.4.3). In this study, students and teachers shared the view that a person needs to be good at solving mathematical problems to learn science. In addition, students' narratives reflected their view that science is difficult due to the calculations it involves, which resonates with findings from previous studies (Oon & Subramaniam, 2013; Taskinen et al., 2013). Although teachers stated that formulae could be used to illustrate relationships between concepts, their instructions in lessons did not provide room for students to use examples to demonstrate how concepts are connected by these formulae. Doing this would have enabled students to relate to the concepts and remember them more easily rather than having to rote memorise or ‘cram’.

English’s primacy over native languages is likely to be because it is the language spoken by the former British colonial masters; hence, it is used in formal settings and students have to be competent in its use in order to learn science. One might have expected the Nigerian government to deviate from a system put in place by the previous colonial administrators; however, it seems clear that the government has not considered as detrimental the presence of the colonial masters’ legacy in the country’s educational sector. As discussed in this section, teachers’ and students’ less than expert use of English indicates that teaching methods relating to a Vygotskian approach will not be feasible and this, along with the overloaded curriculum, explains partly why teachers transmit knowledge. Students’ views of how they prepare for lessons show however that the teaching strategy teachers adopt is not adequate to aid their individual sense-making or even ensure good performance in examinations. The support for the use of Yoruba as a form of code switching in lessons was based on the fact that students are not competent in the use of English. Code switching using Yoruba to explain the ideas while continuing to use the scientific terms could be a method teachers can adopt to aid students’ learning. Furthermore, in line with Vygotsky’s idea, teachers can ask students to share their ideas or give examples using their native language, following which teachers can scaffold them by linking their ideas to science concepts and terms. The features of the language of science described in this section show that to learn science students need to discuss concepts by relating them to examples they are familiar with, and they need to know the meanings of some of these words or how scientists have coined them. Achieving this requires a teaching method that is distinct and contrasts with the traditional method of transmitting knowledge through English that teachers were observed to adopt in lessons.

8.6 LIMITATIONS OF THE THESIS

In addition to the methodological limitations explained in Chapter 3, a number of other limitations emerged during this study. First, no recording was made of the discussions students held in their groups during some of the lessons in School W. If these had been recorded, richer data would have been gathered to help ascertain whether or how students' interactions in their groups aided their construction of scientific knowledge. Nevertheless, the whole class discussion that took place between the teachers and students helped to illustrate what each group had discussed.

Secondly, only one lesson by each teacher was observed during the second and third visits to the field, which might have limited the understanding of science teaching and learning within that context. Despite this, the analysis and exploration of data gathered from four schools located in areas with large populations and multi-tribes in Lagos has provided a deeper understanding of how science is taught within that context.

Thirdly, despite repeated efforts to contact the Lagos state ministry of education, it proved impossible to obtain more recent examination data on students' performances in the science subjects. Fourthly, having only one researcher to conduct this study was a limitation because values that reflect the researcher's personal beliefs or feelings could have influenced the interpretation of the findings and thus affected the credibility of the study (Bryman, 2012). To counter this, throughout the process of collecting and analysing data the researcher discussed her interpretation of the findings with both her supervisors, which helped to enhance the validity of the study.

8.7 RECOMMENDATIONS

The need for a society that is scientifically and technologically advanced, and a focus on students' mass failure in science in WAEC and NECO reported within Nigeria (Agbowuro et al., 2015), calls for an enhanced understanding of the teaching and learning of science. Throughout this thesis, I have used Vygotsky's socio-cultural theory and Watkins' theories of learning to explore students' and teachers' perspectives on how science is taught and learned in secondary school classrooms in Lagos. Based on the findings of this study, I propose the following recommendations to improve teachers' practice and inform the Lagos state government of the need to make science learning more accessible to all students.

8.7.1 STUDENTS' INVOLVEMENT IN LESSONS

The findings have shown that teaching methods that teachers adopt in classrooms are such that do not adequately involve students in lessons because teachers transmit concepts for students to memorise. On this note, this study argues that this minimal involvement of students in classrooms is not beneficial to their learning, even their rote learning. This argument is based on the pieces of evidence from teachers' and students' narratives of teaching methods that aid students' learning. I propose teaching methods that will encourage the involvement of students in lessons, which relates to Vygotsky's socio-cultural perspective of learning in which learning is a socio-cultural endeavour and learners are scaffolded by others; this also relates to Watkins' third view of learning of learners constructing knowledge together.

Students' and teachers' support for group work indicates that adopting this method in class can aid students' learning. Allocating tasks to students in different groups to talk about and allowing them to share ideas they have formed in these groups with the rest of the class could promote students' joint construction of concepts. Within each group, students' talk will entail relating the science concepts to their prior ideas; teachers' role in lessons will include promoting discussions within groups. By allowing students to discuss and relate concepts to their prior ideas in groups, they will understand science appropriately in a cultural way, and this conforms to Vygotksy's emphasis on the importance of culture within a learning context and Watkins' view of learning of constructing knowledge with others. Meanwhile, teachers should set rules of engagement for students so that all students can participate in their groups. Doing practical work in groups is also encouraged to enable students to develop scientific skills and attitudes, which are essential to prepare students for work in science-related careers. With the issues of large class sizes and inadequate equipment facing secondary schools in Lagos, placing students in groups will enable them to share materials.

Teachers' involvement of students to give familiar examples of how science concepts taught in class relate to their personal lives is likely to stimulate students' interest to know more about the concepts. Additionally, teachers can extend this activity by allowing students to talk and share their ideas to make sense of concepts. This kind of talk is exploratory (Mercer, 1996), and teachers' use of formative questions can prompt students to think, talk and understand concepts. By allowing students to connect examples of phenomena around them to science concepts, students will become scientifically literate. Promoting an exploratory talk in science classrooms aligns with Watkins' view of learning of constructing knowledge with others, and with Vygotksy's proposition of aiding students to use their familiar examples of phenomena or the spontaneous concepts to understand the science concepts, that is, the non-spontaneous concepts. To be scientifically literate is one of the aims of science of education that is not currently being met in the science curriculum within the context of this study. Furthermore, reinforcing students' understanding most likely takes place when students are allowed to form notes of topics taught in classrooms, rather than have them rely only on teachers' notes.

The above recommendations of teaching methods proposed in this Section can be feasible if the curriculum is reviewed by paying attention to those who progress to study science and by relating concepts more to students' lives. Teachers should also be included in curriculum development. Similarly, school principals should be involved with the external examination boards to ensure that the content of the curriculum, the examination questions and the outcomes in the form of students' performance and goals in the assessment are in alignment.

8.7.2 LANGUAGE USE IN CLASSROOMS

This study has illuminated the role of language in relation to Vygotsky's socio-cultural perspective of learning. The need for students to talk and share ideas about concepts highlights the vital role of language. English, which is the language of instruction students struggle to use, has been shown to have primacy over students' native languages within the schooling system. At the same time, teachers and students attest to the benefit of allowing the use of students' native languages in classrooms. In a multi-lingual context such as Lagos, teachers should feel comfortable to occasionally use the principal native language (Yoruba) to explain.

Code switching is already in operation in some of the science classrooms observed. Additionally, I propose that students are allowed to speak Yoruba to think through science ideas, share and explain such concepts to one another, which conforms to Probyn's (2005) concept of transliteration. Teachers' role in such classrooms would include translating what students say into English. Even though certain terms, vocabulary, mathematical words and symbols are peculiar to science, students can use these terms to create meaning when they understand the ideas these represent.

8.7.3 TEACHER TRAINING

There is a need to train teachers within Nigeria's educational system, both during initial teacher education and in the form of in-service training programmes, to adopt methods (see Section 8.7.1) that will allow students to collaborate and construct scientific knowledge. To make this feasible, prospective and current teachers must first have a reason to change their teaching methods. The implicit views of learning that teachers bring into their practice, which might contrast with the need for students' involvement and collaborations during science lessons, must be challenged so as to shift their implicit ideas about learning.

Teachers should be trained to ask questions that will lead to the constructive discussion of topics, and to give feedback that will scaffold students' individual sense making and construction of scientific knowledge (Chin, 2007). Similarly, teachers' questions should allow students to collaborate constructively, rather than competing against each other. Furthermore, teachers need to be trained to promote freedom of speech in the classroom, which will enable students to share their ideas freely at times in their native languages, without being embarrassed.

Additionally, an in-service teacher development programme can include a peer-observation approach, where teachers of the same subjects, and in different schools, are allowed to observe their lessons in classrooms and give feedback to enhance practice. According to Torres et al. (2017), adopting peer observation of teaching programme would help teachers to develop self-awareness, confidence and enthusiasm to test any new strategy they observed (p. 835). This approach is distinct from team teaching, mentioned by some teachers in this study.

8.8 IMPLICATIONS FOR FURTHER RESEARCH

This study has provided an exploration of the perceptions of teachers and students on the learning of school science in Lagos senior secondary schools, which is of relevance and benefit for the study of pedagogy. Understanding teachers' implicit views of learning, their practice in classrooms and students' views of what aids their learning has provided insights for researchers to enable them identify specific areas for further investigation. Therefore, the following implications for further research in this Section focus on proposals for further research into teaching practices and students' learning of science.

First, this study found a need to review the current science curriculum, which offers a potential area for future research. Carrying out a systematic review of studies that have focused on the science curriculum within the space of twenty years, after the inception of the Universal Basic Education (UBE) programme in Nigeria, will help researchers and the policy makers to identify the impact of the content of the curriculum on students' learning. Furthermore, carrying out this review will indicate the extent of integration of the aims of science education in the science curriculum.

Secondly, and in line with the curriculum review, is the need to carry out a longitudinal design study of the questions set by examination bodies, WAEC and NECO, on how they relate to the curriculum content and the expectations of students' performance outcomes.

Thirdly, the multiple case study approach in this study has shown that Vygotsky's socio-cultural theory in relation to the role of language needs further exploration in government-funded secondary schools in Lagos, Nigeria. On this note, I suggest a study of how exploratory talk can be promoted in a science classroom, with a focus on how the use of language by students within groups can promote discussion of concepts, and the influence of such talk on students' understanding of concepts.

8.9 CONCLUSION

This research was intended to explore teachers' and students' perceptions on the learning of science in Lagos secondary schools. The multiple case study approach adopted enabled an in-depth exploration of teaching and learning of science in four schools located within a multi-lingual context. The findings of this study have revealed the perceived value of science as that of producing scientists for individual economic and prestigious benefits, rather than for the benefit of the nation. The teachers' implicit view of learning appeared to be learning by being taught and the regulations facing the educational sector inform teachers' practice in classrooms, which suggests that teachers' practices are enforced and limited through the formal educational sector. Likewise, the study has highlighted the unseen but existing legacy of the colonial masters in the educational system as contributing to teachers' practice and students' experience of science.

Previous research on science education in Nigeria has reported on the issues of large class size, inadequate provision of equipment, and a content-loaded curriculum, factors that are corroborated by the findings of this study. This study has contributed to the body of research by considering and taking on board students' views in addition to those of teachers, in order to understand the case of science teaching in the context of this study. Additionally, the study has highlighted teaching strategies that teachers can adopt in light of the issues facing the educational sector, which could conform more closely to a sociocultural perspective of learning. In line with previous research on the language issues surrounding the teaching and learning of science in non-Western contexts, this study has explored and discussed the effect of the language of the curriculum, students' native language and the language of science existing in science classrooms on students' learning.

Finally, recommendations on how to improve science teaching and learning considering students' frequent failure to learn science within the context of this study have been proposed. Taking on board these recommendations and focusing on areas of further research should help to provide a richer experience of science learning for students. This would improve students' performances in examinations, enhance their scientific literacy and enable them to apply scientific knowledge in advancing science and technology in the country.

REFERENCES

Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education*, 30(14): 1945-1969.

Abrahams, I. (2011). *Practical Work in Secondary Science: A Minds-On Approach.* London: Continuum.

Achimugu, L. (2016). Factors affecting the effective implementation of senior secondary education chemistry curriculum in Kogi State, Nigeria. *International Journal of Scientific and Research Publications,* 6(5): 562-566.

Adeyemi, F. (2018). Lagos and the preservation of Yoruba language. Retrieved from https://www.vanguardngr.com/2018/02/lagos-preservation-yoruba-language/.

Adetoro, J.E. (1966). Universal Primary Education and the Teacher Supply Problem in Nigeria. *Comparative Education*. 2(3): 209-216.

Adoti, O. (2018). List of languages in Nigeria and their states. Retrieved from https://www.legit.ng/1119300-list-languages-nigeria-states.html

Agboghoroma T.E. & Oyovwi, E.O. (2015). Evaluating effect of students' academic achievement on identified difficult concepts in senior secondary school biology in Delta State. *Journal of Education and Practice*, 6(30): 117-125.

Agbowuro, C., Oriade, L.T. & Shuaibu, S. (2015). The Nigerian child, science and technology education, current challenges and possible solutions. *International Journal of Education, Learning and Development,* 4(1): 60-69.

Ahmad, J. (2012). Stylistic features of scientific English: A study of scientific research articles. *English Language and Literature Studies,* 2(1): 47-55.

Ahmed, T. (2014). A cultural historical activity theory framework for understanding challenges experienced by Student-teachers of science at secondary level of education in Bangladesh. *Educate,* 14(2): 2-12.

Aikenhead, G.S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education*, 27: 1-52.

Aikenhead, G.S. & Jegede, O.J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching*, 36(3): 269-287.

Aina, J.K. (2017). Authentic science learning experience in Nigerian schools: A desirable education reform in the 21st century. *Continental Journal Of Education Research*, 10(1): 64-84.

Alexander, J.M., Jonhson, K.E., & Kelley, K. (2012). Longitudinal analysis of the relations between opportunities to learn about science and the development of interests related to science. *Science Education*, 96(5): 763-786.

Archer, L., Dewitt, J., & Osborne, J. (2015). Is Science for Us? Black Students' and Parents' Views of Science and Science Careers. *Science Education*, 99(2): 199-237.

Asabere-Ameyaw, A. & Ayelsoma, S.J. (2012). Language proficiency and science learning. *Contemporary Issues in African Sciences and Science Education,* 55–61.

Ayodele, M. O. & Fatoba, J. O. (2017). Effects of small-group learning instruction on attitudes and performance of basic science students in Ekiti State, Nigeria. *European Journal of Social Sciences Studies*, 2(2): 102-118.

Bächtold, M. (2013). What do students "Construct" according to constructivism in science education? *Research in Science Education*, 43: 2477-2496.

Badmus, O.T. & Omosewo, E.O. (2018). Improving science education in Nigeria: The role of key stakeholders. *European Journal of Health and Biology Education,* 7(1): 11-15.

Bajah, S.T. (1985). A Nigerian case-study of perceptions of science. *Prospects-Quarterly Review of Education*, 15(4): 1-5.

Baker, D. & Taylor, P.C.S. (1995). The effect of culture on the learning of science in non-western countries: the results of an integrated research review. *International Journal of Science Education*, 17(6): 695-704.

Balogun, T.A. (2013). In defense of Nigerian pidgin. *Journal of Languages and Culture*, 4(5): 90-98.

Braund, M. & Reiss, M. (2006). Towards a more authentic science curriculum: The contribution of out-of-school learning. *International Journal of Science Education,* 28(12): 1373-1388.

Brock-Utne, B. (2012). Language policy and science: Could some African countries learn from some Asian countries? *International Review of Education,* 58:481-503.

Bryman, A. (2012). *Social Research Methods 4th Edition*. Oxford: Oxford University Press.

Cambridge international dictionary of English (2018). Cambridge: Cambridge University Press.

Chin, C. (2007). Teacher Questioning in Science Classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching*, 44(6): 815-843.

Chin, C. & Brown, D.E. (2000). Learning in Science: A comparison of deep and surface approaches. *Journal of Research in Science Teaching*, 37(2): 109-138.

Chin, C. & Brown, D.E. (2002). Student-generated questions: A meaningful aspect of learning in science. *International Journal of Science Education*, 24(5): 521-549.

Chin, C. & Osborne, J. (2010). Students' questions and discursive interaction: Their impact on argumentation during collaborative group discussions in science. *Journal of Research in Science Teaching*, 47(7): 883-908.

Chukwuebuka, I., Chukwu, J., Nwasum, C. & Nwakpu, E. (2018). Winning parental consents in inter-tribal marriages in Igboland: Considering the public relations option. *Ebonyi State University Journal of Mass Communication,* 5(1): 178-195.

Claussen, S. & Osborne, J. (2013). Bourdieu's notion of cultural capital and Its implications for the science curriculum. *Science Education*, 97(1): 58-79.

Cobern, W.W. (1996). Constructivism and non-western science education research. *International Journal of Science Education*, 18(3): 295-310.

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching*, 44(4): 613-642.

Creswell, W. J. (2013). *Qualitative inquiry & research design: Choosing among five approaches 3rd Edition*. London: SAGE.

Daniels, H. (2016). *Vygotsky and Pedagogy*. Oxford: Routledge.

Danladi, S.S. (2013). Language policy: Nigeria and the role of English language in the 21st century. *European Scientific Journal*, 9(17): 1-21.

Darlington, H. (2015). Increasing students' interest in science: the contribution of practical work. *School Science Review*, 96(357): 105-111.

Day, S.P., & Bryce, T.G.K (2013). The Benefits of cooperative learning to socio-scientific discussion in secondary school science. *International Journal of Science Education*, 35(9): 1533-1560.

DeBoer, G.E. (2000). The globalization of science education. *Journal of Research in Science Teaching*, 48(6): 567-591.

DiBiase, W., & McDonald, J.R. (2015). Science teacher attitudes toward Inquiry-based teaching and learning, the clearing house. *A Journal of Educational Strategies, Issues and Ideas*, 88(2): 29-38.

Dike, V. E. (2015). "Why Nations Fail" to develop: The case of Nigeria. *SAGE Open,* October-December: 1-15.

Donnelly, J.F. (2004). Humanizing Science Education. *Science Education*, 88: 762-784.

Duruji, C. A. (1978), The Dilemma of educational expansion in developing countries: A case study of Nigeria. *Educational Review*, 30(1): 67- 73.

English Oxford Living Dictionary (2018). https://en.oxforddictionaries.com/definition/science

Fasasi, R.A. (2017). Effects of ethnoscience instruction, school location, and parental educational status on learners' attitude towards science. *International Journal of Science Education*, 39(5): 548-564.

Ferro, S. (2017). Why Reading Aloud Helps You Remember More Information. Retrieved from https://www.mentalfloss.com/article/518457/why-reading-aloud-helps-you-remember-more-information

Furió, C., Vilches, A., Guisasola, J., & Romo, V. (2002). Spanish teachers' views of the goals of science education in secondary education. *Research in Science & Technological Education*, 20(1): 39-52.

Gammerdinger, W.J. & Kocher, T.D. (2018). Understanding student perceptions and practices for pre-Lecture content reading in the genetics classroom. *Journal of Microbiology & Biology Education,* 19(2): 1-6.

Gauld, C. (1982). The Scientific attitude and science education: A critical reappraisal. *Science Education,* 66(1): 109-121.

Gauld, C.F. & Hukins, A.A. (1980). Scientific Attitudes: a Review. *Studies in Science Education*, 7(1): 129-161.

Gbenu, J.P. & Lawal, R.O. (2017). Secondary school enrolments, parity level, and teacher employment in Lagos State, Nigeria. *International Journal of Advanced Research in Education & Technology,* 4(2): 112-117.

Gray, B.V. (1999). Science education in the developing world: Issues and considerations. *Journal of Research in Science Teaching*, 36(3): 261–268.

Halliday, M. A. K., & Martin, J. R. (2003). Writing science: Literacy and discursive power. USA: University of Pittsburgh Press.

Hardman, F., Abd-Kadir, J. & Smith, F. (2008). Pedagogical renewal: Improving the quality of classroom interaction in Nigerian primary schools. *International Journal of Educational Development*, 28: 55–69.

Harris, D. & Williams, J. (2012). The association of classroom interactions, year group and social class, British Educational Research Journal, 38(3): 373-397.

Harrison, D.A., Price, K.H. & Bell, M.P. (1998). Beyond Relational Demography: Time and the Effects of surface- and deep-level diversity on work group cohesion. *The Academy of Management Journal,* 41(1): 96-107.

Hewson, P.W., & Hewson, M.G.A. (1987). Science teachers' conceptions of teaching: Implications for teacher education, *International Journal of Science Education*, 9(4): 425-440.

Hodgson, C. & Pyle, K. (2010). A literature review of Assessment for Learning in science. *National Foundation for Educational Research*, 1-34.

Hodson, D. (2014). Learning science, learning about science, doing science: Different goals demand different learning methods. *International Journal of Science Education*, 1(3): 20-31.

Hofstein, A., & Lunetta, V.N. (2003). The Laboratory in science education: Foundation for the Twenty-First Century. *Science Education*, 88: 28- 54.

Holbrook, J., & Rannikmae, M. (2007). The Nature of science education for enhancing scientific literacy. *International Journal of Science Education,* 29(11): 1347-1362.

Hsieh, W-M. & Tsai, C-C. (2017). Exploring students' conceptions of science learning via drawing: a cross-sectional analysis, *International Journal of Science Education*, 1-25.

Howe, A.C. (1996). Development of science concepts within a Vygotskian Framework. *Science Education*, 80(1): 35-51.

Hume, A., & Coll, R. (2008). Student experiences of carrying out a practical science investigation under direction. *International Journal of Science Education,* 30(9): 1201-1228.

Hurd, P.D. (1998). Scientific literacy: New minds for a changing world. *Science Education,* 82: 407-416.

Hwang, W-Y. (2011). The effects of pre-reading and sharing mechanisms on learning with the use of annotations. *The Turkish Online Journal of Educational Technology, 10(2): 234-249.*

Ibenegbu, G. (2017). Teachers salary scale in Nigeria. Retrieved from https://www.legit.ng/1138849-teachers-salary-scale-nigeria.html

Igboanusi, H. (2008). Empowering Nigerian Pidgin: a challenge for status planning? *World Englishes*, 27(1): 68-82.

Ige, A.M. (2013). Poverty of primary education in Nigeria: The way forward. *International Journal of Primary, Elementary and Early Years Education,* 3(13): 36-42.

Ikoya, P.O., & Onoyase, D. (2008). Universal Basic Education in Nigeria: availability of schools' infrastructure for effective program implementation. *Educational Studies*, 34(1): 11-24.

Imam, H. (2012). Educational Policy in Nigeria from the Colonial Era to the Post-Independence Period. *Italian Journal of Sociology of Education,* 1: 181-204.

Investopedia (2019). Top 25 Developed and Developing Countries. Retrieved from https://www.investopedia.com/updates/top-developing-countries/

International Union of Pure and Applied Chemistry (2020). Who we are. Retrieved from https://iupac.org/who-we-are/

Jack, B.M., & Lin, H. (2014). Igniting and sustaining interest among students who have grown cold toward science. *Science Education*, 98(5): 792-814.

Jaramillo, J. A. (1996). Vygotsky's sociocultural theory and contributions to the development of constructivist curricula. *Education,* 117(1): 133-140.

Jegede, O.J. (1995). Collateral learning and the eco- cultural paradigm in science and mathematics education in Africa. *Studies in Science Education*, 25(1): 97-137

Jegede, O.J. (1997). School science and the development of scientific culture: a review of contemporary science education in Africa. *International Journal of Science Education*, 19(1): 1-20.

Johnson, R. (2012). Science and society: reflections on science education sustainability, and the responsibility of scientists. *Rendiconti Lincei,* 23(1): S7-S12.

Kaptan, K., & Timurlenk, O. (2012). Challenges for science education. *Procedia - Social and Behavioral Sciences*, 51: 763-771.

Kempa, R. F., & Ayob, A. (1991). Learning interactions in group work in science. *International Journal of Science Education*, 13(3): 341-354.

King, K., Shumow, L. & Lietz, S. (2001). Science education in an urban elementary school: Case studies of teacher beliefs and classroom practices. *Science Education*, 85, 89-110.

Kpolovie, P. J., Ololube, N.P., & Ekwebelem, B.I. (2011). Appraising the performance of secondary school students on the WAEC and the NECO SSCE from 2004 to 2006. *International Journal of Scientific Research in Education,* 4(2): 105-114.

Kolstø, S.D. (2008). Science education for democratic citizenship through the use of the history of science. *Science & Education*, 17:977–997.

Koosimile, A.T. & Suping, S. M. (2015). An Examination of the influence of globalisation on science education in Anglophone Sub-Saharan Africa. *International Journal of Science Education*, 37(14): 2358-2385.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, 33(1): 27-50.

Kruckeberg, R. (2006). A Deweyan perspective on science education: Constructivism, experience, and why we learn science. *Science & Education*, 15: 1-30.

Kvale, S. (1996). *Interviews: An introduction to qualitative research interviewing*. London: SAGE Publications Ltd.

Ladebo, O.J. (2005) Effects of work-related attitudes on the intention to leave the profession an examination of school teachers in Nigeria. *Educational Management Administration & Leadership,* 33(3): 355–369.

Lagos State Government (2017). *About Lagos*. Retrieved from <http://governor.lagosstate.gov.ng/about-lagos/>

Lagos State University (2020). *Lagos State Model Colleges/Upgraded Junior Secondary Schools.* Retrieved from https://www.lasu-info.com/2018/01/lagos-state-model-colleges.html

LAUGKSCH, R.C. (2000). Scientific Literacy: A Conceptual Overview. *Science Education*, 84(1): 71-94.

Lee, S.W., Lai, Y., Yu, H.A., & Lin, Y.K. (2012). Impact of biology laboratory courses on students' science performance and views about laboratory courses in general: innovative measurements and analyses. *Journal of Biological Education*, 46(3): 173-179.

Lemke, J.L. (1990). *Talking Science: Language, Learning, and Values*. New Jersey, United States of America: Ablex Publishing Corporation.

Lemke, J.L. (2001). Articulating Communities: Socio-cultural Perspectives on Science Education. *Journal of Research in Science Teaching,* 38(3): 296-316.

Le´na, P. (2012). Education in science: its values and the role of the scientific community. *Rendiconti Lincei*, 23(1): 13-16.

Lewin, K.M. (1992). Science education in developing countries; issues and perspectives for planners, Research and Studies, International Institute for Educational Planning. Paris: UNESCO.

Lewin, K.M. (1993). Planning policy on science education in developing countries. *International Journal of Science Education*, 15(1): 1–15.

Lin, T., Deng, F., Chai, C.S., Tsai, C. (2013). High school students' scientific epistemological beliefs, motivation in learning science, and their relationships: A comparative study within the Chinese culture. *International Journal of Educational Development,* 33: 37-47.

Lodge, W. (2017). Science learning and teaching in a Creole-speaking environment. Cultural Studies of Science Education, 12:661–675.

Logan, M.R., & Skamp, K.R. (2013). The Impact of Teachers and Their Science Teaching on Students' 'Science Interest': A four-year study. *International Journal of Science Education*, 35(17): 2879-2904.

Lotter, C., Harwood, W.S. & Bonner, J. (2007). The Influence of core teaching conceptions on teachers' use of inquiry teaching practices. *Journal of Research in Science Teaching*, 44(9): 1318-1347.

Lyons, T. (2006). Different countries, same science classes: Students' experiences of school science in their own words. *International Journal of Science Education,* 28(6): 591-613.

Maathai, W. (2003). *The Green Belt Movement: sharing the approach and the experience.* New York: Lantern Books.

Marshall, S., Gilmour, M. & Lewis, D. (1991). Words that matter in science and technology. *Research in Science & Technological Education*, 9(1): 5-16.

Mason, J. (2002). Linking Qualitative and Quantitative data analysis. In A. Bryman, & R.G. Burgess (Eds), *Analyzing Qualitative Data*. Routledge.

Mason, L. (2007). Introduction: Bridging the cognitive and sociocultural approaches in research on conceptual change: Is it feasible? *Educational Psychologist,* 42(1): 1-7.

McClure, R.K. (2014). Education for economic growth or human development? The capabilities approach and the World Bank's Basic Education Project in Turkey. *Compare: A Journal of Comparative and International Education*, 44(3): 472-492.

McKinley, E. (1996). Towards an Indigenous Science Curriculum. *Research in Science Education,* 26(2): 155-167.

Mercer, N. (1996). The Quality of talk in children's collaborative activity in the classroom. *Learning and Instruction*, 6(4): 359-377.

Mercer, N. (2008). Talk and the development of reasoning and understanding. *Human Development*, 51: 90-100.

Mercer, N., & Fisher, E. (1992). How do teachers help children to learn? An analysis of teachers' intervention In computer-based activities. *Learning and Instruction,* 2: 339-355.

Mercer, N., & Howe, C. (2012). Explaining the dialogic processes of teaching and learning: The value and potential of socio-cultural theory. *Learning, Culture and Social Interaction,* 1: 12-21.

Meyer, X., & Crawford, A.B. (2011). Teaching science as a cultural way of knowing: merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education,* 6: 525-547.

Millar, R. (2014). Designing a science curriculum fit for a purpose. *School Science Review*, 95(352): 15-20.

Mohammed, O.V. (2013). The teachers' role in two districts of Lagos, Nigeria: Teachers' and pupils' perspectives on how teachers can make a difference to pupils' learning, despite the obstacles they face. (Dissertation).

Moja, T. (2000). Nigeria Education Sector Analysis: an analytical synthesis of performance and main issues. New York: World Bank.

Moje, E.B. (1995). Talking about science: An interpretation of the effects of teacher talk in a high school science classroom. *Journal of Research in Science Teaching, 32(4): 349-371.*

Mooed, A. (2011). Successful science learning from practical work. *School Science Review,* 93(343): 121-126.

Morgan, C., Isaac, J.D., & Sansone, C. (2001). The Role of interest in understanding the career choices of female and male college students. *Sex Roles*, 44(5/6): 295-320.

Mpofu, V., Otulaja, F.S. & Mushayikwa, E. (2014). Towards culturally relevant classroom science: a theoretical framework focusing on traditional plant healing. *Cultural Studies of Science Education, 9(1): 221-242*

Msimanga, A. & Lelliott, A. (2014). Talking Science in Multilingual Contexts in South Africa: Possibilities and challenges for engagement in learners home languages in high school classrooms, International Journal of Science Education, 36(7): 1159-1183.

Murphy, C., Varley, J., & Veale, Ó. (2012). I’d rather they did Experiments with us.... Than just Talking: Irish Children’s Views of Primary School Science. *Research in Science Education*, 42: 415-438.

Musingafi, M.C.C., Mhute, I. Zebron, S. & Kaseke, K.E. (2015). Planning to teach: Interrogating the link among the curricula, the syllabi, schemes and lesson plans in the teaching process. *Journal of Education and Practice, 6(9): 54-60.*

National Policy on Education (2013) 6TH Edition. Lagos: NERDC Press, Nigeria.

Nashon, S.M. & Anderson, D. (2013). Interpreting student views of learning experiences in a contextualized science discourse in Kenya. *Journal of Research in Science Teaching,* 50(4): 381-407.

Nwachukwu, C.O. (2012). Revisiting science education and national development:

Nigerian situation and the way forward. *Kuwait Chapter of Arabian Journal of Business and Management Review,* 1(10): 1-21.

Nwadinigwe, C.A. (1985). *A Guide to IUPAC Nomenclature (For Schools and Colleges).* Enugu, Nigeria: Fourth Dimension Publishing Co., Ltd.

Nwagwu, C.C. (1997) 'The Environment of Crises in the Nigerian Education System'. *Comparative Education,* 33(1): 87-95.

Ogunmade, T.O. (2005). The status and quality of secondary science teaching and learning in Lagos State, Nigeria. THESIS.

Ogunniyi, M.B. (1986). Two Decades of science education in Africa. *Science Education*, 70(2): 111-122.

Ogunniyi, M. B. (1996). Science, technology and mathematics: the problem of developing critical human capital in Africa. *International Journal of Science Education*, 18(3): 267-284.

Ogunniyi, M.B. (2007). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 1. *International Journal of Science Education,* 29(8): 963-986.

Ogunniyi, M.B., & Rollnick, M. (2015). Pre-service science teacher education in Africa: prospects and challenges. *Journal of Science Teacher Education*, 26(1): 65-79.

Ojimba, D.P. (2013). Science education reforms in Nigeria: implications for science teachers. *Global Advanced Research Journal of Peace, Gender and Development Studies (GARJPGDS)*, 2(5): 086-090.

Ojo, O.O.S. & Awokola, O.S. (2012). "Determination of Groundwater Physiochemical Parameters of shallow Acquifers in Agbowo and Ajibode communities in Oyo State, South Western Nogeria". *International Journal of Engineering Research and Development,* 3(5): 10-23.

Okebukola, P.A. (1985). The relative effectiveness of cooperation and competitive interaction techniques in strengthening students' performance in science classes. *Science Education, 69(4): 501-509.*

Okebukola, P.A. (1986a). The influence of preferred learning styles on cooperative learning in science. *Science Education*, 70(5): 509-517.

Okebukola, P.A. (1986b). The problem of large classes in science: An experiment in cooperative learning. *European Journal of Science Education, 8(1): 73-77.*

Okebukola, P.A., Owolabi, O., & Okebukola, F.O. (2013). Mother Tongue as default language of instruction in lower primary science classes: Tension between policy prescription and practice in Nigeria. *Journal of Research in Science Teaching*, 50(1): 62-81.

Okedeyi, A.S., Ogunmade, O.T., Oginni, A.M. & Braimoh, D.S. (2013). Nigerian science teachers' perceptions of effective science teaching and their classroom teaching practices in junior secondary schools in Lagos State, Nigeria. *Journal of Education and Practice*, 4:25.

Olatunji, J. (2020). *36 States and capitals in Nigeria*. https://www.legit.ng/1172078-36-states-capitals-nigeria.html

Omorogbe, E. & Ewansiha, J.C. (2013). The challenge of effective science teaching in Nigerian secondary schools. *Academic Journal of Interdisciplinary Studies*, 2(7): 181-188.

Onyia, C.R., Egbo, O. & Onyeneho, N. (2016). Demographic and cognitive factors in teachers' perception of curriculum innovations in Enugu State, Nigeria. *Mediterranean Journal of Social Sciences*, 7(2): 331-342.

Oon, P., & Subramaniam, R. (2013). Factors influencing Singapore students' choice of physics as a tertiary field of study: A Rasch analysis. *International Journal of Science Education*, 35(1): 86-118.

Osborne, J., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: A focus-group study. *International Journal of Science Education,* 23(5): 441-467.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25(9): 1049-1079.

Osborne, R. & Freyberg, P. (1985). *Learning in science. The implications of children's science.* Portsmouth: Heinemann Educational Books.

Osisioma, I.U., & Onyia, C.R. (2009). Capturing urban middle school students' voices on the use of science inquiry in their classrooms. *International Education Studies*, 2(2): 27-38.

Ozoliņš, J. T. (2013). R. S. Peters and J. H. Newman on the Aims of Education. *Educational Philosophy and Theory*, 45(2): 153-170.

Pimentel, D.S., & McNeill, K.L. (2013). Conducting talk in secondary science classrooms: Investigating instructional moves and teachers' beliefs. *Science Education*, 97(3): 367-394.

Powell, K.C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education,* 130(2): 241-248.

Probyn, M. (2001). Teachers voices: Teachers reflections on learning and teaching through the medium of English as an additional language in South Africa. *International Journal of Bilingual Education and Bilingualism*, 4(4): 249-266.

Probyn, M. (2005). Learning science through the medium of English: what do Grade 8 learners say? *Southern African Linguistics and Applied Language Studies,* 23(4): 369-392.

Probyn, M. (2006). Language and Learning Science in South Africa*, Language and Education,* 20(5): 391-414.

Probyn, M. (2009). Smuggling the vernacular into the classroom': conflicts and tensions in classroom codeswitching in township/rural schools in South Africa. *International Journal of Bilingual Education and Bilingualism,* 12(2): 123-136.

Probyn, M. (2015). Pedagogical translanguaging: bridging discourses in South African science classrooms, *Language and Education*, 29(3): 218-234.

Qhobela, M. & Rollnick, M. (2010). The use of discourse in enabling access physics students to construct meaning of magnetic field patterns, *African Journal of Research in Mathematics, Science and Technology Education,* 14(3): 6-19.

Reay, D. (2006). 'I'm not seen as one of the clever children': consulting primary school pupils about the social conditions of learning, *Educational Review*, 58(2): 171-181.

Reiss, M.J. (2014). What place does science have in an aims-based curriculum? *School Science Review*, 95(352): 78-91.

Reiss, M.J., & White, J. (2014). An aims-based curriculum illustrated by the teaching of science in schools. *The Curriculum Journal*, 2(1): 45-51.

Renninger, K.A., Hidi, S., & Krapp, A. (Eds) (1992). *The Role of Interest in Leaning and Development.* East Sussex: Psychology Press.

Robertson, G. (2015). Student voice at the 'heart of learning'. *Research in Teacher Education, 5(1): 27-32.*

Roth, W., & Lee, S. (2004). Science Education as/for Participation in the Community. *Science Education*, 88: 263-291.

Rudolph, J.L. & Horibe, S. (2016). What do we mean by science education for civic engagement? *Journal Of Research in Science Teaching,* 53(6): 805–820.

Sadler,T.D., & Zeidler, D. L. (2009). Scientific Literacy, PISA, and socio-scientific discourse: Assessment for progressive Aims of Science Education. *Journal of Research in Science Teaching*, 46(8): 909-921.

Salami, L.O. (2008). It is still “Double Take”: Mother Tongue education and bilingual classroom practice in Nigeria. *Journal of Language, Identity, and Education,* 7(2): 91-112.

Sarkar, M., & Corrigan, D. (2014). Promotion of scientific literacy: Bangladeshi teachers’ perspectives and practices. *Research in Science & Technological Education*, 32(2): 162-181.

Savasci, F. & Berlin, D.F. (2012). Science teacher beliefs and classroom practice related to constructivism in different school settings. *Journal of Science Education*, 23: 65-86.

Schroeder, S., Ritcher, T., McElvany, N., Hachfeld, A., Baumert, J., Schnotz, W., Horz, H. & Ullrich, M. (2011). Teachers’ beliefs, instructional behaviors, and students’ engagement in learning from texts with instructional pictures. *Learning and Instruction,* 21, 403-415.

Schultink, J. (2013). The Learning Pyramid (NTL). Retrieved from https://slidemagic.blog/blog/2013/12/the-learning-pyramid.html

Schulzke, M. (2014). The Prospects of Global English as an inclusive language. *Globalizations, 11(2): 225-238.*

Scotland, J. (2012). Exploring the philosophical underpinnings of research: Relating ontology and epistemology to the methodology and methods of the scientific, interpretive, and critical research paradigms. *English Language Teaching,* 5(9): 9-16.

Scott, D., & Hargreaves, E. (2015). *The SAGE Handbook of Learning*. London: SAGE Publications Ltd.

Seah, L.H. (2016). Elementary teachers’ perception of language issues in science classrooms. *International Journal of Science and Mathematics Education,* 14: 1059–1078.

Seah, L.H. & Yore, L.D. (2017). The roles of teachers’ science talk in revealing language demands within diverse elementary school classrooms: a study of teaching heat and temperature in Singapore. *International Journal of Science Education*, 39(2): 135–157.

Seah, L.H., Clarke, D. J. & Hart, C.E. (2014). Understanding the language demands on science students from an integrated science and language perspective. *International Journal of Science Education,* 36(6): 952-973.

Shumba, O. (1999). Relationship between secondary science teachers' orientation to traditional culture and beliefs concerning science instructional ideology. *Journal of Research in Science Teaching*, 36(3): 333-355.

Song, Y. & Carheden, S. (2014). Dual meaning vocabulary (DMV) words in learning chemistry. *Chemistry Education Research and Practice*, 15(2): 128-141.

Stake, R. (1995). *The Art of Case Study Research.* London: SAGE Publications Ltd.

Statement of Ethical Practice for the British Sociological Association (2002)

Stears, M. (2009). How social and critical constructivism can inform science curriculum design: a study from South Africa. *Educational Research*, 51(4): 397-410.

Strevens, P. (1976). Problems of learning and teaching science through a foreign language. *Science Education,* 3: 55-68.

Sutton, C. (1992). *Words, Science And Learning.* Buckingham: Open University Press.

Symington, D. & Tyler, R. (2003). What would they know about school science? *Australian Science Teachers Journa*l, 49(2): 22-27.

Taskinen, P.H., Schütte, K., & Prenzel, M. (2013). Adolescents' motivation to select an academic science-related career: the role of school factors, individual interest, and science self-concept. *Educational Research and Evaluation*, 19(8): 717-733.

Tooley, J. & Yngstrom, I. (2014). School choice in Lagos State. *Department for International Development (DFID),* 1-29.

Torres, A.C., Lopes, A., Valente, J.M.S. & Mouraz, A. (2017). What catches the eye in class observation? Observers' perspectives in a multidisciplinary peer observation of teaching program. *Teaching in Higher Education,* 22(7): 822-838.

Tsai, C-C (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *International Journal of science education*, 24(8): 771-783.

Tsai, C-C. (2004). Conceptions of learning science among high school students in Taiwan: a phenomenographic analysis, *International Journal of Science Education*, 26(14): 1733-1750.

Tsai, C-C., Ho, H.N.J., Liang, J., & Lin, H. (2011). Scientific epistemic beliefs, conceptions of learning science and self-efficacy of learning science among high school students. *Learning and Instruction*, 21(1): 757-769.

Udoye, I.E. (2016). The Impact of the National Policy on Education (NPE) on Multilingual Proficiency in Nigeria. *European Journal of English Language and Literature Studies*, 4(3): 14-22.

Uitto, A. (2014). Interest, Attitudes and Self-Efficacy Beliefs Explaining Upper-Secondary School Students' Orientation towards Biology-Related Careers. *International Journal of Science and Mathematics Education*, 12(3): 1425-1444.

UNESCO (1998). *The State of Education in Nigeria*.

Urevbu, A.O. (1987). School science in West Africa: An assessment of the pedagogic impact of Third World investment. *International Journal of Science Education,* 9(1): 3-12

Van der Veer, R. & Valsiner, J. (1994). *The Vygotsky Reader*. Oxford: Blackwell Publishers.

Van Laere, E., Aesaert, K. & Van Braak, J. (2014). The Role of Students' Home Language in Science Achievement: A multilevel approach. *International Journal of Science Education,* 36(16): 2772–2794.

Vlachou, M.A. (2018). Classroom assessment practices in middle school science lessons: A study among Greek science teachers. *Codent Education,* 5(1): 1-19.

Vossen,T.E., Henze, I., Rippe, R.C.A., Van Driel J.H. & De Vries, M.J. (2018). Attitudes of secondary school students towards doing research and design activities, *International Journal of Science Education,* 40(13): 1629-1652.

Vygotsky, L. (1986). *Thought and Language (A. Kozulin, Translation).* Cambridge, MA: MIT Press (Original English translation published 1962).

Walberg, H.J. (1991). Improving School Science in Advanced and Developing Countries. *Review of Educational Research*, 61(1).

Waldrip, B.G. & Taylor, P.C. (1999). Permeability of Students' Worldviews to Their School Views in a Non-Western Developing Country. *JOURNAL OF RESEARCH IN SCIENCE TEACHING*, 36(3): 289–303.

Wallace, S. (2008). *A Dictionary of Education*. Oxford: Oxford University Press.

Wan Idros Wan Sulaiman, Mahbob, M.H. & Azlan, A.A. (2011). Learning outside the classroom: Effects on student concentration and interest. *Procedia Social and Behavioral Sciences,* 18: 12-17.

Warren, B., Ballenger, C., Ogonowski, M., Rosebery, A.S. & Hudicourt-Barnes, J. (2001). Rethinking diversity in learning science: The logic of everyday sense-making. *Journal of Research in Science Teaching*, 38(5): 529-552.

Water-Adams, S. (2006). The Relationship between understanding of the nature of science and practice: The influence of teachers' beliefs about education, teaching and learning. *International Journal of Science Education*, 28(8): 919-944.

Watkins, C. (2005). *Classrooms as Learning Communities: What's in it for schools?* Oxon: Routledge.

Watkins, C. (2006). When Teachers Reclaim Learning. *FORUM: for promoting 3-19 comprehensive education,* 48(2): 1-7.

Watkins, C. (2011). *Managing classroom behavior.* London: ATL – the education union.

Watkins, C. (2016). Moving Beyond 'Shut up and Learn'. *FORUM,* 58(1): 27-34.

Watkins, C., Carnell, E., Lodge, C., Wagner, P. & Whalley, C. (2001). Learning about Learning enhances performance. *The National School Improvement Network,* 13: 1-9.

Watkins, C., Carnell, E., Lodge, C., Wagner, P. & Whalley, C. (2002). Effective Learning. *The National School Improvement Network,* 17: 1-8.

Watters, D.J., & Watters, J.J. (2007). Approaches to Learning by Students in the Biological Sciences: Implications for teaching. *International Journal of Science Education*, 29(1): 19-43.

Webb, P. (2017). Science education in South Africa: Issues of language and scientific literacy. In Otulaja, F. & Ogunniyi, M. (Eds.), The World of Science Education: Handbook of Research in sub-Saharan Africa. The Netherland: Sense Publishers.

Wee, B. (2012). A Cross-cultural Exploration of Children's Everyday Ideas: Implications for science teaching and learning. *International Journal of Science Education*, 34(4): 609-627.

Wegerif, R., Mercer, N., & Dawes, L. (1999). From social interaction to individual reasoning: an empirical investigation of a possible socio- cultural model of cognitive development. *Learning and Instruction*, 493-516.

Wellington, J. & Osborne, J. (2001). *Language and Literacy in Science Education*. Buckingham: Open University Press.

Wellington, J. (2001). What is science education for? *Canadian Journal of Science, Mathematics and Technology Education*, 1(1): 23-38.

World Education News Review (2017). *Education in Nigeria.* Retrieved from https://wenr.wes.org/2017/03/education-in-nigeria

Yin, R.K. (2011). *Qualitative Research from Start to Finish*. New York: The Guildford Press.

Yore, L.D. (2008). Science literacy for all students: Language, culture, and knowledge about nature and naturally occurring events. *L1 – Educational Studies in Language and Literature,* 8(1): 5-21.

Yore, L.D. & Treagust, D.F. (2006). Current Realities and future possibilities: Language and science literacy—empowering research and informing instruction, International Journal of Science Education, 28(2-3): 291-314.

Yore, L.D., Bisanz, G.L. & Hand, B.M. (2003). Examining the literacy component of science literacy: 25 years of language arts and science research, International Journal of Science Education, 25(6): 689-725.

Yore, L.D., Hand, B.M. & Florence, M.K. (2004). Scientists' Views of Science, Models of Writing, and Science Writing Practices. *Journal of Research in Science Teaching*, 41(4): 338–369.

Yore, L.D., Pimm, D. & Tuan, H-L. (2007). The literacy component of mathematical and scientific literacy. *International Journal of Science and Mathematics Education,* 5: 559-589.

Yusha'u, A.I. (2014). *Tackling mass failure in WAEC, NECO*. Retrieved from https://dailytrust.com/tackling-mass-failure-in-waec-neco

Appendix 1: Voluntary Consent Form

VOLUNTARY CONSENT LETTER

My name is Victoria Olubunmi MOHAMMED a PhD student at the Institute of Education, University of London in the United Kingdom. I am conducting a study to explore the influence of students' experiences, and their management of these in their engagement in effective learning of science in Nigerian Secondary schools. I am writing to ask if you will be willing to participate in my research that will entail observing some of your lessons and conducting interviews with you. This will take out some of your time.

As a participant you are entitled to your privacy and any confidential information will not be disclosed. Using pseudonyms that will not allow any information you give to be linked back to you will preserve your anonymity and you are free to withdraw from the research at any time you wish to do so.

Your approval of the use of tape recorder to record conversations in classes observed and interviews will be appreciated, as this will assist me to gather accurate data. The recorded data will be securely stored and destroyed after the research is completed. I do not foresee any risk to your participation in this research rather your contributions will shed light on the education in Nigeria, especially in the effective learning of science. Your participation will also contribute to the academic literature and the well being of the society since data gathered might be shared with other researchers.

If there are questions you will not like to answer kindly inform me and I will change them. There will be no penalties for your withdrawal or non-participation. You may not be offered any compensation for your time, but your gesture will be highly appreciated.

For further enquiries on my research, you can contact me and my supervisors, Dr Paul Davies and Dr Eleanore Hargreaves, at the UCL Institute of Education in London as references for my research.

CONSENT

I have read the above consent of which I have a copy and I understand what is required of me. I agree on my own free will and volition to participate in this research.

______________________________ ______________________

Signature **Date**

Appendix 2: Voluntary Consent Form

VOLUNTARY CONSENT LETTER

My name is Victoria Olubunmi MOHAMMED a PhD student at the UCL, Institute of Education in the United Kingdom. I am conducting a study to explore the Students' and Teachers' perceptions of the teaching and learning of science in senior secondary schools in Lagos, Nigeria. I am writing to ask if you will be willing to participate in my research that will entail observing some of your lessons and conducting interviews with you. This will take out some of your time.

As a participant you are entitled to your privacy and any confidential information will not be disclosed. Using pseudonyms that will not allow any information you give to be linked back to you will preserve your anonymity and you are free to withdraw from the research at any time you wish to do so.

Your approval of the use of tape recorder to record conversations in classes observed and interviews will be appreciated, as this will assist me to gather accurate data. The recorded data will be securely stored and destroyed after the research is completed. I do not foresee any risk to your participation in this research rather your contributions will shed light on the education in Nigeria, especially in the effective learning of science. Your participation will also contribute to the academic literature and the well being of the society since data gathered might be shared with other researchers.

If there are questions you will not like to answer kindly inform me and I will change them. There will be no penalties for your withdrawal or non-participation. You may not be offered any compensation for your time, but your gesture will be highly appreciated.

For further enquiries on my research, you can contact me and my supervisors, Dr Eleanore Hargreaves and Professor Simon Shirley, at the UCL Institute of Education in London as references for my research.

CONSENT

I have read the above consent of which I have a copy and I understand what is required of me. I agree on my own free will and volition to participate in this research.

________________________________ ______________________

Signature **Date**

Appendix 3: Transcript of a student interview (3rd District, School Z)

Participant: Gbenga (pseudonym)
I read out the voluntary consent letter to the participant (see Appendix 2), and he agreed to participant in the research before the interview started.

Interviewer: Tell me about yourself
Gbenga: I am a male student in S.S.2 and I am 16 years old. I live with my parents here in Lagos.
Interviewer: Are your parents educated up to the university level?
Gbenga: No ma, they did not attend the university.
Interviewer: How many languages do you speak and kindly mention them?
Gbenga: I speak a foreign language. I mean, English language.
Interviewer: Why did you refer to English language as foreign?
Gbenga: Because it is a general language that is understood by everyone, and it is brought to us by the English people.
Interviewer: Do you speak any other language apart from English?
Gbenga: Yes, I speak vernacular. I speak Yoruba because I am from Oyo state. And I speak Yoruba at home with my parents so that they can understand what I am saying.
Interviewer: Why are you learning science?
Gbenga: I am learning science because it talks about life. Without science there is nothing we can do. And we benefit from science in many ways. For example, through science we produce chemicals to fertilise our soil and grow food in a large quantity. Through science we have crude oil that we use in our cars to move around. So, transportation is made easier. Raw materials are also found to make cements, which we use to build our homes.
Interviewer: Can you tell me more about crude oil?
Gbenga: We get crude oil from – by drilling ummmm [silence].
Interviewer: Crude oil is the remains of dead plants and animals buried underground millions of years ago. Crude oil is also a hydrocarbon. Are you familiar with the word 'hydrocarbon'?
Gbenga: Yes, I am familiar with it. Hydrocarbon is the study of hydrogen and carbon.
Interviewer: Hydrocarbon is not a study but a scientific name given to compounds consisting of carbon and hydrogen elements. The products we get from the fractional distillation of crude oil such as propane, butane, pentane and others, are made up of chains of hydrogen and carbon, which is why scientists refer to them as hydrocarbon.
Gbenga: I enjoyed the way you explained crude oil and hydrocarbon. I will like our teachers to explain further and deeply let us know more about the topic and let us know what science is. I have never heard our teacher teach us like that, although we have covered the topic already in class with what you told me. You explained further to me. So, if they try to explain the topic deeply and explain what science is, it will be easier for us to be interested in it.
Interviewer: How do you find the botanical names mentioned by your teacher in the previous lesson? Can you give an example?
Gbenga: Botanical names? [silence] No, ma, I have no idea.

Interviewer: Do you know what streptococci mean?
Gbenga: No, ma.
Interviewer: Did you hear her mention *Bacillus anthracis*?
Gbenga: No, ma, I did not hear her mention that word. What I heard her mention are bacteria, virus, and protozoa.
Interviewer: How do you find science learning with all the botanical names and other scientific terms?
Gbenga: Ah, it is really interesting. I find it easy to remember because we have to read more and more to enable us to learn it more when our teacher teaches us in class. And if we do not understand, we can ask our teacher, and she will explain it again.
Interviewer: Can you remember what your teacher mentioned in the previous lesson about algae?
Gbenga: Algae? Algae? - It is a plant found in aquatic environments.
Interviewer: Can you give an example of algae mentioned by your teacher in that lesson?
Gbenga: Red and blue?
Interviewer: What is red and blue? Is there another name?
Gbenga: Ummm (silence)
Interviewer: Have you heard of the word '*Spirogyra'*?
Gbenga: Yes, I have heard of it, but I do not know what it is.
Interviewer: *Spirogyra* is an example of algae. Moreover, your teacher mentioned this during the lesson.
Gbenga: Silence
Interviewer: Do you understand science when your teacher teaches you the botanical names?
Gbenga: Silence
Interviewer: So how would you like to be taught to enable you to learn science?
Gbenga: First of all, by myself, I have to read more and more to make myself understand. And if I don't, I will go and meet my teacher to explain more to me. Secondly, in class, I will like our teachers always to encourage us to read, for example, during prep time, they should make us read instead of roaming about the school. Or they should tell us to ask them anything we don't understand before they leave the class. Also, we should be having series of test so that everybody will close all notes and bring out pieces of papers. This will enable us to read our notes up to date since we do not know where our teachers will set questions. It will help us know the topics better and encourage us to read more and be good in class. They should also use examples to explain some of the topics to us like how you explained crude oil to me; I really enjoyed it ma. Our teachers always use Yoruba at times to explain because not all the students in school understand English very well. I want them to continue mixing Yoruba with English to explain. And if our teachers give us projects to do in groups, it will help us to work as a team, so we will be able to find out things more, and explain to each other over and over again, which will help us to learn.
Interviewer: Do you have science textbooks to read?
Gbenga: No, I do not have any science textbook. But I sometimes borrow from some of my friends when our teachers give us assignments.
Interviewer: That was a detailed explanation of how you can learn science better.

We need to end this interview because it is almost the end of your break time. Thank you for agreeing to spend part of your break time for this interview.

Appendix 4: Transcript of a teacher interview (2nd District, School X)

Participant: (Chemistry teacher)
I read out the voluntary consent letter to the participant (see Appendix 2), and he agreed to participant in the research before the interview started.

Interviewer: Can you tell me something about yourself? How long have you been teaching chemistry in a government secondary school?
Teacher: I have been teaching chemistry for about 16 years now. Teaching chemistry, in a way, I will say it is abstract. Because most of what we are doing here, we cannot physically see them most of the time. We cannot put into practice most of what we are teaching. So, everything is just theory-based, which I believe if we perform practical on them will be better or far better than just theory. The theory is somehow because if it is practical oriented, it will look more interesting to the student and be eager to know more. But this theory that we base our teaching on is not interesting.
Interviewer: Why are you not able to make your lessons practical oriented?
Teacher: Ummm what we have in our laboratory here is not standard. Most of what we need to carry out the practical are not available, and the ones available are obsolete, they are no longer used, which is a major challenge that we have teaching chemistry and physics. Sometimes we improvise but not all the resources can be improvised.
Interviewer: Can you give examples of the resources that you have improvised before?
Teacher: Like the gas law, we can have a tank and fill it with water, and when there is no space in the tank or volume is zero, you will see the that the pressure of water will be very high and when you open the tank, water will rush out of it quickly. This example is to demonstrate what Boyle's law is all about. When you talk about Charles' Law, we can improvise it. For example, when we have a big water tank, we cannot use candlelight to heat it.
Interviewer: These examples you are giving are the ones that students are familiar with, which can explain the two gas laws. Are these examples of improvising resources you mentioned initially?
Teacher: They are examples that students are familiar with, which can help them understand the topic and help the teacher not have a headache. So, these are the improvisation that I am talking about.
Interviewer: There are some words you mentioned during the last lesson, such as constant and proportional. Are these words peculiar to a science, or are they used as English words during conversations?
Teacher: If you are familiar with mathematics, you will find that these words are common mathematical words. Nevertheless, we can categorise them as English words.
Interviewer: Are there words peculiar to a science, and how do you teach such words to aid the students' understanding?
Teacher: There is no other way to teach students such (science) words other than English. For example, you can't interpret the scientific words using the Yoruba

language; it will be very difficult. So, there is no other thing to do than for them to cope with such scientific words. Sometimes we can use words that they are familiar with, but they will not give a close meaning to what we want them to learn in science. However, most of the time, it is not always easy to find such words to use to explain. These words such as constant, proportional are mathematical words that students would have come across in mathematics, so they might not pose problems for students to learn them.

Interviewer: What do you think will impact science learning for a student who is struggling to understand mathematics?

Teacher: It will be a bit difficult for that student. Mathematics is science; it is the bedrock of science because there is nothing they do in science that does not involve mathematics. It is the basis. Everything you talk about in science is mathematics except in biology, but when you are talking about physics and chemistry, they are majorly mathematics.

Interviewer: How can you, as a teacher, assist your students struggling in mathematics to understand chemistry?

Teacher: What I am doing is to encourage the students; 'you can do it'. Giving them one to one encouragement and the constant one of asking them 'how did you do this?' 'go and do this'. That is, giving them one to one teaching, which is a method I have been using, and it is helping them. What they are continually doing will enable them to be familiar with the concepts. And if the environment is conducive, they can do better.

Interviewer: Can you explain what you mean by a conducive environment?

Teacher: You as a teacher make the environment conducive by interacting with them. Telling them, 'you can do it', 'sit down', 'this is how to do this'.

Interviewer: Are you referring to the teaching technique adopted by the teacher in class?

Teacher: Yes.

Interviewer: Does the technique include engaging the students during the lesson?

Teacher: Yes. You will allow the students to do more of the work; you will just be like a catalyst, facilitating them to do more. Those struggling can even be in groups to read and explain things to one another. If there are any concepts they don't understand, others will help them, and they will continue with their work. That's what I mean by a conducive environment.

Interviewer: Do you have adequate time to engage the students as you have just explained and still cover all the topics in the scheme of work?

Teacher: That time has always been the problem. Time is not always there; like here now by 2.15 pm the school closes. Between 2.15 pm and 5 pm, something can still be done, and it is not all the students that will have the time depending on where they are living. But for those that have the time, they have the advantage. They can still spend a long time in school after school hours. But when talking generally, time is an issue. If one adopts that teaching method, not much of the scheme of work will be covered at the end of each term.

Interviewer: What is your understanding of science education? Is it useful, and what are the applications of scientific knowledge in our society?

Teacher: To me, science is the bedrock of – without science, there is no development. Without science, the country will not be developed. As a teacher, I

have always encouraged students to study science. Science will make a country to develop technologically. We have to let our students know the basis of development, which is science.
Interviewer: Do you think your students are learning science in your school?
Teacher: Hmmm. The environment we have here is not encouraging. The students here do not have much interest in education as a whole. They don't really enjoy or show much interest in education. They are not interested in education, not to talk about science and this is a big problem.
Interviewer: What could be responsible for students' lack of interest in education and science in this school?
Teacher: They don't listen in class, give them assignments, they will not do it, tell them to do this, they will not. Write notes for them; they will not even go over it. They are not eager to read on their own no matter how much you encourage them. Some other environments are better than this.
Interviewer: What measures have the school put in place with parents' cooperation to ensure that students are committed to their learning?
Teacher: The school is trying, and some of them are now changing, we have just started, we have not seen much improvement. But I believe these students will change over time. Everything will soon be okay. But as it is now, most students still have a nonchalant attitude towards their academics. They ask where the job they will do after studying when they see others, who are not educated, live big. This is the orientation they have, and it is major work to make them change their mindset. It is a major challenge for the school.
Interviewer: Thank you for spending your time to participate in this research.

Appendix 5: Transcript of a group interview (1st District, School W)

Participant: Linda, Oscar, Charles, Bianca, Andrew, and Lanre (pseudonyms)
I read out the voluntary consent letter to the participants (see Appendix 1), and they agreed to participant in the research before the interview started.

Interviewer: Why are you studying science subject?
Andrew: I love science, and I want to be an engineer. I love science because you encounter and practice things that relate to science every day.
Interviewer: Can you give examples of those things?
Andrew: Sometimes when I am less busy I build a car with cardboard, wire, batteries based on my experience of science in electricity (physics) and I build the car to know more about the topic.
Bianca: I like science because I want to be a medical doctor and science subjects are compulsory for a medical doctor. I like chemistry little due to the equation aspect of it. I like science, and I want to gain more knowledge about it so that when someone is sick, by looking, I will know that the person is sick.
Lanre: I love science because I want to be a medical doctor.
Charles: I want to be a civil engineer. And science provides the knowledge I need for my future.
Linda: I love science because I realize that most magician tricks are science, but people do not know that. For example, where you fill up a bottle with water and forcefully hit the bottle, this will make the bottle's bottom fall out. The other one is where they mix chemicals with newspapers, roughen the newspaper, put it on a table, and rub the palm seriously besides the newspaper. This newspaper catches fire; this is science.
Interviewer: What type of chemical did they rub on the newspaper that could ignite it?
Linda: Most likely, it will be natural gas or fuel.
Interviewer: Can someone tell me what he or she learnt in the chemistry lesson you had yesterday?
Lanre: I learned about the uses of oxygen in the environment and the atmospheric pressure and the industrial preparation of oxygen.
Oscar: I learnt about the apparatus and how to prepare oxygen, and without the application of heat, the reaction will not begin.
Interviewer: How do you find the method of teaching the teacher used in your last chemistry lesson?
Charles: The changes I saw is that when the teacher asked us to gather as a group, I learned that as we grouped ourselves and we are the ones that choose the person to represent us to explain the topic, I found out that the aspect that I decided to explain, I crammed it and it stayed in my brain better than the ones the teacher teaches us.
Interviewer: What do you mean by the word 'crammed'?
Charles: It means I understood it and was able to remember it.
Bianca: I think it helps in a way but when you gather as a group like that, what I realize is that we children learn more from ourselves. But when we gather as a group,

and the same person keeps speaking, the remaining people in the group will rely more on that person, and if that person cannot talk, that means the group loses. I think what the teacher should do is to allow competition among us. If the teacher divides us into groups, she should ask everyone in that group questions that will make everyone to think, but if she tells someone in the group to explain or someone to answer questions, it may be only one person that will be doing that, and she will think the whole group is learning.

Oscar: Group method is good **i**f the teacher will make sure all the students that know the answer keep quiet and allow those who are ignorant to try and participate. Also, I prefer doing practical work because whatever you practise, even if they give you an oral test, your brain is going to give you the image of what you have seen and you can get everything right.

Linda: The group method is good but doing practical is better because I realize that I learn more when the teacher demonstrates the practical and explains the topic, and I can practice it myself later. If I read, I will not be able to understand properly and I will just try to grasp and assimilate what I have read. But when the teacher demonstrates and explains, I will be able to capture and remember during exams the steps followed by the teacher and this will help me better.

Charles: I prefer the practical method because during exams it will be very easy for you to remember what you have done during the practical.

Interviewer: Do you do practical work often during your science lessons in the school now?

Students Chorus: Yes, we do practical work.

Andrew: But is mainly the teacher demonstrating and showing us the apparatus, as she did in our lesson yesterday.

Oscar: Sometimes, the teacher calls on two or three students that she feels are more sensible to come out and work with the teacher to set up the apparatus, like the girl called to write the note on the board.

Interviewer: Are you motivated to learn science, and do you think it is useful to you?

Students Chorus:

Yes, science is useful.

Interviewer: Why do you think science is useful?

Andrew: Science is useful because most of the things we use in our homes are all science. Also, without science if someone is sick, you will not know how to take care of the person or know the type of drugs to take.

Lanre: Science is good for the community and the nation. For example, like the making of home apparatus, cooking gas, iron and also for medical attention.

Oscar: I love studying science because sometimes when I watch something on TV or see it in real life if a patient needs medical attention, the knowledge of science makes that possible.

Interviewer: Is there anyone that has motivated you to study science?

Lanre: A man who lived in my compound, a medical doctor, worked in the hospital. The day I went to the hospital, I saw a man fainted, and some nurses came to attend to the person. My neighbour, who lives in my compound, was called to attend to the fainted patient, and he revived the person. From that day, I became interested in being a medical doctor.

Linda: One of my uncles is an engineer, and whenever I see him, he is always telling me about science and engineering, how good it is, and this inspired me to study science.
Bianca: My dad said I should study science because there was a day that my sister had an injury in her leg, he wanted to take her to the hospital, but I told him not to that he should put a methylated spirit in a cotton wool and place it on the wound to kill the bacteria and heal the wound.
Charles: There are some things I watch on TV related to engineering, which also inspired me.
Linda: I was inspired to study science when I was in my previous school. Any time I saw the senior students they mostly did practical work like opening up some specimens and closing them back as if they are performing surgery and this surprises me. Also, I want to break a record in my family because most of my siblings are doing Art and commercial subjects but none did science subjects. I kept asking why none of my siblings is studying science, so I am studying it now.
Interviewer: Do you find science difficult to learn?
Linda: No, science is not difficult to learn.
Oscar: No because science is a course that when you put your heart in it to learn it, and you say 'I am sent to the world to learn this', and you put your interest to do so, you will learn it.
Interviewer: Does this mean that you need to have the interest to enable you to learn science?
Andrew: Yes, because if there is no interest, you cannot learn science.
Linda: It depends on if the environment inspires the person since the environment greatly impacts our lives. If you are not interested in science but you are pressurized to study science, and by the time you study the subject and see what is going on in the science class and see that everything around you is made up of science, you will start to learn it.
Lanre: I will like to do more practical work. The teacher demonstrates it and asks us to go home and try some of them.
Charles: I prefer the group method and doing practical work at the same time.
Lanre: Even if our apparatus is not enough, they can group us table by table and they should put apparatus on each table; at least if not all the students can use it, we can see those using it on our table, do things ourselves and everyone will contribute on the steps to take. And once someone has done it, we can allow those that are less privileged to contribute to the lesson on the same table and learn.
Andrew: I prefer group work and practical too because both methods help me understand better.
Oscar: I prefer doing practical work to group work. The practical work will stick to your brain than using only the group method.
Interviewer: But can you do practical work on all science topics?
Oscar: Not all topics will require practical work so they can still put us in groups for other topics.
Interviewer: It has been lovely speaking to all of you, and I want to say 'thank you' for sparing your time during your lunch break to have this interview session.

Appendix 6: Field Notes Extract

A. ***Field notes extract from biology lesson observed in school W, class WBio1:***
The biology teacher came out of her office; a room adjacent to the biology laboratory, to start the lesson. However, she spent five minutes of the lesson time to organise the class. Majority of the S.S.2 (106) students, were standing because there were no seats for them to use in the laboratory. She told the students standing to get chairs from the chemistry laboratory. Eventually, the lesson started at 8.25 am. However, at 8.30 am the lesson was disrupted by some S.S.3 students, who came to use the laboratory for a mock examination. One could see the disappointment in the S.S.2 students' eyes as they sluggishly dragged their feet from the laboratory to return to their classroom; thereby causing another ten minutes delay. The teacher called some of the students to help her carry some charts.
The teacher asked a question and called on a student to answer instead of leaving it open for any student to answer. She probably called the student, whom she knows will respond positively to her question, or she called the student to involve him in the lesson. Nevertheless, the teacher did not call some students on the side of the room where I sat, and they were not focusing.
Having the lesson in the laboratory where there are resources would have enabled the teacher to explain the topic better instead of carrying charts to the classroom. The teachers pasted the charts on a board, which she placed on a stool for students to see. Some of the students in the classroom stood up to see the charts and blocked other students' views, thereby creating some murmurings.

B. ***Field notes extract from morning assembly in school Y:***
I got to school Y early to start the day with students and teachers. The chemistry teacher had agreed to have me observe his first lesson. A bell started to ring at 7.50 am for the morning assembly. Students gathered and lined up according to classes, with their teachers standing at the back of each line. I stood beside the chemistry teacher at the back of one of the classes, and looking at the front, I saw the school principal and two vice-principals standing on an elevated platform. One of the vice-principals spoke to everyone using a megaphone she held in her hands. Immediately she started to speak, many students ran to join the lines, but some arrived late, and one of the teachers told them to stand on one side. The vice-principal led a Christian prayer in the English language, and the school principal called a teacher to lead the Muslim prayer. Afterwards, the school principal spoke to the students about the day's activities and expectations in the English language; interjecting some Yoruba language to buttress her points. It seems that the students understood the school principal's message because most of them silently shook their heads. The assembly ended at 8.15 am and the students orderly left the assembly ground to their classrooms for their first lesson, which would start at 8.30 am. However, those who came late to the assembly ground stayed back to pick up paper pieces littered across the school

compound. I still had time, so I stayed for five minutes to see how these students moved across the school to pick rubbish. I later saw the students wipe their hands on their uniforms after dropping the rubbish in the bin. There was no tap water nearby for them to use to wash their hands. While thinking about the students' hygiene and the strict discipline they started their day with, I walked to the chemistry laboratory to observe the first lesson for the day.

C. Field notes extract from physics lesson observed in school Z, class ZPhy:

I walked alongside the physics teacher to the S.S2 class to observe his lesson on that rainy day in March 2019. He explained how the government is planning to rebuild the laboratories; hence, their lessons occur in classrooms. On entering the classroom, the students hurriedly stood up to greet both of us. I was expecting to see a crowded classroom, but I saw fewer students (69 of them); probably fewer students choose to study science in that school. Rain filtered into the classroom in some parts through the missing blinds in the windows. The students sitting close to the window moved their desks and chairs away from the wall.

The physics teacher briefly introduced me to them. He started the lesson without wasting much time by recapping what he taught them in their previous lesson; acceleration due to gravity, and an example of a moving car. He continued by explaining oscillation and wrote a question on the board after a while for them to solve. The students seemed lost as they looked at the word 'compute' written on the board, and one of them later asked the teacher for the meaning. The teacher explained the meaning, but he continued to use the same word 'compute' when solving the question. It appears that the word is stated as a keyword in the physics curriculum. During the lesson, most of the students repeated the terms and formula mentioned by the teacher. Few of the students were involved as they used calculators to work out questions using the formula, and calling out their answers to the teacher. However, many of them struggled to calculate the questions written on the board, and the teacher spoke the Yoruba language 'Mi o mo maths te mo' (Meaning 'I don't know the maths you all claim to know'), to make a mockery of the students. There were many murmurings during the lesson, with some of them yawning and stretching, while the teacher carried on solving more questions using the formula. I could see the students' relief when the bell rang in the school compound for the end of lesson, and the teacher gave them parts of the textbook to read ahead for the next lesson.

Appendix 7: Coding of data

Data Source	Data extract	My interpretation of data extract	Code
School W	Sade: When I was very young, my father normally tells me that he wants be an engineer, though he is not an engineer but my uncle is a construction engineer. I like how he is living very comfortably, getting contracts from Lagos state government to make roads.	At least some students choose to study for science-related careers. This suggests that such careers lead to well remunerated jobs within that society.	Economic value
School Y	Festus: I am learning science because that's what … I want to become someone big in life… being successful.	To be someone big in life means to be rich and successful.	
School W	Physics teacher: We learn science to know basic things about theories and laws governing natures … Secondly, to be able to make scientific discovery.	Studying science makes it possible to develop scientific attitudes to invent and know how scientists come up with laws and theories about phenomena.	Developing scientific skills and attitudes
School X	Physics teacher: The impact of science cannot be over-emphasised in the development of a child. Because learning science makes them see themselves as young scientists who can create things in their own respects.	The study of science enables students to think and act like scientists.	
School W	Bola: Also, in the world people who dominate the world are the scientists. They dominate by contributing to the knowledge of the world, and making it a better place.	The word 'dominate' suggests superiority over other disciplines or fields of work.	Prestige

	Ade: Because people say that the most brilliant students are found in the science class, I wish to be among those brilliant students.	Academic status conferred on students studying science.	
School Y	Chemistry teacher: Actually, to study science, you have to be intelligent.		
School X	Kunbi: I am offering these science subjects because they make me to know more things about my health, and the way we should live our lives.	Students are able to know more about having a healthy lifestyle.	For health and lifestyles
School Z	Wale: The scientists have proved to us that without science we can't do anything. For instance, science has provided us with some drugs that we use when we are ill.	Scientific knowledge is applied to manufacture medicines to cure sicknesses.	
School W	Tope: And in biology, I learn about how we can relate to animals and know more about them.	Acquiring scientific knowledge to know how to take care of animals in one's environment.	Environmental reasons
School Z	Florence: When I see water on the floor, I will know that there would be some microorganisms in it, so I will clean it up, make the environment hygienic and protect everyone at home.	Applying scientific knowledge gained in the classroom enables students to become aware of their environment and prevent them from having diseases.	
School Y	Chemistry teacher: But at least for a science student ... even if you don't proceed, you should be able to explain or they talk to you in a scientific word ... or the government gives an information, you will be able to explain to others that this is what they mean by saying this.	Students are able to use scientific knowledge they acquire in class to understand and engage in discussions relating to scientific issues in society.	Citizenship reasons
School W	Kike: Because in some cases, there are some topics that you need to read, read, read, and	Emphasising the word 'read' four times reflects the	Students' preparation for lessons

	read before you understand even though the teacher explains. You need to read on your own.	importance that this student placed on reading. The emphasis on reading after being taught scientific concepts in classrooms could imply that the teaching methods adopted are not sufficient to aid students' deep understanding of science.	
School W	Valerie: I will tell the person to go ahead to study science if the person is determined. We know that it is only those that are determined that try to make it in science. Anyone that succeeds in a science class did so because of his or her ability and determination.	Valerie's use of the words 'make it' appears to mean that students will understand scientific concepts and succeed in examinations if they are determined. Relating the learning of science to being determined implies that science can be challenging for students to learn.	
School W	Bianca: I think it helps in a way but when you gather as a group like that, what I realize is that we children learn more from ourselves.	Students' ability to learn in this way is made possible when they are allowed to discuss concepts.	Group work
School W	Donald: I found the lesson interesting because it was somehow like a challenge between two groups. When one is explaining, another group is asking them questions. This makes students get involved and makes them bring their ideas to the lesson.	Donald's association of the words 'interesting' and 'challenge' suggests that the activities students performed in groups were sufficiently stimulating to have aroused their interest.	
School Z	Yemi: Oscillation and acceleration are related to	Yemi linked an everyday example	Using familiar examples

	everyday things around us. For instance, a moving car can be used to explain acceleration.	(car) to the scientific concept of acceleration, which suggests that this student has been able to make sense of the concept.	
	Dorcas: I would like them (teachers) to use examples I can see around me to explain. This will help me to understand science.	According to this student, using familiar examples to explain topics aids students' understanding of scientific concepts. Dorcas's view resonates with Sadler and Zeidler (2009)'s argument that concepts, which relate to students' lives and focus on socio-scientific issues enable students to reason, socially engage, and motivate them to participate in class.	
School X	Goke: What actually motivated me to be in the science class is the practical, which I watch on the television and see how little children who do experiments find out things.	Watching how little children do practical work on the television motivated this student to study science	Performing practical work
School W	Alfred: I will prefer a method based on doing project more than theory. What I mean by the project is practical work than just theory, doing writing. I like practical work because dealing with something physically makes you have the experience rather than just theory, writing.	As Alfred suggests, performing practical work enables students to experience real objects. The word 'experience' could be explained in terms of the phrase "dealing with something physically" in Alfred's statement. This means being able to come into contact	

		with and work with these real objects, which might be novel and constitute an active form of learning.	
School X	Physics teacher: In the previous lesson I used Yoruba to explain words like upright, inverted, and magnified under the topic 'The Refraction of Light in Lens', because I wanted them to understand the topic. And I could see on their faces that they did.	The teacher might have used the native language to explain these concepts because the students were not fluent speakers of Standard English. Explaining the concept in this manner seems to be a form of scaffolding employed to support students within Vygotsky's (1986) proposed ZPD to aid their understanding.	Views about the native language
School W	Physics teacher: If I want to teach science in Yoruba, that means someone still has to write the physics textbook in Yoruba. And as the physics teacher I will now have to study it because to interpret into Yoruba will be very difficult. This is because, even as a Yoruba man, I don't know the names of the scientific terms in Yoruba.	According to this teacher, to teach science in Yoruba would be difficult for teachers because it means they have to give Yoruba terms for scientific words. This would require teachers to know the elements, customs, and traditions of both the native language and of science (Seah & Yore, 2017).	
School W	Chemistry teacher: Now we talk of the laboratory preparation of oxygen. Mo fe ki e ya aworan yi. Se e ti gbo? (I want you to draw this diagram. Can you hear me?). This is the diagram (She pointed to a diagram on a chart). Cs: YES MA.	The teacher could have conveyed her message using the formal language of instruction (English) but she did not. Therefore, it appears that she wanted to strongly emphasise to	Use of native language in science lessons

		the students the importance of drawing the diagram.	
School X	Chemistry teacher: Hello o E DAKE! (BE QUIET!) You are making noise. This is where we consider to be zero. Are you with me? Cs: Yes sir.	The chemistry lesson had not ended because it was scheduled for two periods; hence, it seems the teacher spoke the native language (loudly) to manage students' behaviour in the classroom.	
School Z	Physics teacher: English is a universal language spoken in the country and I believe it is a means of communication for effective learning. Since we are in school, we are in a formal setting, so it should be English.	The teacher's reference to the use of English as a "means of communication" in a "formal setting" appears to place more value on the status conferred on the language within that society.	Views about the use of English
School Y	Biology teacher: I don't believe that the differences in the English and science meaning of some common words such as cells or gravity will make science difficult for the students to understand. What I actually feel concerning the understanding of students is that most of them are not well grounded in English.	This biology teacher referred to several words that are used in science and in everyday life with distinct meanings. Song and Carheden (2014) described such words as a 'dual meaning vocabulary' (DMV) (see Section 2.4.3.1). The teacher seems to relate the difficulties students faced in science to their non-proficient use of English rather than to how the words are introduced to them in classrooms.	
School W	Biology teacher: I want you to	The biology teacher	Naming words

	know that enzymes end up with 'ase'. Just few of them end up with 'nin'. Are you with me? Cs: Yes ma.	clarified the scientific names of enzymes, including amylase, maltase, and renin, to facilitate easy identification when students encounter such names. For example, although 'enzyme' might be a familiar word that students have used in sentences outside the classrooms, they might not be familiar with the different types of enzymes and their names.	
School Z	Biology teacher: You can also classify bacteria based on their shape. The first one that we discussed is when you classify bacteria based on the use of oxygen. The second way to classify bacteria is based on their ~ Cs: Shapes. Biology teacher: Who can tell us the different types of shapes that bacteria can take? Cs: Streptococci Biology teacher: Yes. Another one~ C: Bacillus anthrax Biology teacher: Yes. The third type? Cs: (Chorus answering with many of them making fun of the names) Biology teacher: Which other one do we have? We have four. We have streptococci, we have Bacillus anthracis, leptospirra and we have spirilla in shape. Now let's look at examples of bacteria that are cocci in shape, that is they are ~	The teacher's use of scientific terms during the lesson shows that she had taught them the topic prior to when the lesson was observed and audio recorded. And students were making fun of the names when the teacher was mentioning the words.	

	Cs: Circular in shape		
School Y	Biology teacher: Repeat after me: Excretion can simply be defined as the removal of ~ Cs: (students repeated the words) Biology teacher: waste products of metabolism from the body of ~ Cs: (students repeated the words) Biology teacher: an organism to avoid its toxic effect. Cs: (student repeated the words) Biology teacher: That's it. From that definition, you will see that we mentioned waste product of metabolism, not just ordinary waste products.	Here, the students repeated the definition of excretion word for word after their teacher. By stating the exact words, the teacher appeared to want them to learn the meaning of excretion. Repeating the words might also help to foreground the concepts.	Use of exact words
School W	Junior: Momentum before a collision is equal to momentum after the collision.	Junior simply repeated the words the teacher had used during the lesson to define momentum instead of explaining the meaning of the word using one or more real-life examples.	
School W	Chemistry teacher: Since my elementary days I have been good at calculations, mathematics and this gave me the confidence to study science.	In the view of this teacher, learning science is linked with having mathematical skills. He suggests that students might find science challenging if they are struggling to learn mathematics.	Use of mathematics: words and symbols
School Y	Chemistry teacher: So, a student that does not know the chemical formula of sodium chloride, which is $NaCl$, but knows how to calculate the molar mass, might get confused.	The teacher's narrative indicates that teaching scientific formulae aids students' performances in	

	What I am trying to tell the students is that if they know the chemical formula, when they see such questions they will get them right.	examinations.	
School W	Biology teacher: That is how we are supposed to teach them, group work, because when students are together and you give them work to do, they do it, they interact with each other in the process.	According to this biology teacher, students are more likely to focus on and complete tasks when they interact with one another.	Teachers' views on teaching strategies: Group work
School Z	Physics teacher: You can give them projects to do and to explain. Give them a topic to build on in groups and allow them to present the topic.	The teacher seemed to believe that adopting a group method in classrooms allowed students to participate in classroom discussion and explanation of concepts. If comprehending a new concept necessitates being given a chance to talk about the concept using the exact words and thinking about its meaning (Wellington & Osborne, 2001, p. 83), then the group method indeed aids students' comprehension of knowledge.	
School W	Chemistry teacher: I want students to understand rather than cramming. This makes it possible for them to relate to what is happening around them. I usually use examples from the environment to teach them. For example, oxygen is used by welders for combustion. Relating such concepts to day-to-day activities will enable	Relating science concepts to examples students can find around them aids their understanding and retention of concepts. Cramming could mean having a cognitive overload, which seems likely to make it difficult for	Using familiar examples

	students to understand science and retain knowledge.	students to develop an understanding of scientific concepts (Kruckeberg, 2006).	
School Z	Biology teacher: Activity-based learning, where we do more experiments, can make them feel involved. When the students participate they gain better knowledge, they remember what they have been taught.	According to this biology teacher, carrying out experiments keeps students involved in lessons, which leads to increased retention of concepts.	Performing practical work
School X	Physics teacher: Science is a part of philosophy that we call realism. Realism we talk about, you have to lay your hands on parts and not the idea alone. So when you see things, you appreciate it better.	Philosophy is the study of questions about existence and knowledge, which could explain why this teacher related it to science.	
School W	Biology teacher: If we have a projector, we can use it to show them what we are teaching them. But if we have a generator and projector, we can set it up in the laboratory and use it to teach.	A generator is a machine that produces electrical energy, and as mentioned by the biology teacher in School W, this will be needed when there is a lack of electrical supply. Lack of electricity when there is no generator does impede the use of visual aids by the teachers in this study when it referred to use of projector.	Using visual aids
School X	Physics teacher: You can show them video clips of different materials. But electricity is a fundamental challenge that we are facing.		
School W	Biology teacher: I was giving them notes because I realised that some are lazy and cannot take their own notes. In this present SS2, what I did for them last term that yielded good results is that when I took notes for the week, they took their own for the following week.	Laziness was one of the reasons cited by the biology teacher to explain why she provided notes to students to copy during lessons rather than allowing them to write their own after each session.	Note copying

School X	Physics teacher: Before the end of the lesson, some were not too sure because I discovered that once I asked questions, I knew when a student was not coping and that is why I had to revise it with them.	The physics teacher mentioned that she assessed students by asking questions to ascertain whether they have understood the concepts she taught them. Asking questions to find out about students' misconceptions is one of the strategies of assessment for learning and it is necessary for students' learning (Hodgson & Pyle, 2010).	Assessing students
School W	Biology teacher: So if you look at *Planaria*, you will see that it is a flatworm. What are invertebrates? Animals ~ Cs: Without backbones (chorus answering)	This biology teacher encouraged students to complete her sentence about invertebrates, which resonates with the oral cloze procedure reported by Wellington and Osborne (2001, p. 28) as one way in which teachers initiate students into the language of science.	Teachers' use of teaching strategies: Explaining concepts
School Y	Chemistry teacher: When you were in S.S1, you had done the separation technique right? Cs: Yes sir. Teacher: So, now you can recover your solvent from a solution. So, the last question states 'list two methods that can be used to recover the potassium sulphate from the solution'.	Ideas previously taught and recalled in class could be prior ideas held by students that they can then talk about, if allowed, to make sense of new concepts.	
School Y	Chemistry teacher: What term is used to describe the stage indicated by a change in colour	The question asked by this chemistry teacher seems to be a 'closed	Questioning

	of a methyl orange? What term? End what? Cs: End point	one' requiring students to give short answers (Chin, 2007).	
School W	Biology teacher: OK' let's go on, number three of our objectives. What is a canal? There are three of them in my notes.	The phrase "in my notes" in the above extract appears to confirm that this teacher gave her notes to the students to copy, perhaps before the lesson. The extract also suggests that the teacher followed the scheme of work and made notes based on this.	Note copying
School Y	Chemistry teacher: The volume of a base is the one you used the pipette for. The normal ml they use is 25. If you use 20 ml in WAEC, you will indicate it so that it would be much easier for the marker to know. So, in the question, you will be asked to indicate the volume of the pipette you used, but most people use 25 ml. It is a general one.	This teacher taught students in his class how to answer questions relating to the topic, titration, in WAEC. Thus, when teachers referred to examination questions, they were teaching students the language of examinations in addition to the language of science.	Preparing students for examinations