Investigation of school-based factors affecting the enrolment and attainment of senior secondary school physics students in Rivers State, Nigeria.

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Abstract

This study addresses the question what school-based factors influence enrolment and attainment in physics in the senior school certificate examinations in Rivers State, Nigeria?

In Nigeria, low enrolment in physics is coupled with concerns about levels of attainment. One outcome of this situation is interest in effective teaching and learning in the subject in Nigeria.

Purposive sampling was utilized to select 8 schools in high and low performing local government areas of Rivers State to ensure boys', girls' and co-educational schools were represented. All 14 physics teachers in the schools participated in the study, together with 248 physics students and 116 non-physics students.

A mixed methods research design was adopted for the study. The research instruments comprised questionnaires for teachers and students, interviews, classroom observations and a Physics Attainment Test developed specifically for the study. Descriptive statistics and correlations were utilised for quantitative data analysis alongside qualitative data coding and analysis.

The study found that teachers' qualifications, resource availability and utilization and the teaching strategies that teachers adopt all significantly influence students' physics enrolment and attainment. However, particularly for attainment, teachers' years of teaching do not significantly influence student attainment. Also, there was no significant difference in the correlations of teacher and resource factors with attainment and enrolment by gender.

The study proposes a number of recommendations. To boost students' interest in physics, teachers need to present content in ways that connect physics ideas to the everyday experiences of students. Policy makers should consider making the study of science compulsory in all classes in secondary schools with the introduction of 'science for arts' for the non-science oriented students. Of particular importance is the need for a consistent and conscientious government policy to provide schools with qualified physics teachers and science laboratory facilities.

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Author’s declaration

I declare that the results and conclusions contained in this thesis are my original work and contribution to knowledge except as specified in acknowledgements and references, and that the entire thesis or any part of it has not been submitted by me or any other person to this university or any other institution of learning for the award of a degree. However, part of this study has been included in the conference paper below:

Adolphus, T. (2016). School-based factors and physics students’ enrolment and attainment in Nigeria. A paper presented at the 2016 Winter meeting of the American Association of Physics Teachers held at Hyatt Hotel, New Orleans, Louisiana, USA, January, 9-13.

Chapter 1: Introduction

1.1 Background to the research study

This research, 'Investigations of school-based factors that affect the enrolment and attainment of senior secondary school physics students', is carried out to examine how school-based factors might affect the enrolment and performance of physics students in the Senior Secondary School Certificate Examination (SSCE) in Nigeria. School-based factors here include availability and utilization of teaching and learning resources, teacher availability, teacher quality, teacher experience, teaching strategies, workspace, availability of textbooks, computers/internet facilities and classroom interactions. Resources here include both human and material resources such as the physics teacher, laboratory technician, laboratory, laboratory apparatus, online learning resources, library, and text books.

Despite the relevance of Physics and Physics education, the teaching and learning of physics is still bedeviled by several challenges. Physics is relevant in the pursuant of courses such as medicine, pharmacy, all fields of engineering, applied mathematics, space science and information and communication technology. There has been a growing concern about the teaching and learning of science subjects in Nigerian secondary schools in recent time. Studies on the state of teaching and learning of sciences in Nigeria have shown that most students learn by rote with little or no engagement in science classes as most teachers find it difficult to utilize skills acquired during their training in their lesson delivery (Patrick, 2009; Ogunmade, 2005). In Nigeria, that all is not well in the teaching and learning of Physics in particular is captured in the curriculum document which states that:

> 'physics is crucial for effective living in the modern age of science and technology. Given its application in industry and many other professions, it is necessary that every student is given an opportunity to acquire some of its concepts, principles and skills. Unfortunately, the teaching and learning of physics has been fraught with challenges which prevent many students from performing well in external examinations' (Federal Ministry of Education 2009:ii).

From the statement above, it is clear that the curriculum developers acknowledged the relevance of the knowledge of physics and desire that most students reasonably get involved in the study of the subject and that teaching and learning associated problems have discouraged young people from performing well in the subject. Generally in literature, the challenge of the effective teaching and learning of physics and sciences in general has been attributed to the nature of the subject that appears to have a high difficulty perception, shortage of qualified teachers, inadequate teaching facilities and irrelevance of some of the content to the everyday experience of the learners (FME, 2009; Angell, Guttersrud & Henriksen, 2004; Williams, Stanisstreet, Spall, Boyes & Dickson, 2003; Freedman, 1996). Freedman (1996) noted that “the dominant public perception of Physics is that it is tedious, abstract and fundamentally irrelevant”. Students tend to be interested and motivated in learning subjects that make them link classroom experiences with situations they encounter in the real world around them and outside the school environment. In an attempt to make the curriculum relevant and appropriate in its content and context, and to address the challenges of effective teaching and learning of physics in Nigeria, the general objectives of the physics curriculum were stated as follows:

1. provide basic ‘literacy’ in physics for functional living in the society;
2. acquire basic concepts and principles of physics as a preparation for further studies;
3. acquire essential scientific skills and attitudes as a preparation for technological application of physics; and
4. stimulate and enhance creativity. (FME, 2009:ii)

For students to acquire ‘basic concepts’, ‘essential skills’ and ‘attitudes’ for technological application and to stimulate creativity, it is important that they get involved with hands-on activities with adequate resources provided. The curriculum has made clear learners’ and teachers’ activities specifically for the various lessons and concepts in the curriculum. Whether teachers actually implement the curriculum and have teaching and learning resources to teach physics is of interest in this study.

The challenge of effective delivery and learning of science subjects is also closely followed by the problem of low enrolment. In Nigeria, many researchers have decried the low level of enrolment in science subjects, especially in the secondary schools (Aina & Adedo, 2013; Aina &

Akintunde, 2013; Bello, 2012; Akanbi, 2003). Akanbi (2003) observed that the trend in the enrolment and performance of senior secondary school students in science related subjects, especially physics, has assumed threatening and frightening dimension. Bamidele (2004) observed that students' lack of interest in physics as a result of preconceived idea that physics is a difficult subject has affected the enrolment and performance of students.

The situation on the enrolment and performance in physics appears not different in some other countries. Some researchers also agree that of the three core science subjects of biology, chemistry and physics, the enrolment rate for physics is generally lower (Williams, *et al.*, 2003; Angell, Guttersrud, Henriksen & Isnes, 2004).In Kenya, Musasia, Abacha & Biyoyo (2012) investigated the effect of practical work in physics on girls' performance, attitude change and skills acquisition, and observed that physics was the least studied science subject at the final form level of secondary schools. They opined that "Interest in high school physics is decreasing, learning motivation is declining, and the examination results are getting worse" (p.152). Williams *et al*. (2003) carried out a study to determine why fewer year 10 school students are interested in physics than in biology in schools in England and observed that secondary school students 'decreasingly see physics as able to contribute to solutions to environmental or medical problems, and increasingly see physics as requiring mathematical ability'(p.325). Similarly, Gill & Bell (2013) in their study on factors determining the uptake of A-level physics noted the concern expressed in several quarters in the UK about the number of students studying physics in post-compulsory education beyond age 16. Angell et al (2004) investigated pupils' and teachers' views of physics and physics teaching in Norway and expressed the widespread concern for the decline in the enrolment of school physics. They argued that "the number of physics pupils is too small to cover estimated future demands for a skilled labour force *and* may be also too small to ensure a sufficient number of informed citizens in a democracy"(p 702).

The enrolment and performance of students in the senior secondary school certificate examination in the science subjects in Nigeria from 2004 – 2013 is presented in Table 1(a) and (b) below.

Table 1(a): Showing enrolment of students in Biology, Chemistry and Physics at the SSCE in Nigeria from 2004-2013.

Year	Total SSCE Enrolment	Biology		Chemistry		Physics	
		Enrolment	% Enrolment	enrolment	% Enrolment	enrolment	% Enrolment
2004	1051246	1044445	99.4	340570	32.4	333783	31.8
2005	1091763	1084914	99.4	361566	33.1	355633	32.6
2006	1184223	1175639	99.3	394027	33.3	221494	18.7
2007	1275330	1267572	99.4	434462	34.1	424147	33.3
2008	1369142	1360636	99.4	468299	34.2	464199	33.9
2009	1373009	1362724	99.3	478136	34.8	475001	34.6
2010	1351557	1342730	99.3	483998	35.8	481830	35.6
2011	1540250	1530793	99.4	574854	37.3	572143	37.1
2012	1695878	1685051	99.4	640493	37.8	637712	37.6
2013	1689188	1679249	99.4	649709	38.5	647358	38.3

(Source: West African Examinations Council, Lagos, Nigeria)

Table 1(b): Showing performance of students in Biology, Chemistry and Physics at the SSCE level in Nigeria from 2004-2013.

Year	**Subjects**					
	Biology		**Chemistry**		**Physics**	
	Total sat	% credit pass	Total sat	% credit pass	Total sat	% credit pass
2004	1044445	28.7	340570	36.5	333783	47.8
2005	1084914	35.0	361566	49.8	355633	40.8
2006	1175639	48.3	394027	44.0	221494	56.9
2007	1267572	32.8	434462	45.1	424147	42.9
2008	1360636	33.3	468299	43.3	464199	47.1
2009	1362724	27.7	478136	42.5	475001	46.2
2010	1342730	48.5	483998	49.5	481830	50.2
2011	1530793	37.5	574854	48.0	572143	62.6
2012	1685051	34.7	640493	42.2	637712	67.2
2013	1679249	50.8	649709	71.2	647358	46.0
Mean		37.7		47.2		50.8

(Source: West African Examinations Council, Lagos, Nigeria.)

A look at Table 1(a) shows that only about 33.4% on the average of students enrolled for the SSCE choose physics. Chemistry is also seen as not popular among students with an average enrolment of 35.1%, while Biology with an average enrolment of 99.4% appears to be the most popular and chosen science subject among the core sciences. In terms of performance, Table 1(b) shows the poor performance of students in science subjects in Nigeria for the period under study. The erratic nature of the performances with dips and peaks that are not consistent poses a great challenge in describing the attainment of students in these subjects in Nigeria. Between 2004 and 2013, Biology and Chemistry recorded only one year (2013) when more than 50% of students enrolled in SSCE passed with credit level or higher grades, while Physics had four years (2006, 2010, 2011 and 2012). All these show that the teaching and learning of sciences in general and physics of particular interest is not well in Nigeria.

Williams *et al.*,(2003) reported that 'the major general reasons for finding physics uninteresting are that it is seen as difficult and irrelevant' (p.324). According to Adeyemo (2010a), physics is perceived a difficult subject because of its abstract nature. What has generated this public perception and how this perception can be reversed so that many of our young boys and girls will develop interest in physics at both the secondary school level and beyond is the concern of most science educationists. Unfortunately, the current trend in the teaching and learning of physics in Nigeria, where most public schools that are attended by the majority of the school age population lack the supply of adequate materials and facilities for teaching and learning of the subject (Onwioduokit, 2001), has forced most teachers to use the traditional lecture method in teaching physics (Dayal, 2007; Alamina, 2008). This has greatly impacted on the performance of students, particularly in Physics, and more generally in the science subjects as several studies have associated students' attainment with resource availability and utilization. (Berghel, Daly & Lavelle, 1984; Hussain, Azeem & Shakoor, 2011; Veselinovska, Gudeva & Djokic, 2011; Hussain, Ahmed, Mubeen & Tariq, 2011; Bello, 2012;Thomas & Israel, 2013). For instance, Berghel, Daly & Lavelle (1984) reported the result of a 6-year study 'on the effects of different teaching methodologies on student performance in a computer literacy program'. The study revealed that 'noticeable changes in student performance are related to the teaching method in use' (p 9). In another study, Veselinovska, Gudeva & Djokic (2011) investigated the effect of teaching methods on cognitive attainment in biology using laboratory, slide demonstration and lecture methods. They used 3 groups with the first group starting the course with experiments in the laboratory, followed by relevant theory taught by lecture method and then the slide show. The sequence of the methods was rearranged for the 2nd and 3rd groups. Their result showed that the 'academic attainment in lessons began with experiment or slide demonstration was higher than lesson beginning with lecture method' (p2526). Similar studies have shown the effectiveness of guided-inquiry and laboratory related methods over traditional methods especially in the sciences (Oludipe & Oludipe, 2010; Quarcoo-Nelson, Buabeng & Osafo, 2012; Daluba, 2013; Uside, Barchok & Abura, 2013; Koksal & Berberoglu, 2014).

On the performance of Physics students in SSCE examinations, Adolphus (2013) examined the performance of students enrolled for physics in the SSCE in Nigeria between 2001 and 2009 and observed that apart from 2006, candidates who registered for the SSCE made less than 50% credit level passes. The implication is that more than 50% of these candidates cannot gain university admission for courses like engineering, medicine and others that require physics as a prerequisite for admission.

It is worthwhile at this point to give a brief of the structure of education, particularly secondary education in Nigeria. This will help guide readers, especially those not conversant with the educational system in Nigeria.

1.2 The educational system in Nigeria

Nigeria is the most populous country in Africa with an estimated population of over One hundred and Eighty Million – 180,000,000 (CIA World Factbook, July 2015). Of this population, about 19.4% are between ages of 15 – 24 years. The population that falls between 15 – 19 years within that group (15-24) is where most of the students in the senior secondary classes of the three - year secondary education in Nigeria are located. Nigeria was one of the British colonies in the West coast of Africa. Consequently, English Language is officially used as the mode of instruction in the formal school system in the country from age six (6) when formal, basic and compulsory education begins.

Presently, Nigeria adopts the 6 – 3 – 3 – 4 system of education. That is, 6 years of Basic primary school, 3 years of Junior Secondary School, 3 years of Senior Secondary school and 4 years of university education (even though courses in engineering and medicine or their allies take 5 and 6 years respectively). Basic and formal education begin at age 6 for six (6) years of primary education. Thereafter, children are expected to proceed to the first three (3) years of secondary education which is referred to as the Junior Secondary School (JSS) at about age 12. The 6 years of primary school and the 3 years of Junior Secondary school comprise 9 years of basic, compulsory and free education as enshrined in the national policy on education (FRN, 2004: 13). These 9 years of mandatory schooling within the 6-3-3-4 system is now what is referred to as the Universal Basic Education (UBE). The UBE was launched as a strategy by the Federal Government of Nigeria intended to fulfil the aim of Education For All (EFA) as sanctioned by the World Conference on Education held at Thailand in 1990. The position of the World Conference on Education is that Basic education be made free and compulsory irrespective of gender, class or religion.

Basic Science is taught in primary schools while Basic Science and Technology is taught at the JSS level. After a successful completion of the 3 years of Junior Secondary School, students' progress to the last three years of secondary education referred to as the Senior Secondary School (SSS) at about age 15 which is equivalent to the secondary KS 4 in England and Wales. This is where students make choice of subjects and science taught separately as Biology, Chemistry and Physics from SSS 1. Because the age of schooling is not strictly enforced in the country, the age of students in SSS 1 will normally range between 13-16 years.

The subjects offered at the senior secondary school level as stated in the new senior secondary education curriculum structure are divided into five (5) groups of 'compulsory cross-cutting core subjects', 'senior secondary science and mathematics', 'senior secondary business studies', 'senior secondary humanities' and 'senior secondary technology'. Subjects in the compulsory cross-cutting core group are English Language, General Mathematics, one trade with entrepreneurship studies, computer studies/ICT and Civic education. In the science and Mathematics group are Biology, Chemistry, Physics, Further Mathematics, Agriculture, Physical Education and Health Education. According to the policy document,

> 'All students must offer all 5 compulsory core crossing subjects. Students will offer 3 – 4 subjects from their field of specialization. One (1) elective may be offered outside their field of specialization provided the total number of subjects

is not more than nine (9), the minimum number of subjects is eight (8)' (FRN, 2008:1).

The implication from the foregoing is that no science subject other than general mathematics is made compulsory for students at the senior secondary school level. Only students who are in the science and mathematics and technology specializations may study science related subjects. This is in contrast with the earlier policy which divided subjects in the senior secondary school into three (3) groups of 'core', 'vocational electives' and 'non-vocational electives'. Subjects in the 'core' group were English language, Mathematics, A major Nigerian Language, one of Biology, Chemistry, Physics or Health Science, one of Literature-in-English, History, Geography or Religious Studies and a vocational subject (FRN, 2004:21). According to the National policy on education,

> 'Every student shall take all the six (6) core subjects in group A and a minimum of one and a maximum of two (2) from the list of elective subjects in groups B and C to give a minimum of seven (7) and a maximum of eight (8) subjects' (p.21).

The implication from the above condition was that every student offered at least one science and one vocational subject which have been reviewed with the focus on specialization in the new senior secondary school curriculum structure.

1.3 The history of science education in Nigeria

Formal education (or western education as is commonly referred to) started in Nigeria through the activities of Christian missions at about 1842 when Rev. Thomas Birch Freeman arrived in Badagry together with Mr & Mrs William de Craft as assistants (Fafunwa, 1974; Abdullahi, 1982). The main goals of the missionary education then was to teach the native converts basic rudiments of English language - reading and writing so as to enable them read the bible and communicate effectively. Subsequently, the missionaries saw the need of training their converts to become catechists and lay preachers to assist them in the evangelistic work. The curriculum of the mission schools was the 4Rs, namely Religion, Reading, Writing and Arithmetic. There was no standard or regulation of the content of instruction of the different missions. There was also no particular consideration for teacher quality as the missionary and his wife in most cases were the teachers in the schools that were usually organized in the same building that was used for worship services (Oni, 2009). So far, the missionaries where only running primary schools majorly in the south west Nigeria like Badagry, Abeokuta, Ibadan, Lagos and later Calabar in the south south of Nigeria with no content of science. Ogunleye (1999) citing Omolewa (1977) posited that:

> “before 1859, all educational institutions in the country taught primary school subjects such as languages, writing, geography, drawing, hygiene, singing and history to the exclusion of science (*and that*) geometry and algebra were introduced at a later stage into the primary school curriculum but science continued to be absent in schools teaching programmes” (p. 1).

Although Omolewa (1977) has argued that science was not taught in primary schools before 1859 (when the first secondary school was opened in Nigeria), the citation, may suggest that some elements of ‘science’ were possibly taught in the primary schools though not as ‘science’ as a subject, but as in the subject ‘hygiene’ which may have some rudiments of biology and possibly chemistry. It is difficult to find in available literature when science was actually introduced into primary schools in Nigeria. It may however be argued following Omolewa’s (1977) assertion that pupils in primary schools in Nigeria started learning some rudiments of ‘science’ with the identification of ‘hygiene’ in the curriculum of primary schools before 1859. In line with the argument of Omolewa (1977), Abdullahi (1982) posited that the teaching of some form of science in Nigeria started between 1861 and 1897 when some of the missionary secondary schools and teacher training colleges began the teaching of some elements of science.

Although the missionaries were only concerned with the running of primary education, some of the missionary converts who had gained some form of enlightenment through the exposure to formal education started demanding for the provision of secondary education that would enable their wards and children aspire to careers and professions such as medicine, engineering, law, science and technology which eventually led to the inauguration of the Church Missionary Society (C.M.S) grammar school, Lagos in 1859, and later on, the C.M.S. Girls School, Lagos (1869), St Gregory college, Lagos (1876) opened by the Roman Catholic Mission, the Methodist Boys’ high school, Lagos (1878), and a few others (Fafunwa, 1974; Adeyinka, 1988; Ogunleye, 1999; Ojebiyi & Sunday, 2014). Between 1851 and 1970, the missions opened many schools some of which were grammar schools, teacher training, pastoral, vocational and agricultural colleges. As said earlier, current literature seem to suggest that the teaching of rudiments of science began in secondary schools in Nigeria after 1859. According to Ogunleye (1999), science teaching developed in Nigeria with the establishment of more and more schools by the missions. However, Bajah (1982) cited by Ogunleye (1999) claimed that what was taught in schools in Nigeria as science at the time was 'Nature study' where the students learnt "about the environment in form of outdoor observation of plants, animals and non-living things" (p. 2).

It is obvious that at the time the missionaries, most of whom were British, started with primary education in Nigeria in 1842 and later secondary schools from 1859, the content of the primary and secondary school curricula and science were fully developed and used in British schools both to develop the learners and prepare them to tackle future societal needs. This was not the case in Nigeria. Gbamanja (1999) noted that:

> "The colonial masters in many parts of Africa, did not concern themselves much with the teaching of science in the schools. The main objective of the educational system in the British-oriented countries, for example, was to train catechists" (p. 32).

Ogunleye (1999) observed that science teaching and learning in Nigerian schools between 1859 and 1882 was characterized by the:

> "lack of science laboratories, lack of qualified science teachers, lack of interest or enthusiasm shown by the colonial government in Nigeria towards encouraging and supporting the efforts of the missionaries, lack of instructional objectives in science teaching, lack of funds to promote science education, lack of science textbooks, lack of any uniform curriculum in science" (p. 3).

That was the state of the foundation of science teaching and learning in secondary schools in Nigeria with the colonial government having no control of the curriculum and general educational standards for the mission schools.

It was not until 1882 when the colonial government ventured into the control and regulation of missions that were involved in education with the enactment of the first Education

Ordinance for the Gold Coast Colony in 1882. The Education Ordinance of 1882 provided the missions with financial aids and maintenance of the schools. With the provision of financial assistance by the government, many of the missions were able to procure some science laboratory equipment and open more secondary and teacher training colleges mostly in the southern part of the country which resulted to the spread of science teaching and learning in many schools in the country (Ogunleye, 1999, Gbamanja, 1999). Ogunleye(1999) noted that King's College, Lagos established in 1909 as King's School was the first government secondary school that had a chemistry laboratory and Taiwo (1975) as cited by Ogunleye (1999), reported that "King's School remained for many years the only school which consistently offered science to the standard of Cambridge University Senior Local Examination" (p. 3). According to Gbamanja(1999), most secondary and teacher training colleges in Nigeria and indeed some West African states taught science in the 1920s in the form of Agriculture, Hygiene, Nature study or Rural science and that until the 1960s, Rural science and Nature study were taught both in the primary and secondary school curricula with general science as the main focus of secondary school science. The situation was however different in the Northern part of Nigeria that was predominantly Islam and resisted the entry of formal education into the territory. Despite the progress made in the teaching and learning of science with the involvement of the colonial government in education in Nigeria at the time, the yearnings and aspirations of the people could not be satisfied as the educational system and science that was taught in schools as inherited from the missionaries and the colonial masters was not relevant to the needs of the indigenous society and the learners.

The agitations of some nationalist on the irrelevance of the educational system led to the setting up of the Phelps-Stokes commission in 1920 with a mandate to investigate the needs and resources of African colonies with the aim of providing them with an education that was relevant to their needs. The commission's recommendation gave a further boost to science teaching and learning in Nigeria. The commission reported its displeasure with the manner and content of science teaching in Nigerian schools and recommended that science subjects be incorporated into all secondary school curricula (Ogunleye, 1999). According to Abdullahi (1982), general science as taught in British high schools started gaining grounds in Nigerian schools and in 1928, the School Certificate Examination in Nigeria started with Cambridge and Oxford Boards as moderators of the examinations. Ogunleye (1999) reported the lack of popularity of science subjects in schools before 1932 and that the few that choose science failed at the external examinations. The establishment of the Yaba College in Lagos in 1932 “with the objective of providing well qualified assistants in medical, engineering and other vocations and also to provide teachers to teach basic science subjects in secondary schools” (Ogunleye, 1999:10), gave a good boost to the state of science teaching and learning in Nigeria. Abdullahi (1982) argued that the groundwork for the advancement of an appropriate science curriculum was laid in Nigeria at about 1936 when the first set of products of the Yaba College, Lagos were sent to secondary schools to teach science. Between 1931 and 1959, before Nigeria’s independence, several schools were opened in parts of South and Western Nigeria that promoted the teaching and learning of science. The introduction of the Higher School Certificate (HSC) in some secondary schools in 1951 provided opportunity for many students to study physics, chemistry and biology up to the HSC level. Ogunleye (1999) reported that HSC curriculum at that was same as British schools and that the failure rate recorded by the Nigerian students was very high. In 1952, an examination board for West African colonies with Nigeria, Ghana, Sierra-Leone and Gambia as member nations was set up by the British government and named the West African Examinations Council (WAEC). WAEC was later to significantly influence the curriculum of science subjects in schools in the member states. In 1957, the concern of science teachers to promote the teaching and learning of science culminated in the establishment of the Science Teachers’ Association of Nigeria (STAN). One of the main aims of Science Teachers Association of Nigeria was “to promote cooperation among science teachers in Nigeria with a view to raising the standard of science education in the country” (STAN, n.d). The introduction of the free universal primary education by the western and eastern regions of Nigeria in 1955 and 1957 respectively led to the massive enrolment of pupils in primary schools and exposure to science at that level. Also, the take-off of the Federal Colleges of Arts, Science and Technology in 1950, 1952 and 1954 at Ibadan, Zaria and Enugu respectively further promoted the teaching and learning of science and science related fields such as engineering, pharmacy and architecture. In 1958, the Federal School of Science was opened in Lagos to further encourage young pupils in the study of the sciences especially physics, chemistry, biology and mathematics and to prepare candidates both for the ordinary and advanced levels of the general certificate of education so as to pursue future careers in science related fields. The need to harmonize the teaching and learning in the many schools and higher institutions across the country at the time led to the establishment of the Joint Consultative Committee on Education by the Federal government in 1955 (Ogunleye, 1999).

The political independence gained by Nigeria in 1960 increased the awareness of national consciousness among the elites and nationalists which led to the establishment of some commissions to investigate the educational priorities of Nigeria. Some of these commissions established in 1960 were The Banjo Commission of the Western region and The Ashby Commission of the Federal government. For instance, the Ashby Commission was to investigate the manpower needs of Nigeria up to 1980. Some recommendations of the Ashby Commission were:

(i) a progressive increase in primary school enrolment in Northern Nigeria which in effect could make more pupils learn science.

(ii) The injection into the secondary education system of vocational/technical courses to reduce the bias for literary studies, and the expansion of enrolment into secondary schools.

(iii) The introduction of more courses in technical education and the establishment of more technical institutes

(iv) The establishment of a National Universities Commission to secure and disburse funds to universities and also to co-ordinate their activities (Ogunleye, 1999:17).

Following the report of the Ashby Commission, 3 universities were established in 1962– the University of Ife (now Obafemi Awolowo University), the University of Northern Nigeria (now Ahmadu Bello University) and the University of Lagos. Abdullahi (1982) reported that the feeder role of these universities in producing science teachers together with the assistance of Technical Aids from the Canadian University Services Oversees and the American Peace Corps Program popularised and increased science enrolment such that available resources and facilities were overstressed.

The Science Teachers Association of Nigeria has been at the forefront of science curriculum review in Nigeria. From 1968 in response to the request made by the West African Examinations Council, WAEC, to review the existing curricula of the science subjects, STAN inaugurated committees to work on the Integrated, Biology, Chemistry and Physics curriculums.

Okebukola (1997) cited in Ogunleye (1999) remarked that the STAN Committee report resulted in the production of the Nigerian Integrated Science Project (NISP) with pupils' workbook, pupils' textbook and teachers' guide published in 1971. After the launching of the National Policy on education in 1977, STAN reviewed its Nigerian Integrated Science Project and produced 3 separate books for the first 3 years of secondary education with their workbooks and teachers' guides in line with the national policy on education. The success of NISP motivated STAN to venture into aggressive development of science textbooks in Nigeria. Subjects panels composed of specialists were used by STAN for the writing of text books. Ogunleye (1999) remarked that

> "subject panels were also mandated to organise one week annual workshops on various strategies for teaching and learning science so as to make science more enjoyable and less difficult for both science teachers and student" (p. 80).

These subject panel workshops and the STAN annual conferences have regularly featured in Nigeria over the years. Currently in Nigeria, there are many volumes of STAN textbooks used in schools on all subjects of school science such as Integrated science, Chemistry, Biology, Physics, Primary science, Mathematics, Agricultural science and Further mathematics.

Apart from the Science Teachers Association of Nigeria, the Federal government through its agencies has influenced the development of science teaching and learning in Nigeria. Some of these agencies are the Comparative Education Study and Adaptation Centre (CESAC) established in 1968 noted for its Nigerian Secondary School Science Project (NSSSP) books in physics, chemistry and biology for years 3-5 of secondary schools, published in 1970. Another one was the Nigerian Educational Research Council (NERC) inaugurated in 1971 and credited with the National Primary School Science Project (NPSSP) that produced primary science text books and resources. In 982, the NPSSP was reviewed and named National Primary Science and Mathematics Project (NPSMP). In 1988, the NERC, CESAC and other related bodies were merged to form the Nigerian Educational Research and Development Council (NERDC). The NERDC has positively influenced the growth of science education in Nigeria through the improvement and production of science resource materials. The body produced the primary science and mathematics curricula together with the relevant instructional materials for both the pupils and the teachers. At the junior and senior secondary school levels, The NERDC has produced the curriculum of all subjects listed in the National Policy on Education including Agricultural science, Integrated science, Introductory Technology, Mathematics, Physics, Chemistry and Biology with the production of the required instructional materials such as textbooks, workbooks and guide for teachers. From the forgoing, it is evident that science education is firmly established in all levels of education in Nigeria. Many scholars are however concerned with the quality of teaching and learning of the subject in schools with such issues as lack of adequately qualified teachers, ill-equipped and sometimes unavailability of laboratories, lack of funds to purchase science equipment, lack of electricity in some schools, inadequate teaching methodologies and poor implementation of measures of new innovations (Aina, 2012; Omorogbe & Ewansiha, 2013; Osuafor & Okoli, 2013; Njoku & Ezinwa, 2014; Osuolale, 2014).

1.4 Science–teacher education and specialization in Nigeria

In Nigeria, the least teaching qualification is the Grade II teacher certificate (TCII). This is obtained after a 5-year post primary education in specialized teacher training institutions in the country. Holders of this certificate are made to teach in primary schools as classroom teachers. However, at the inception of the National policy on Education in 1977, the Nigeria Certificate in Education (NCE) became the minimum teaching qualification in Nigeria (FRN, 1977). The NCE is a 3-year post-secondary education programme that is run in Colleges of education with affiliation to universities and the National Teachers' Institute. Subject specialization begins at the NCE level as candidates get admitted to study specific subjects. For instance, in the sciences, candidates may study courses as double combinations of Mathematics and physics, Mathematics and Chemistry, Mathematics and Biology, Biology and Chemistry, Physics and Chemistry, primary science, integrated science with Mathematics, physics, Chemistry or Biology combinations. Holders of the NCE are normally admitted for a 2 or 3 year Bachelor's degree leading to the award of a Bachelor of Science in Education (B.Sc. [Ed]) or Bachelor in Education (B.Ed.). The number of years to obtain the B.Sc. (Ed) or B.Ed. after an NCE depends on the grade point obtained in the NCE programme. At the B.Sc. (Ed) or B.Ed. level, students generally further narrow down in their specialization to study courses like Mathematics, Biology, physics, Chemistry, Integrated science. Few universities however still offer combination of subjects even at the degree level. Non-education graduates who which to pursue a career in teaching are allowed to undergo a one year Post Graduate Diploma in Education (PGDE) at colleges of education, National Teachers' Institute or universities to qualify them as professional teachers. Graduates, for instance, with B.Sc. in Mathematics, Chemistry, Physics qualify as mathematics, physics and chemistry teachers in Nigeria after obtaining the one year post graduate diploma in education from recognized institutions.

It is therefore common to see science educators in Nigeria pick research interest in a specific subject area such as physics, chemistry and biology, for instance, as this interest may have been developed over time as a result of early specialization and research inclination.

1.5 My interest in the research on physics enrolment and attainment

My interest in research on physics students' attainment was developed as I observed the general poor performance of physics students in certificate examinations nation-wide. Even though there was a general public cry of dismal performance of students in certificate examinations in Nigeria (Akinsolu, 2010; Owoeye & Yara, 2011), as a science educator, my concern has been particularly in physics that usually records a relatively lower enrolment compared to the other science subjects.

Physics is one of the three core science subjects with chemistry and biology. This concern started to get deeper as I reflect on the growing technological and knowledge explosion world-wide and the significant role of the sciences especially physics in all spheres of science and technology. The low enrolment and performance in physics at the secondary and post-secondary levels coupled with the lack of adequate number of qualified teachers together with the fewer number of girls choosing to do physics further deepened my interest to research in this area as to why students continue to record low attainment in the subject over the years. What possibly can be done to reverse this trend that has persisted despite several curriculum and educational policy 'renovations' in Nigeria, is a motivating drive for my research interest. An introductory note in the current national physics curriculum (FME, 2009) reads thus:

> In order to stimulate creativity and develop process skills and correct attitudes in students, the course is student-activity oriented with emphasis on experimentation, questioning, discussion and problem-solving (p.iii).

These are very lofty thoughts and ideas that if implemented to the letter in an enabling environment should bring about a positive change in the attainment of students. It is thought that a qualitative investigation into the teaching and learning situations – quality of teachers, state of resources for the teaching and learning of the subject, quality of teaching, motivation for learning and students' involvement in learning will bring to the fore salient indicators by which the status quo and the ideal can be identified. The establishment of the gap if any and the implementation of recommendations, may lead to the improvement of attainment in physics and increase the popularity of the subject among school children in Nigeria.

Science teaching today has been made interesting for both teachers and students with the advent and use of many resources that enhance students' understanding of science and at the same time, promoting their interest in the subject. There are many such resources for the teaching and learning of Physics in secondary schools. Are these resources available for use in secondary schools? Where available are they appropriately utilised for the benefit of students? The current National physics curriculum is richly packed not only in content but also in delivery to ensure effective teaching and learning of physics in Nigerian secondary schools. This according to the curriculum document is 'to achieve the stated objectives of the curriculum' (FME, 2009: iii). How well do teachers maximise the provisions of the curriculum? How has the availability and utilisation of teaching and learning resources impacted on the academic attainment of Physics students at the SSCE level? Or do the grades achieved at SSCE level reflect the level of availability and utilisation of physics resources? These are of great concern to this research. This research therefore intends to qualitatively investigate some school-basedschool-based factors and how they might affect the enrolment and attainment of students in physics in the senior secondary school certificate examinations in Rivers State, Nigeria.

1.6 School-based factors

Literature has shown several factors that affect attainment of students or enable effective learning in school. Some of these factors with a consensus among many researchers are ability or prior attainment of the student, chronological maturation, motivation or self-concept, quantity of time the student engages in learning, the quality of instructional experience, the home, classroom interactions, peers and the amount of leisure time. (Walberg, Haertel, Pascarella, Junker & Boulanger, 1981; Walberg, 1984; McGrew, 2008). Most of these factors can be categorized under the following:

i. Student related (ability, maturation, self-motivation, time engaged in personal study)

ii. Home related (psychological, economic and social comfort from the home) and
iii. School related (quality and quantity of instruction, classroom psychological climate).

Several others have broadened the study of school-based factors affecting students attainment to include supervision of instruction, school leadership, guidance and counseling, student-to-teacher ratio, enrolment, availability and usage of teaching/learning facilities, school type and teacher characteristics (Atanda & Jaiyeoba, 2011; Mbugua, Kibet, Muthaa, &, Nkonke, 2012; Rockstroh, 2013). Atanda & Jaiyeoba, (2011) for instance investigated the effects of school-based quality factors on secondary school students' attainment in English language in south-western and north-central Nigeria and found that instructional materials, quality of instruction and supervision contributed significantly to students' attainment in English language.

The extent to which school-based factors or other socio-economic factors affect students' performance may be varying across the nations. Fuller (1986) reported the result of a study conducted in 22 developing countries and reported to the world bank that school-based factors were highly recognized as influencing factors in determining students' academic attainment in developing countries while socio-economic factors were stated as influencing factors in determining students' academic attainment in developed countries.

The concern of this research is basically on school related factors that can affect students' attainment or enable effective learning. Thus, School-based factors to be investigated in this study include input factors such as availability and utilization of teaching and learning resources, teacher availability, teacher quality, teacher experience, teaching strategies employed by teachers, work space, availability of textbooks, computers/internet facilities and classroom interactions; while students' enrolment and performance in the SSCE are the output variables. Particularly, this research seeks to study qualitatively the state of the resources for teaching and learning, the teaching strategies employed by physics teachers, students' engagement in classrooms and the general classroom environment and how these might explain the attainment of students in physics.

1.7 Aim and objectives of the study

The main aim of this study is to investigate the school-based factors that affect the enrolment and attainment of senior secondary school physics students in Rivers State, Nigeria. The study shall adopt both quantitative and qualitative methods to specifically investigate the following objectives.

i. To examine the pattern of enrolment for physics in the Senior Secondary Certificate Examination (SSCE) in Nigeria.

ii. To examine the pattern of attainment of physics students who enrolled in the SSCE.

iii. To investigate the relationship between teacher qualification and experience with enrolment and attainment of students in physics.

iv. To investigate the extent of available physics resources for teaching and learning in secondary schools.

v. To determine the extent of utilisation of available physics resources for teaching and learning in secondary schools.

vi. To investigate the effect of resource availability and utilisation on students' enrolment and attainment in physics.

vii. To investigate teaching strategies and classroom interactions adopted in physics classrooms.

viii. To examine the effect of teachers' teaching strategies and classroom interactions on student enrolment and attainment.

ix. To determine the effect of school climate on the teaching and learning of physics in the school.

1.8 Research Questions

One principal research question has been formulated to guide the study.

What school-based factors influence enrolment and attainment in physics in the senior school certificate examinations in Rivers State, Nigeria?

In answering this research question, the study will adopt both quantitative and qualitative methods to attempt answers to the following sub-research questions:

i. What is the pattern of enrolment for physics in the Senior Secondary Certificate Examination?

ii. What is the pattern of attainment of physics students who enrolled in the Senior Secondary Certificate Examination (SSCE)?

In answering these questions, secondary data would be used to investigate the level of enrolment and pattern of attainment in terms of gender, resource availability and utilization.

After a thorough examination of the patterns of enrolment and attainment in physics, the next obvious thing to do will be to conduct a qualitative investigation as to the 'why' and 'how' of the outcome of the physics attainment. Thus, the following sub- research questions will be addressed.

i How do teacher qualification and experience relate to the enrolment and attainment of students in physics?

ii What is the extent of availability of physics resources for teaching and learning in secondary schools in Rivers State, Nigeria?

iii. To what extent are available physics resources utilized for teaching and learning in secondary schools?

iv. To what extent does the availability and utilization of physics resources influence students' enrolment and attainment in physics?

v What are the teaching strategies and classroom interactions adopted by physics teachers?

vi To what extent does the teaching strategy and classroom interactions adopted by teachers influence the students' enrolment and attainment in physics?

vii To what extent does the school climate affect teaching and learning in the school?

1.9 Research strategy and techniques

The study adopted the survey and case study designs. 'Typically, surveys gather data at a particular point in time with the intention of describing the nature of existing conditions, or identifying standards against which existing conditions can be compared, or determining the relationships that exist between specific events' (Cohen, Manion & Morrison, 2011:256). The researcher intends to gather Senior School Certificate Examination results from the examination body to examine the overall national situation, also from schools within the study area as case studies. The researcher gathered information using questionnaires, interviews and classroom observations on school-based factors that are likely to influence students' enrolment and attainment in the subject. The case study approach was employed as a follow up to have an in-depth understanding of the problem being studied. According to Bell (2010:8), 'Case studies may be carried out to follow up and to put flesh on the bones of a survey'. The survey and case study designs are therefore considered most appropriate for this research. The research is particularly both descriptive and analytical. Analytical in the sense that relationships between variables were examined.

The National Senior Secondary Certificate Examination results were accessed and obtained from the West African Examination Council in Nigeria and the specific schools that were used for the study. The physics grades in the result were analysed to classify schools into 'High', 'Moderate' and 'Low' attainment groups. To ensure confidentiality in research, the names of the schools and candidates have not been used. The principals and relevant education authorities were assured of this confidentiality.

The basic and required instructional resources and materials stated in the Nigerian National Physics Curriculum for the effective teaching and learning of associated concepts and topics were extracted and included in the teachers' questionnaire to ascertain the level of availability and utilization of resources for teaching and learning. Generally, 'physics resources' in this study include qualified physics teachers, laboratory technicians, physics laboratory, equipment, library and books, simulations and online teaching and learning resources. Well-structured questionnaires were also designed and used to elicit the school-based factors that are responsible for the enrolment and performance of students in physics in the SSCE. Observation technique was also employed to observe Physics teachers and also, the students' activities during teaching sessions in the classrooms. These were used to report on how teachers teach physics lessons, students' involvement rate in the teaching-learning process and also to discuss major findings of the research. Other than the questionnaires and observation of actual classroom practice of teachers and students during physics lessons, relevant permission was sought to interview both teachers and students to probe their views on the state of the teaching and learning of the subject and the likely effects on enrolment and attainment. This, it is believed will elicit specific problems that will guide the researcher in addressing the research problem exhaustively.

Chapter 2: Literature Review

Introduction

A Literature review involves a well-organized, systematic and logical presentation of both theoretical and empirical information and previous research findings that are related to the study. It presents a synopsis of what has been done previously by earlier researchers in the current area of research interest and is necessary to provide insights and to guide readers to comprehend not just the present research, but to build on, make a link between the present and prior works and learn from previous studies and scholarship on the topic or piece of research (Boote & Beile, 2005; Creswell, 2012; Pautasso, 2013). In this chapter, the researcher presents theoretical and quantitative based literatures of prior studies relating to the research topic. Having defined my research focus in terms of the objectives and research questions, the traditional or narrative literature review has been adopted with the selection of relevant literature in areas covering each research question. For instance, the study may be classified as a school effectiveness research, literature bothering on this area has therefore been searched, read and appropriately reviewed. For a better organization of materials, literature related to this study on investigations of school-based factors that affect the enrolment and attainment of senior secondary school physics students is reviewed under the following headings:

2.1 Theoretical Framework.

2.2 Review on School Effectiveness Research

2.3 Students' choice of post-compulsory school science and physics.

2.4 Explanations for decline in physics uptake among secondary school students.

2.5 Students' attainment in physics – a global perspective.

2.6 Teaching strategies, students' enrolment and academic attainment

2.7 School resources, students' enrolment and academic attainment.

2.8 Effect of teacher quality and experience on students' enrolment and academic attainment.

2.9 Professional development and teacher effectiveness

2.10 School climate, students' enrolment and academic attainment

2.11 School location, students' enrolment and academic attainment.

2.12 Issues of gender and attainment in science and physics.

2.13 Summary of Literature Review.

2.1 Theoretical Framework

Research has shown several factors that affect attainment of students or enable effective learning in school. Some of these factors with a consensus among many researchers are ability or prior attainment of the student, chronological maturation, motivation or self-concept, quantity of time the student engages in learning, the quality of instructional experience, the home, classroom interactions, peers and the amount of leisure time. (Walberg, Haertel, Pascarella, Junker & Boulanger, 1981; Walberg, 1984; McGrew, 2008). Most of these factors can be categorized under the following:

(1) Student related (ability, maturation, self-motivation, time engaged in personal study)

(2) Home related (psychological, economic and social comfort from the home) and

(3) School related (quality and quantity of instruction, classroom psychological climate).

The concern of this research is basically on school-related factors that can affect students' enrolment and attainment or enable effective learning. Some other researchers have broadened the study of school-based factors affecting students attainment to include supervision of instruction, school leadership, guidance and counselling, student-to-teacher ratio, enrolment, availability and usage of teaching/learning facilities, school type and teacher characteristics (Fuller, 1986; Atanda & Jaiyeoba, 2011; Jaiyeoba & Atanda, 2011; Mbugua, Kibet, Muthaa, &, Nkonke, 2012; Rockstroh, 2013). Atanda & Jaiyeoba, (2011) for instance investigated the effects of school-based quality factors on secondary school students' attainment in English language in south-western and north-central Nigeria and found that instructional materials, quality of instruction and supervision contributed significantly to students' attainment in English language. Also, in a similar study to examine the effects of school quality on the attainment of secondary school students in mathematics in Nigeria, Jaiyeoba & Atanda (2011), investigated the effects of school-based factors such as supervision of instruction, school leadership, quality of instruction, guidance and counselling services, health services, school library, conveniences (toilets) instructional materials and sports facilities on students attainment. Their study which involved only school principals and mathematics teachers utilized the use of school-based quality inventory and school factor questionnaire as instruments of data collection. They concluded that "instructional materials and conveniences (toilets) are strong school-based quality factors which have the tendency of contributing significantly to students' attainment in Mathematics" (p.98).

Their study did not however explain how the lack of toilets and instructional materials affect the attainment of students in mathematics.

Fuller (1986) has reported the varying effects of school-based or other socio-economic factors on students' performance in developed and developing nations. This also supports the finding of Heyneman & Loxley (1983) that school and teacher effects are stronger in low income countries than in developed countries and that for social status effects on students' attainment is stronger in developed countries than developing ones. The findings of Jaiyeoba & Atanda (2011), for instance may be seen as evidence supporting the position as reported by Fuller (1986) and Heyneman & Loxley (1983). It may be difficult to have the lack of provision of adequate conveniences in public schools and the provision of basic instructional materials for effective teaching and learning in educational institutions in most developed countries. In the same vein, Heyneman and Loxley (1983) studied the effect of primary school quality on academic attainment across high and low income countries and concluded that 'in low-income countries, the effect of school and teacher quality on academic attainment in primary school is comparatively greater' (p.1162).

The focus of this study is to identify school-based factors that have effects on the teaching and learning of physics in Nigerian secondary schools and so possibly affect the uptake of the subject after the compulsory years of secondary education and students' attainment. Thus, school-based factors to be investigated in this study include input factors such as availability and utilization of teaching and learning resources, teacher availability, teacher quality, teacher experience, teaching strategies employed by teachers, computers/internet facilities and classroom interactions; while students' enrolment and performance in the SSCE are the output variables. Particularly, this research seeks to qualitatively study the state of the resources for teaching and learning, the teaching strategies employed by physics teachers, students' engagement in classrooms and the general classroom environment and how these might explain the enrolment and attainment of students in physics.

Key concepts that will be explored in this study therefore include resource availability, resource utilization, teaching strategies, students' engagement and classroom interaction. Walberg's theory of educational productivity (1981) and the Von Bertalanffy input-output systems theory (1968) shall form the theoretical framework for this research.

2.1.1 Walberg's theory of educational productivity

Walberg's theory (1981) is a psychological theory of educational productivity. The theory had its root in Cobbs-Douglas (1928) economic productivity theory of national, industrial and agricultural productivity in Austria, England and Sweden (Walberg, Haertel, Pascarella, Junker and Boulanger, 1981). According to Walberg *et al.*, the key features of the theory of economic productivity were that "adding more farm labor, land, or plows and other equipment increases grain yield, and (that) each factor is necessary but insufficient by itself for production" (p. 234). Going from the two-factor theory of Cobb and Douglas where economic output was represented as a function of capital and labor (Walberg *et al.*, 1981), Walberg widely reviewed about 3000 studies on school attainment and identified nine productive factors which were grouped into three classes of Aptitude (student ability/prior attainment, motivation, age/developmental level), Instruction (quantity of instruction and quality of instruction) and Psychological Environment (Classroom climate, Home environment, Peer group and Exposure to mass media outside of school), (Reynolds & Walberg, 1992). The theory posits that:

> "psychological attributes of individual students and their psychologically proximate environments influence cognitive, behavioral, and attitudinal outcomes of education" (Reynolds & Walberg, 1992).

The implication here is that the student attributes such as ability and those things or events in his environment both at home and in school could affect his cognitive outcomes (attainment) and behavioral and attitudinal outcomes (like or dislike of the subject or school environment) which could affect subject and school enrolment.

Walberg's (1981) educational theory was therefore partly adapted as a basis for the theoretical framework of this research. Although nine productive factors were identified to have positive relationship with learning outcomes, three of these factors are considered in this study as school-based factors. These factors are quality of instruction, quantity of instruction and classroom psychological climate. The teacher, his teaching strategies and interaction with his students play very vital role in the enhancement of learning outcomes of students. Similarly, a safe, friendly and conducive classroom environment where students find stimulating experiences ensures a good motivation for effective learning. According to Greenberg, Weissberg, O'Brien, Zins, Fredericks, Resnik & Elias (2003: 470), "safe and orderly school and classroom environment, caring relationships between students and teachers that foster commitment and connection to school and engaging teaching approaches such as cooperative learning and proactive classroom management" are some factors that produce improved school outcomes. It is therefore the concern of this research to investigate how physics teachers interact with the curriculum and their students in terms of lesson delivery, how this encourages the establishment of student friendly learning environment and how these factors might explain students' enrolment and performance. According to Barge (2013), "effective teachers promote student learning by using research-based instructional strategies relevant to the content to engage in active learning and to facilitate the students' acquisition of key knowledge and skills". That teaching strategies have some effects on learning outcome of students is well known (Mortimore & Sammons, 1987; Ramsden, 2003; Coe, Aloisi, Higgins & Major, 2014).

Walberg's theory (1981) is much respected for its empirical review of several studies on school learning and outcomes (McGrew, 2008; DiPerna, Volpe & Elliott, 2002; Greenberg *et al.*, 2003; Walberg, 1984). The theory however does not include school-based factors such as resource availability and utilization and the teaching strategies that teachers use especially in science classrooms that research has shown to have effects on students' interest in learning and enhancement of learning outcomes or attainment. According to Mortimore & Sammons (1987), "much of the variation between schools can be accounted for by the differences in school policies and practices within the control of the principal and teachers" (p.4). This view is corroborated in the assertion of Patrick (2009:119) that the general and specific objectives of science education "are only achieved by the teacher through giving the right types of instructions to the science students". Although many studies show that student previous knowledge, interpersonal skills, and motivation impact student attainment significantly (Walberg, 1984; DiPerna, Volpe & Elliott, 2002; Greenberg *et al.*, 2003; McGrew, 2008), some studies have shown that when those variables are controlled, teachers are very important determinants of student attainment (Wright, Horn, & Sanders, 1997; Darling-Hammond, 2000; Gallagher, 2004). It is therefore the concern of this research to investigate how certain school- based factors such as teacher qualification, strategies employed in teaching physics, resource availability and resource utilization for teaching could explain students' enrolment and attainment in physics.

2.1.2 The Von Bertalanffy input-output systems theory

The system's theory (input-output) model was developed by Ludwig Von Bertalanffy (1968) who saw the need for a model or theory that will give direction to research concerning all systems in most disciplines as according to him, "systems thinking plays a dominant role in a wide range of fields from industrial enterprise and armaments to esoteric topics of pure science" (p.1). According to Von Bertalanffy (1968), "there appear to exist general system laws which apply to any system of a certain type, irrespective of the particular properties of the system and of the elements involved". This according to him led "to the postulate of a new scientific discipline which we call general system theory" (p.36).

This general system is one in which its components interact with one another. In education for instance, the school is seen in the light of Von Bertalanffy's theory as a system composed of the school leadership or administration, teachers, students, policy makers, teaching and learning resources and the curricula as component parts of the system. These component parts of the system interact and inter-depend on one another for the overall success of the goals of the system. According to Friedman & Allen (2011), Von Bertalanffy considered simple linear cause and effect relationship to explain the growth and development of parts of a living organism as a system. They reported that these conditions hold when there is interaction between the component parts and that the condition that describes the relationship of that interaction is linear. According to them, "when these two conditions are present, Von Bertalanffy felt, (that) the interaction was measurable and was subject to scientific inquiry" (p.4). Stichweh (2011) outlined the features of the general systems theory which include "the interdependency of the parts of a system; the reference of any structure and process in a system to the environments of the system; equilibrium and adaptedness and continuous re-adaptations to environmental demands as core elements of the understanding of a system". Von Bertalanffy in his theory talked about open and closed systems. He posited that "every living organism is essentially an open system" (p.38) and explained that the interaction between components of an open system is such that the system is maintained with the steady inflow (input) and outflow (output) of the component parts of the system.

In adapting this theory, the school is here considered as an educational system with the teachers, students, curriculum content as component parts and the society as its environment within which it operates. This is an open system in which the component parts interact with one another and with the environment for the overall good of the system and the environment. The resources for teaching/learning, teacher training and re-training are all inputs into the system for the attainment of set goals and expectation of the societal (environment) goals. As an open system, the school receives information from the environment or society which it uses to interact with its components in a dynamic way. The information the school receives from the society may be in the form of what society expects of the worth of the schooling experience or products of the system. The teaching, learning, instructions, laboratory exposure, field trips, classroom interactions, counselling and all that take place under the direct or indirect auspices of the school becomes the 'processing' tools of the system to produce a worthwhile output. The products of the system are turned into the environment (output) to contribute to the development of the environment.

2.2 Review on school effectiveness research

Some research questions for the present study focuses on school-based factors such as teacher qualification, experience, teaching strategies, classroom climate, resource availability and utilisation. School effectiveness research is an area of educational research that looks at factors within the school that could influence students' learning outcomes. Relevant literature in this area has therefore been searched and appropriately reviewed to get abreast with current research findings in the area, identify gaps and develop an adequate guide to effectively answer the research questions.

School effectiveness research according to Reynolds, Sammons, De Fraine, Damme, Townsend, Teddlie & Stringfield (2014) is the investigation of 'all the factors within schools in particular, and the educational system in general, that might affect the learning outcomes of students in both their academic and social development' (p.197). Quite a lot of studies have been conducted to identify the factors that contribute to or influence the learning outcomes of students in schools (Hedges, Laine & Greenwald, 1994; Hanushek, 1997; Gamoran & Long, 2006; Yu, 2007; Lips, Watkins & Fleming, 2008). The reason for these studies on school effectiveness is not farfetched as researchers and stake holders in the education industry are interested not only to identify these factors but also to see how those with positive influence are boosted while those with negative influence are meaningfully minimized, discouraged and or eliminated. Literature has shown that several factors that could potentially affect teaching and learning outcomes in schools such as school policies, school environment, financing and resourcing, teacher characteristics including teaching strategies, family background of pupils, peer group influence and the motivation of the learners have been of interest to researchers in school effectiveness.

Another aspect of school effectiveness research is that of ‘attainment equity’ and ‘equitability’. Kelly (2012) cited The European Union’s (EU) definition of equity as:

> “…the extent to which individuals can take advantage of education in terms of opportunities… and outcomes. Equitable systems ensure that the outcomes of education are independent of [all] factors that lead to educational disadvantage…” (p.2).

By this definition, policy makers are not only interested in the success stories of schools in external examinations but also, the extent to which the success is proportionate with the school population. In this regards, it is important to view the school’s examination success with that of the prior attainment of its population.

This concept of equity and equitability has been canvased in the educational policies of many countries and international organizations (Kelly, 2012). The situation is same in Nigeria as captured by the National Policy in Education (2013):

> “The goals of education in Nigeria are the: …provision of equal access to qualitative educational opportunities for all citizens at all levels of education, within and outside the formal school system… The specific goals of education in Nigeria are to: ensure and sustain unfettered access and equity to education for the total development of the individual…” (p.2).

Despite these lofty ideas of equity enshrined in the National policy, many studies that have been conducted in Nigeria suggest the high existence of “inequity” with public schools very poorly financed with poor facilities for teaching and learning while privately owned schools have relatively better facilities and are not within the reach of the ‘common’ Nigerian (Onwioduokit, 2001; Adeyemi, 2008; Bello, 2012). These privately owned schools apart from being patronized by the ‘well-to-do’ in society who are also likely to provide better learning facilities for their kids at home, also are selective in their admission process. In terms of the “Attainment Equity” (AE)

Index and “Contextual Value Added” (CVA) measure (Kelly, 2012, 2015), most public schools in Nigeria may be described as “Uniformly ineffective schools” with low AE and low CVA while most ‘successful’ private schools in Nigeria may fall into the upper right quadrant as “Differentially effective schools”. However, the present study is not investigating Attainment Equity and or Contextual Value Added measures in Nigerian schools, but the factors within the schools that influence physics enrolment and attainment.

It is important that government, society, parents and educational managers know those factors that have direct impact on students’ learning outcomes so that such areas will be more supported to meet the desires and challenges of education. This in general, is the goal of school effectiveness research. Every government’s desire as demonstrated by policies on education and huge funding both on research and especially years of compulsory schooling, is therefore to see how best to advance education and scrutinize the effectiveness of schooling and school systems in a bid to improve the quality of teaching and learning so as to equip its citizenry with the necessary skills, knowledge and experience to function effectively in the society and meet the challenges of the global economy (Yu, 2007; Lips, Watkins & Fleming, 2008).

The importance of education in any society cannot be over emphasized. Today, education is seen as the key to industrial, environmental and societal development as it help individuals to inculcate national consciousness and the appropriate values for the worthwhile survival of the individual and the society. One of the national educational goals of the Federal Republic of Nigeria is the ‘development of appropriate skills, mental, physical and social abilities and competencies to empower the individual to live in and contribute positively to the society’ (FRN, 2013:2). The implication of the above cited from the national policy on education is that government intends by the means of education, to equip its citizenry with necessary skills and knowledge not only to live responsibly and survive in the society, but also by what is acquired through the means of education to contribute meaningfully to the well-being of the society. The National curriculum in England expects all state-funded schools to offer a balanced and broad-based curriculum that ‘prepares pupils at the school for the opportunities, responsibilities and experiences of later life’ (DFE, 2013:5). What this means is that products of basic schooling in English schools are expected to acquire what is needed as skills, knowledge and experiences that would enable them fit well in society in terms of employability and contribute significantly to societal needs and challenges. This is why Boit, Njoki & Chang’ach (2012), posited that ‘the purpose of education is to equip the citizenry to reshape their society so that the flaws and inequalities are eliminated' (p.179). This relevance of education both for the populace and society at large is the reason why many countries invest heavily in the education of their young ones, especially at the pre-school, primary and secondary stages of education.

It is this recognition of this place of education in both individual and national development that has prompted many nations and governments to invest massively in the education of their citizenry especially at the primary and secondary education levels. The recommended minimum budgetary allocation to education by the United Nations Educational, Scientific and Cultural Organization (UNESCO) for all countries is 26% of its annual budget. In Nigeria, the budgetary allocation to education over the years has been poor with less than 11% (Oseni, 2012; Ejiogu, Ihugba & Nwosu, 2013). In Africa for instance, countries like Uganda, Cote d'Ivoire and Ghana allocate about 27%, 30% and 31% respectively of their annual budgets to education. Some other African countries with a substantial percentage of their national budget that is on the average allocated to education include Botswana (19), Swaziland (24.6), Lesotho (17), South Africa (25.8), Burkina Faso, (16.8), Kenya(23), and Tunisia (17) (Ejiogu, Ihugba & Nwosu, 2013). For member countries in the OECD, allocation or expenditure for education is measured in relation to their Gross Domestic Product (GDP). As reported by the National Center for Education Statistics (NCES), the National expenditure in percentage of member nations of OECD for education in relation to their Gross Domestic Product (GDP) shows Denmark, Iceland, The Republic of Korea, Israel, the United States of America and New Zealand spending over 7 percent of their GDP on education (National Centre for Education Statistics, 2014).

Some researchers have expressed concern as to whether or not the investment of public funds in the education sector is correspondingly yielding the desired results. The report tagged 'equality of educational opportunity' by Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld & York (1966) and submitted to the United States government sparked off much debate as to whether the spending of more funds on education improves academic attainment (Purkey & Smith, 1983; Hedges, Laine & Greenwald, 1994; Hanushek, 1997; Gamoran & Long, 2006; Lips, Watkins & Fleming, 2008). Coleman *et al.* have reported that 'variations in the facilities and curriculums of the schools account for relatively little variation in pupil attainment' and that 'a pupil's attainment is strongly related to the educational backgrounds and aspirations of the other students in the school' (p.22).

There have been several studies and arguments on the subject of school effectiveness research. Hanushek on several of his studies (1994, 1997, 2006) has maintained that school resources do not significantly affect students' performance. Hanushek (1997) did an article review of about 400 studies of students' attainment on available educational production literature and concluded that 'there is not a strong or consistent relationship between student performance and school resources, at least after variables in family inputs are taken into account' (p. 141). Also, Glewwe, Hanushek, Humpage & Ravina (2011) investigated the effects of school resources and educational outcomes in developing countries. They started with over 9000 studies out of which only 43 studies survived their screening and were termed 'high quality' studies. They concluded that 'the estimated impacts on time in school and learning of most school and teacher characteristics are statistically insignificant' (p.1). They also argued that 'the most useful conclusion to draw for policy is that there is little empirical support for a wide variety of school and teacher characteristics that some observers may view as priorities for school spending' (p.42). The position of Hanushek and his colleagues has not been unchallenged. A group of researchers that has consistently challenged the position of Hanushek and those of similar inclination is Hedges, Laine & Greenwald (1994a, 1994b.1996). For instance, in their paper 'Does money matter? A meta-analysis of studies of the effects of differential school inputs on student outcomes', they criticized the inference procedure utilized by Hanushek (1981, 1986, 1989, 1991) that concluded that school expenditures are unrelated to student performance. They argued that 'the data upon which this conclusion is based support exactly the opposite conclusion and demonstrate that expenditures are positively related to school outcomes' (Hedges, Laine & Greenwald, 1994a:p.5). They also queried that Hanushek failed to describe his criteria for choosing coefficients from his selected studies and procedures used to obtain publications and extract information from them (Greenwald, Hedges & Laine, 1996). In his paper 'Economic consideration and class size', Krueger (2003) disagreed with Hanushek on his avowed position that there is no strong or consistent relationship between school inputs and students' performance. He argued that Hanushek in drawing estimates from his selected studies considered more estimates from some studies than others and applied equal weights to every estimate during his analysis. He maintained that 'Hanushek's pessimistic conclusion about the effectiveness of schooling inputs results from the fact that he inadvertently places a disproportionate share of weight on a small number of studies that frequently used small samples and estimated misspecified models'(p.F35). Krueger argued that when studies are given equal weights, school resources are seen to be systematically related to pupils' attainment. Pan, Rudo, Schneider & Smith-Hansen (2003) examined resource allocation in education and its effect on student performance. They examined data on student performance and fiscal and human allocation from all independent school districts within Arkansas, Louisiana, New Mexico and Texas all in the United States of America. The findings of their research 'demonstrated a strong relationship between resources and student success' (p. v).

While the argument on the effectiveness of school resources on students' attainment is evident in scholarly literature with most samples drawn from developed countries, Heyneman & Loxley (1983) investigated 'The Effect of Primary School Quality on Academic Attainment across Twenty –nine High- and Low-Income Countries'. They argued that most studies that concluded that the effect of school resources and teacher quality on students' academic performance was less than that of family and students' characteristics drew their evidence and generalizations from developed school systems in Europe, North America and Japan. They explored data from Africa, Asia, Latin America and the Middle East and discovered that 'children who attend primary school in countries with low per capita incomes have learned substantially less after similar amounts of time in school than have pupils in high-income countries' (p.1162). Heyneman & Loxley (1983) concluded that quality of school and that of teachers to which the pupils are exposed is the predominant influence on students' attainment. Woessmann (2003) investigated the effects of family background, school resources and educational institutions on students' performance on Mathematics and science with over 260 000 students from 39 countries. His finding was that international differences in students' attainment were considerably related to institutional differences and not school resource differences. Woessmann listed institutional factors that had positive effects on student performance to include centralized examination and control system, school autonomy, teacher-influence over choice of teaching methods, competition from private schools and restrictions of teacher unions' influence on curriculum scope. Also, Gamoran & Long (2006) in the review of 'equality of educational opportunity' after 40 years of debate since after the launching of Coleman's report, concluded that 'despite recent claims to the contrary, attainment in countries with very low per capita incomes is more sensitive to the availability of school resources' (p.1).

In Africa, Kasirye (2009) investigated determinants of learning attainment in Uganda. 163 schools were selected with 20 pupils in grade 6 from each school who were administered tests in Mathematics and Reading. Teacher questionnaire to elicit information on teacher characteristics was also administered to all grade 6 teachers of Mathematics and Reading. His study revealed that teacher characteristics and access to school resources raised the cognitive outcomes of children. Glewwe & Jacoby (1994) studied student attainment and schooling choice in Ghana. Their study found 'that improving schools is an important way of raising productivity' and 'also uncovered the relative effectiveness of repairing school buildings over investments in instructional materials, such as books, desks and blackboards and in teacher quality'(p. 862-863). This finding is interesting as physical resources such as books, desks, and blackboards will certainly wear out fast if the school building is dilapidated. Teachers' motivation is also most likely to be affected negatively in such unconducive working environment. It may therefore be difficult to conclude if that study claims the existence of a relationship between school resources and students' attainment.

In Nigeria, Atanda & Jaiyeoba, (2011) investigated the effects of school-based quality factors on secondary school students' attainment in English language in south-western and north-central Nigeria and found that instructional materials, quality of instruction and supervision contributed significantly to students' attainment in English language. Adeyemi (2008) examined the effect of science laboratories on the quality of output in terms of student performance in secondary schools in Ondo state of Nigeria. Sample for the study was drawn from 168 out of the 257 secondary schools that presented candidates for the Senior Secondary School Certificate Examination from the state in 2003. His findings show that the students from schools having laboratories in the three science subjects of Biology, Chemistry and Physics performed better than those from schools who had either none or less. In a similar vein, Bello (2012) using a descriptive survey investigated the 'effect of availability and utilization of Physics laboratory equipment on students, academic attainment in senior secondary school physics' with a sample of 900 randomly selected students and 50 Senior Secondary physics teachers purposively selected from 45 Senior Secondary schools in the South-western region of Nigeria. The results showed that 'the optimal utilization of physics laboratory equipment is effective in the teaching of physics' (p. 1). The study also revealed that students from Federal Government owned schools with better resources and higher utilization had higher mean scores than students from privately owned schools, while students from public schools with least minimum available resources and utilization had the lowest mean scores. In a similar study on the importance of a solid foundation of science education for national building in Nigeria, Onwioduokit (2001) lamented the poor state of science laboratories and facilities for the teaching and learning of science subjects in the school system. Contrary to the findings of Adeyemi (2008) and Bello (2012), Ajayi (2013) carried out a study to see if resource utilization could predict students' attainment drawing sample from 20 out of 52 secondary schools from Ilorin local government area of Kwara state in Nigeria. He used correlation to investigate the degree of association between resource utilization and students' attainment in the SSCE. He reported that there was no significant relationship between utilization of science laboratories and students' academic performance. Similarly, Bello (2012) investigated the effect of physics resource availability and utilization in lessons on the academic attainment of secondary school students in the subject in Nigeria and reported that students learnt better when teachers utilize physics laboratory equipment and resources in the lessons and that "public schools with the minimum available equipment and least utilization capacity had the minimum mean score"

Although several studies have been carried out in the area of school effectiveness, especially effect of school resources on students' attainment, a clear consensus cannot be said to be reached. There is therefore the need for further research in this area especially in developing countries like Nigeria. The concern of this research is basically on school related factors that can affect students' enrolment and attainment or enable effective learning. Particularly, this research seeks to qualitatively study the state of the resources for teaching and learning, the teaching strategies employed by physics teachers, students' engagement in classrooms and the general classroom environment and how these might explain physics students' enrolment and attainment in secondary schools in Rivers State.

2.3 Students' choice of post-compulsory school science and physics

The present study is concerned about the school-based factors that affect students' enrolment and achievement in physics after the compulsory years of secondary education. Literature on factors that generally influence student choice of school science and particularly physics has therefore been reviewed to get properly acquainted with current research findings in the area and also, to give direction and proper basis for the discussion of findings of the present study.

In most countries, science is taken as basic science, integrated science, nature study or simply as science in the compulsory school classes or years. In Nigeria, compulsory schooling or what is referred to basic education as enshrined in the National Policy on education is between ages 5 to 15 years (FRN, 2013). According to the policy, the basic education 'encompasses kindergarten 1 year, 6 years of primary education and 3 years of Junior Secondary Education' (FRN, 2013: iv). In Nigeria, Science is taught as Basic Science at the Basic classes of primary 1 to junior secondary 3. At the one year kindergarten level, the policy did not specify the curriculum for that year. However, the content of learning science at that level was expressed when it stated as one of the objectives of kindergarten education: 'inculcate in the child the spirit of enquiry and creativity through the exploration of nature, the environment…' (FRN, 2013: 6).

In South Africa, education is compulsory for all South Africans from the age of seven to age 15, or the completion of the 9th grade as stated in the South African Schools Act 84 of 1996: 'Subject to this Act and any applicable provincial law, every parent must cause every learner for whom he or she is responsible to attend a school from the first school day of the year in which such learner reaches the age of seven years until the last school day of the year in which such learner reaches the age of fifteen years or the ninth grade, whichever occurs first' (Section 2(3),part 1). Science is studied as Natural Sciences as one of the eight learning areas in the 9 years of compulsory schooling in South Africa. Natural sciences in the South African context is divided into four components of 'Life and Living', 'Energy and Change', 'Planet Earth and Beyond' and 'Matter and Materials' (Department of Basic Education, 2011, p. 9). Beyond the years of compulsory schooling, science is studied as 'Physical Sciences' made up of concepts of physics and chemistry and integration of both and 'Life Sciences'

In the United Kingdom, the compulsory schooling is between age 5 and 16 and pupils in KS 1, KS 2, KS 3 and KS 4 at both primary and secondary school level take science as a compulsory subject. In South Australia, the compulsory school age is between 6 and 16 (year 1 to year 9 or 10) and parents have the responsibility to ensure that their children of that school age regularly attend school (South Australia Education Act, 1972). School education is similar across all of Australia with very minor variations. School education is 13 years and is divided into three segments of primary (which runs for 7 or 8 years, starting at kindergarten to year 6 or 7), secondary (which runs for 3 or 4 years from years 7 or 8 to 10) and senior secondary school of two years (years 11 and12). Science is offered as a compulsory subject through all 13 years of compulsory schooling in Australia. The government's motivation for the inclusion of science as a compulsory subject is captured in the rationale and aims of the curriculum document: "science provides opportunity for students to develop an understanding of important science concepts and processes, the practices used to develop scientific knowledge, of science's contribution to our culture and society and its application in our lives" (p. 3).

Several studies have been conducted to investigate factors that may affect students' choice of science and physics in particular at the senior secondary school level (Akpan, 1986; Omosewo, 2003; Francis & Greer, 1999; Breakwell & Beardsell, 1992; Oriahi, Uhumuavbi & Aguele , 2010; Ormerod, 1975; Stables, 1990; Semela, 2010;Ezeweani & Atomatofa, 2012; Daso, 2013; Aina & Akanbi, 2013; Akiri, 2013). The way people feel and think about certain things and life-long engagements affect their involvement and motivation either positively or negatively. For instance, Akpan (1986) investigated the effect of age, sex, attitudes to science, IQ and students' personality on choice of science subjects among secondary school students in Nigeria. His study used 1240 students between 12 and 18 years from 31 secondary schools in Benue and Cross River States of the country. Using t-test analysis, correlation and multiple regression analyses, Akpan reported that 'attitudes to science was the most important factor in science choice, followed by IQ' and that 'sex and personality were important to a lesser degree' (Akpan, 1986:99). The implication is that students choose science as a result of their positive attitude and interest in science probably because of what they may have considered to derive from such choice.

Recent studies on the influence of students' career or future choice indicates that parents are the most influential factors (Atkinson, 2012). Omosewo (2003) investigated variables like parents, school counsellors, peer group, friends, relatives and self (the student) that influence their choice of physics. She used simple percentages and observed that parents and school counsellors ranked the highest influencing factors on students' choice of physics with 48% and 31.5% respectively. Another factor that has been highly debated is that of gender. In most under developed and developing countries, gender-defined role differentiations and beliefs are very strong even in their society and communal lifestyles. Women in such societies are groomed early in life to be better house wives and mothers and are encouraged to choose subjects like Home management and Music. For instance, while some (Francis & Greer, 1999; Breakwell & Beardsell, 1992) reported that males have more positive attitude towards choice of science with greater levels of participating in science related extracurricular activities than females, others (Ormerod, 1975; Stables, 1990) did not agree that gender difference affect students uptake of science. According to Perera & Velummayilum (2008), 'masculinity is characterized traditionally as dominance and competitiveness, while, in contrast, women select careers that have regular hours of work to enable them to fulfil family obligations. It is also suggested that women prefer work that is predictable, subordinate and less financially productive, with low stress levels' (p.186). Amunga, Amadala & Musera (2011) reported that 'girls are socialized into characteristics of dependence, nurturance and passivity' and 'therefore develop a set of attitudes and beliefs that do not promote high levels of attainment and participation in science' (p.234). Research has shown that females have more negative attitude toward science and perceive science subjects to be more useful to boys (Wasanga, 1997; Amunga, Amadala & Musera, 2011). This seems to be true in Nigeria where the major religions of Christianity, Islam and African Traditional Religion relegate females as subservient to their male folk. Oriahi, Uhumuavbi & Aguele (2010) have argued that students' interaction inside and outside the classroom with peers and other classroom activities affect their interest and performance in science.

Whilst the factors that influence the choice of science and particularly physics is of concern to many researchers in science education and other stake holders, the issue of the level of enrolment of school pupils in science and physics in particular has raised more concerns. In Nigeria, available records show that more students after the compulsory schooling classes choose to study non–science subjects compared to the sciences (Aina & Akanbi, 2013; Bukunola & Idowu, 2012). Also, of the three core science subjects of Biology, Chemistry and Physics, Physics is seen to have the least popularity among students in the senior secondary school classes (Akanbi, 2003; Bello, 2012; Aina & Adedo, 2013). According to Bello (2012), 'students shun sciences particularly physics when given an option' and that 'given a choice, students would rather drop physics in favour of other science subjects' (p.2). Apart from the fact that there is low choice of physics among students in SSS classes, there is also gender disparity in enrolment (Aina & Akintunde, 2013).

The problem of low enrolment of science and particularly physics in the post-compulsory classes is not peculiar to Nigeria. The enrolment in physics at all levels of education is low in many African countries (Musasia, Abacha & Biyoyo, 2012) and indeed in most countries of the world (Semela, 2010; Osborne, Simon & Collins, 2003). Woolnough, Guo, Leite, Almeida, Ryu, Wang, & Young (1997) discussed the growing concern of the fewer number of students who which to continue with their school science in many countries. In South Africa for instance, Mundalamo (2006) reported the decreasing number of students who choose physics as one of their subjects. He went further to state that 'before the 1994 democratic elections, the South African physics community was dominated by whites' as 'most African pupils did not have the opportunity to choose mathematics and science as subjects at school' (p. 5). He quoted the then Minister of Education in South Africa, Naledi Pandor thus:

> "Mathematics and science have for a long time been a preserve of a select few. Many generations of young people have been denied access into these important subjects because of apartheid and because of the myth that one is born either with or without an ability to handle these subjects" (p. 5).

This raises questions on the goals of early western and missionary education to most African countries which of course is not the focus of this research. In Ghana, Taale (2011) observed that relatively, few numbers of students choose physics as an elective subject at the post-compulsory school level. Atagabe (2011) also reported that students' enrolment in the science in the Upper East region of Ghana was poor. She revealed that 'out of 13,134 students who enrolled into the Senior Secondary School in 2008/2009 academic year, only 10% of them offered General Science'. This is despite the important position of physics as a pre-requisite to most careers and courses in Science and Technology that drive industrialization and technological breakthrough pursued by most economies of the world. In Kenya, Musasia, Abacha & Biyoyo (2012) reported a low enrolment of students in science and physics after the compulsory years and that the 'far fewer girls opt to study physics in form three and form four compared to the boys' (p. 154). Forms three and four in Kenya are the last two years of secondary education. Wambugu & Changeiywo (2008) also reported a low enrolment of Kenyan secondary school students in physics as an elective subject.

The problem of relatively fewer students choosing science and physics in particular after the post-compulsory secondary classes has also been reported in developed countries like the United States, Canada, United Kingdom and Australia (Tobias & Birrer, 1999; Osborne, Simon & Collins, 2003; Bennett, Hampden-Thompson & Lubben, 2011; Mujtaba & Reiss, 2012). Osborne, Simon & Collins (2003:1050) for instance reported 'the stark nature of the decline in the numbers choosing to do three sciences at 16 for A-level, at the point of choice' in England and Wales. They also reported that in England and Wales physics and chemistry were found to be two of the least popular subjects among post-14 pupils and that 'physics has been the subject of a continuing 15-year decline in numbers enrolling and passing'(p. 1058). In 2012 for instance, the percentage of students that took A levels in science subjects in the UK were 8% (Physics), 11% (Chemistry), and 14% (Biology) (Questions for Governors, 2014). Gill & Bell (2013) reported the concern on the decline in the number of students choosing physics beyond age 16 in the UK. Smithers & Robinson (2009) reported that between 1982 and 2006, the A-level physics entries reduced to about 50%. They also reported a decline in physics uptake in Australia, Republic of Ireland, Finland, New Zealand and Scotland with an increase in the United States of America. However, Sparkes (1995) investigated the situation of physics enrolment and attainment in physics in England and Scotland and reported that more young pupils in Scotland take physics beyond 16 and attributed this to the fact that physics was taught by well qualified physics teachers in Scotland. A later study by Reid & Skryabina (2002) also reported that physics was a popular subject among school pupils in Scotland unlike many other countries. In a similar vein, Mujtaba & Reiss (2013) reported that 'the number of students entering physics A-Level has begun to see a rise over the past five years, having reached a low in 2006' (p.2980). They also reported that only 3.6% of the entre cohort that sat for the A-Levels entered for physics. Smithers & Robinson (2008) reported that 'physics has been in steep decline in schools in England, particularly in comprehensive schools. But that there are some schools in which physics is thriving' (p.49). Their work attempted to draw some lessons in schools where physics was thriving, what they do right, and to see if the trend can be reversed in schools with general decline when those principles are applied. Mullis, Martin, Robitaille & Foy (2009) in their international report of the Trends In Mathematics and Science Study (TIMSS) conducted in 2008 observed that the percentage of students in the age cohort receiving physics was considerably low in the participating countries with the Russian Federation having the lowest enrolment of 2.6% and Sweden with 11%. They reported that the 'range of the coverage index for physics is considerably smaller than was the case for advanced mathematics' (p.224).

In the United States of America, White & Tesfaye (2010, 2014) have reported a steady growth in High school physics enrolment since 1987. They reported for instance that 'by 2008-2009, more than 1.3 million students were enrolled in physics courses in U.S. high schools' which represents a 2% increase from four years earlier and that '37% of the students who graduated from U.S. high schools during the 2008-2009 academic year (both public and private) had taken at least one physics course before graduation'. They also reported that 'during the 2012-2013 school year, nearly 1.4 million students were enrolled in a physics course in a U.S. high school' with 3.3 million U.S. high school graduates in the same year. In a study of under-represented minorities in High school physics in the United States, White & Tesfaye (2011) reported that in 2009, the percentage of Black and Hispanic high school students in the U.S. who took at least one physics course prior to graduation was 25% which was well below that of white and Asian students with 41% and 52% respectively. They attributed the differences to more of socioeconomic factors than racial.

The story appears different in Australia with a reported steady decline of the proportion of high school students opting for science subjects at the senior secondary level (Lyons & Quinn,2010). Lyons (2006) citing Fullarton, Walker, Ainley & Hillman (2003) reported that 'between 1990 and 2001, for example, Year 12 (final year) enrolments in physics, chemistry and biology courses decreased by 23, 25 and 29% respectively' (p.285). Other researchers have also reported a decline in the enrolment of High school students for physics in Australia (Rennie, Goodrum & Hackling, 2001; Hackling, Goodrum & Rennie, 2001; Melone, Cavanagh, Webster, Dekkers, Toomey, O'Donovan & Elliot, 1997; Dekkers & Laeter, 2001). Melone *et al.* (1997) observed that 'although there has been national increase in the participation rates for post-compulsory education, there has not been a proportional increase in participation in courses of advanced mathematics and science, and *that* the drop-out in these subjects is now regarded as critical' (p. 331). In their study on the 'Enrolment trends in school science education in Australia' between 1980 1nd 1998, Dekkers & Laeter (2001) reported that of the three core science subjects, physics had remained the most unpopular subject among Year 12 Upper secondary school students in Australia. For instance 'in 1998, 26 percent of the Year 12 student cohort enrolled in Biology, 20 percent in Chemistry, 18 per cent in Physics' (p.496). The ‘worrying decline in the uptake of physics by students at secondary level’ in Australia necessitated the Physics decadal plan of the Australian Academy of Science in December 2012 (Australian Academy of Science, 2012). The plan was a presentation of the Australian physics community’s strategic vision for the ten years of 2012-2021. On achieving a physics literate workforce and community in Australia, the Decadal objectives as stated in the plan were:

1. attract and retain students in physics at all educational levels
2. increase the quality and number of appropriately qualified physics teachers across the school sector
3. reduce the gender differential in physics competency at all school levels
4. improve physics-literacy amongst the lay community
5. improve the use of the physics evidence base to inform policy development (p.12).

Dekkers & Laeter (2001) acknowledged the significant contribution of the scientific community in Australia to primary and secondary level science education. They noted that the scientific community through the Australian Academy of Science has ensured that ‘science education features prominently in schooling and that curricula are appropriate and relevant’ with the production of ‘series of text-books at both the secondary, and more recently at the primary level, to provide up-to-date and educationally sound science educational materials to the school system’ (p.488).

The effort by the Australian Academy of science to popularize physics and increase the uptake of the subject by school pupils is worthy of commendation and emulation. Considering the relevance of physics as the heart of science and technology with its undisputable contributions in the fields of medicine, information technology, space science and industrial revolution, it is hoped that much more can be achieved when countries make conscientious efforts to popularize and strengthen the study of physics especially at the primary and secondary levels of education. While most developed countries are towing this line, much is not yet done especially in most African countries to match words with action.

2.4 Explanations for decline in physics uptake among secondary school students

Concerns on the decline on enrolment in physics among secondary school students and school-factors that may affect it is a key focus in the present study and runs through most research questions for the study. Subsequently, relevant literature on possible explanations for the decline is included here, in an attempt to establish the status quo, familiarise with physics enrolment issues from different countries with their peculiar school systems and to provide good basis for the discussion of the findings on physics enrolment from the present study.

That fewer numbers of young people are choosing to study physics beyond the compulsory years of schooling not just in Nigeria or developing countries, but also in developed countries is evident in literature. In this section, attempt shall be made to present possible explanations from literature for the decline in the uptake of physics. In Nigeria for instance, the number of students choosing physics at the senior secondary level is least compared to other science subjects and this trend is maintained in the number of students enrolled to study physics or physics education in tertiary institutions (Erinosho, 2013). It is a common perception among students, teachers and parents that science is generally difficult and in particular, physics.

Aina & Akanbi (2013) studied the perceived causes of students' low enrolment in science in Nigerian secondary schools and reported lack of qualified teachers, motivation, instructional materials, nature of the subject, and low students' interest among factors that cause low enrolment. Their study reported teachers and the nature of the subject ranking highest among other factors. In particular, they reported that 'Physics is too abstract, biology is too wide in scope, chemistry is very hard to learn and science is too mathematical' (p 20). Erinosho (2013) studied students' perception of the difficulty of physics in Nigeria and listed 'the nature of the subject, teaching/teacher factors and curriculum/assessment' (p 1510) as the major sources of difficulty. According to her, 'students were found to have difficulty understanding specific topics in the curriculum that are usually characterized as lacking concrete examples and requiring a lot of mathematical manipulations or visualization' (p 1510). Semela (2010) investigated the factors influencing the choice of physics in Ethiopia and reported among others that weak mathematics background, poor teacher qualification and pedagogical content knowledge were reasons for the low enrolment of students for physics.

The reasons or explanations to the low physics enrolment after post-compulsory schooling in developed countries are not different. Williams, Stanisstreet, Spall, Boyes & Dickson (2003) investigated why secondary school students (in the UK) are not interested in physics and reported that 'the most obvious factor raised by students was the link between finding a subject boring and perceiving it as being difficult' (p 329). There is evidence in literature that students' perception of difficulty of a subject has the possibility of developing in the students, a negative attitude towards the subject. Kelly (1988) worked with children of 10 co-educational comprehensive schools in their third year in the UK on their subject choice and discovered that interest, support from parents, teachers and friends to continue with the subject, perceived future relevance and academic self-concept were dominating factors that influenced attitude towards school subjects. In the Netherlands, Stokking (2000) investigated the prediction of the choice of physics in secondary education and revealed that future relevance, appreciation and self-confidence were among dominant predictors to the choice of physics.

In summary, there is enough evidence in literature that fewer students enrol in physics relative to the other science subjects after post- compulsory school classes not only in Nigeria or developing and under-developed countries but also in many countries of the world (Smitters & Robinson, 2009; Bennett, Lubben & Hampden-Thompson, 2013). Common factors from literature that influence this low enrolment and lack of interest in physics can be summarized to include the perceived nature of the subject, lack of qualified physics teachers, lack of self-confidence and perceived future irrelevance of the subject. Recognizing the relevance of physics and the key role it plays in careers driving a fast developing scientific world with breakthroughs in medical science, space technology, agriculture and food technology, it is important to identify by research and implement workable policies that would encourage young people to develop positive interest in the study of physics at all levels.

2.5 Students' attainment in physics – a global perspective

The main aim of this study was to investigate the effect of school-based factors on physics enrolment and attainment. Attainment and its measures is therefore a key concern for this study as can be noted in the research questions. Literature on students' attainment in physics and science in general has therefore been reviewed in the sections that follow with a view of having a better understanding of attainment issues on a global perspective.

In this section, a review shall be made on the attainment of students enrolled for physics in certificate examinations. Added to the problem of low enrolment for the subject after post-compulsory classes, there seem to be a general outcry of the dismal performance of students enrolled for physics in certificate examinations (Erinosho, 2013; Osborne, Driver & Simon, 1998). Although some have argued that 'physics and chemistry are taken by students who do well and are not taken as incidental or additional subjects' (see Osborne, Driver & Simon, 1998, p 30), it becomes worrisome that those who consider themselves as 'able' and so enrol for the subject (physics), do not record impressive outcomes.

In Nigeria, there has been a recurring unacceptable attainment of students in physics. Record of students' attainment from the West African Examinations Council shows that between 2001 and 2009 (except in 2006), less than 50% of students who enrolled for physics obtained credit level pass and above to secure admission into the university to pursue courses that require physics (Adolphus, 2013). Table 1(b) shows that the failure rate continued from 2007 to 2009 (42.9%, 47.1% and 46.2%) and in 2013 (46%) with an improved performance in 2010, 2011 and 2012 (50.2%, 62.6% and 67.2%). In general, this cannot be considered an acceptable performance as many have lamented that performance of Nigerian students in physics at the Senior Secondary Certificate Examination (SSCE) has been generally and consistently poor (Adegoke, 2011; Oladejo, Olosunde, Ojebisi & Isola, 2011; Erinosho, 2013; Aina, 2013). The report of this performance of students in the subject (physics) is indicative of the fact that all is not well with its teaching and learning in Nigeria. For instance, the Federal Ministry of Education, Nigeria in its National Physics curriculum for secondary schools in justifying the review of the curriculum lamented that "unfortunately, the teaching and learning of physics has been fraught with challenges which prevent many students from performing well in external examinations" (FME, 2009: ii).

The story appears similar in Ghana – a neighbouring country in West Africa. Buabeng, Ossei-Anto & Ampiah (2014) reported that 'performance of Ghanaian students in physics has been generally and consistently poor over the years' (p. 41). They reported that majority of the students did not obtain the required grades (A – D or A1 – C6) for admission into tertiary institutions between 2003 and 2009. According to them, 'from 2003 -2005, out of 33,043 candidates who sat for the SSSCE physics papers 13.067 (39.5%) obtained grade A – D *and that* from 2006 to 2009, 41,973 (47.5%) candidates, out of 88,294 who sat for the WASSCE physics papers obtained grade A1 – A6' (p. 41). Similar concerns have been shown on the dismal performance of South African students especially blacks in the physical sciences (Gaigher, Rogan & Braun, 2006). According to the South African Institute of Race Relations (SAIRR, 2013), only 20% of students enrolled for mathematics and physics at the school certificate level achieved a pass mark of more than 50%. In South Africa, a summary of candidates' performance for 2011, 2012 and 2013 shows that at 40% pass threshold, the percentage of candidates who enrolled and passed in the physical sciences were a dismal 33.8%, 39.1% and 42.7% respectively while those who passed with distinction in the physical sciences were 3.2% in 2012 and 3% in 2013 (Republic of South Africa, 2013). This sorry state and performance level in a key subject like physics that offers fundamental knowledge that is most needed for technological advancement should be considered seriously not only by the science education community in these countries, but indeed the respective governments if their dream to actualize industrialization must come true.

In the UK, the story is interestingly different from the report of performance in most African countries. According to the Science Learning Network (2014), 91.3% of students gained A* - C grades in the 2014 physics examination. In 2013 and 2012, the percentage of students who scored A* - C grades were 90.8 and 93.2 respectively. A further breakdown of the 2014 result shows that 14.9% of students obtained A* grade with 42% obtaining the A* - A grades while 70.9% gained A* - B grades. This is considered an excellent performance especially when compared to the performance of students at similar school age cohorts in developing countries. However, for international comparison, UK did not participate in the International Association for the Evaluation of Educational Attainment (IEA's) 2008 Trends in International Mathematics and Science Study (TIMSS) attainment in Advanced Mathematics and Physics in the Final year of secondary school where international performance of students in final year of secondary education was compared in physics. Netherlands with an average of 582 came first followed by Slovenia (535) and Norway (534). The TIMSS scale average for physics was 500. Lebanon and Italy with average scores of 444 and 422 were at the bottom of the table. However, UK participated in the 2012 Programme for International Student Assessment (PISA) of the OECD for 15-year old pupils' scholastic performance on Reading, Mathematics and Science. UK occupied the 20th position scoring 514 points on the average in science above the OECD average. China (Shangai and Hong Kong) came tops with average scores of 580 and 555 respectively followed by Singapore with 551. United States of America at 28th position had an average score of 497 below the OECD average with Qatar, Indonesia and Peru at the bottom of the table with average scores of 384, 382 and 373 respectively. Although international assessments like those of PISA and TIMSS may not be used to strictly define the National attainment of students in the subjects, from the participating countries considering the different educational and particularly, science educational philosophies and goals of the various countries, they, to some extent evaluate the educational systems of the participating countries as to how well young pupils have gained reasonable knowledge and skills that would enable them to participate internationally in the knowledge society.

2.6 Teaching strategies and students' enrolment and academic attainment

Two of the research questions for the present study focus on teaching strategies regularly adopted by physics teachers and how that might affect students' enrolment and attainment in the subject. Relevant literature on research findings on teachers' use of teaching strategy in science classrooms and how that has affected students' enrolment and attainment has therefore been searched and reviewed to facilitate the discussion of findings of the present study.

It has been the interest of the science education community not only to determine what students should be learning in science lessons or the assessment as to whether or not students are actually learning but also, the 'how' in terms of what strategies or approaches teachers use that would ensure maximum understanding and effective lesson delivery. According to Tanner (2013), this is in view of drawing "attention to questioning the efficacy of traditional lecture methods and exploring new teaching techniques to support students in more effectively learning…" (p.322). The use of the traditional or conventional teaching method which is generally referred to as the 'talk-chalk' or lecture method has been much discouraged not only in science classrooms but generally in schools as a result of its gross ineffectiveness in equipping learners with life-long skills and knowledge (Raine & Collett, 2003; Selcuk & Caliskan, 2010). Bar-Yam, Rhoades, Sweeney, Kaput & Bar-Yam (2002) described the traditional/conventional teaching approach where educational goal is viewed as the transmission of knowledge from the teacher to student as a 'convergent' teaching approach and geared towards "the teaching of specified subject matter". According to them, "the convergent approach is highly structured and teacher-centered *were* the students are passive recipients of knowledge transmitted to them…"

They further stressed that where educational goals are geared towards “facilitating students’ autonomous learning and self-expression” then approaches that enhance “open ended and self-directed learning” which they termed ‘divergent’ teaching” would be stressed.

Some researchers have investigated the common teaching methods adopted by school science teachers especially in developing countries and reported that most teachers employ the traditional, teacher-centered approaches in their classroom interactions (Buabeng, Ossei-Anto & Ampiah, 2014; Faremi, 2014; Modebelu & Nwakpadolu, 2013; Mehmood & Rehman, 2011). For instance, Buabeng, Ossei-Anto & Ampiah (2014) examined the teaching and learning of physics in senior high schools in Ghana and concluded most physics teachers adopted teacher-centered approaches in their classroom interaction such as lecture and discussion methods. A similar finding was reported by Mehmood & Rehman (2011) who conducted their study in Pakistan on the teaching and classroom interactions used by secondary school teachers in the country. They reported a step-by-step activity of both teachers and students as follows:

> “(1) teachers’ presents a brief overview of the contents;
>
> (2) teacher’s uses A.V. aids to enhance the student’s comprehension of the concepts;
>
> (3) teacher speaks at a rate which allows students time to take notes;
>
> (4) teacher evaluates the success of his teaching by asking questions about the topic at the end of the session and;
>
> (5) teacher assigns homework and checks it regularly” (p.313).

This approach of teaching as illustrated above clearly presents the students as passive learners who ‘take notes’ while the teacher does the speaking or teaching. It does not present the teacher as a facilitator of learning where students are encouraged to engage with learning tasks both individually and in groups with relevant facilities and resources under the guidance and support of the teacher. This sort of teacher-centred approach to teaching is what Wise (1996) described as “teachers dispense knowledge to passive student audiences, with textbooks alone constituting the science curricula; students are rarely involved in direct experiences with scientific phenomena” (p.337). It is not very likely that students would gain substantial understanding of scientific knowledge when taught science in such didactic manner.

Several researchers have investigated the effect of teaching approaches on the attainment of learners in physics. (see for example, Wise, 1996; Raine & Collett, 2003; Selcuk & Caliskan, 2010; Celik, Onder & Silay, 2011; Bello, 2011; Hussain, Azeem & Shakoor, 2011; Hussain, Ahmed, Mubeen & Tariq, 2011; Thomas & Isreal, 2013; Uside, Barchok & Abura, 2013). For instance, Wise (1996) conducted a secondary meta-analysis to investigate the effect of experimental teaching approach on students' attainment in middle and high schools in the United States and concluded that the experimental teaching strategies at the secondary schools level were more effective at enhancing students' attainment than the traditional science teaching approaches. Uside, Barchok & Abura (2013) investigated the effect of discovery approach on physics students' attainment in Kenya. They compared the relative effectiveness of the Discovery Experimental Method, DEM and the Teacher Demonstration Method, TDM. Their study revealed that "there was a significant difference in the physics attainment of students in experimental and control groups among secondary school students in favour of the DEM" (p. 357). Their study further revealed that the Discovery Experimental Method "enhanced memory retention and instilled confidence in students to remember and apply knowledge accurately" (p. 357). In another study, Musasia, Abacha & Biyoyo (2012) investigated how girls' performance, attitude change and skills acquisition is affected by practical work in physics. They concluded that students "involvement in meaningful practical work contributes to improved performance in the topics from which the practical was derived" and that "a significant change occurred in the attitude (of girls) towards physics in the experimental group compared to the control group" (p. 163). In Nigeria, Akanwa & Ovute (2014) compared the effects of conventional and constructivist teaching approaches on the attainment of physics students. The students were taught lessons on sound and waves in 2 separate groups, with each group taught with either of the methods. They reported that students who were taught using the constructivist approach achieved significant high scores compared to those taught with the conventional method. Also in Nigeria, Thomas & Israel (2013) investigated the degree of effectiveness of some teaching strategies in measuring the performance of students in physics. They compared the effects of Polya's heuristic, project based and lecture methods on students' attainment and reported that "the use of Polya's heuristic method enhanced students' attainment" (p. 123). Karakuyu (2010) in Turkey compared the effects of concept mapping and conventional teaching approaches on physics students' understanding of electricity. 2 equivalent groups were taught using either method for a period of 6 weeks, with 2 classes of 1 hour each per week. At the end of his study, he reported that "the scores of the experimental group were consistently higher than those of the control group while the standard deviations were consistently lower" (p. 728). McCrory (2013) in his article, "in defence of the classroom science demonstration" maintained that demonstrations in science classroom emotionally engage students and make them focus and curious on what is the content of demonstration. According to him, "demonstrations are perfectly suited to exploiting curiosity (which is) the powerful engine driving most of our learning" (p. 83).

The implication of these findings is that schools need well trained teachers who are conversant with the use of relevant and diverse methods or approaches together with the knowledge of use of necessary scientific appliances and equipments in physics classrooms. Also, that these necessary resources are made available not only for the teachers' use in class demonstration, but also for the use of the individual students in their discovery learning tasks. For most developing countries, the provision of these learning resources and the utilization of appropriate teaching and learning techniques will no doubt better the performance of students in physics and science in general.

2.7 School resources, students' enrolment and academic attainment

All research questions for this study are concerned with school resources – either teachers as resources or other non-human teaching and learning resources. The study is basically concerned with the effect these school resources on students' enrolment and attainment. Relevant literature has therefore been traditionally reviewed to appraise research findings on the effect of school resources on enrolment and attainment both in developing and developed economies. The bulk of literature has been utilised to inform the discussion of the findings of the present study on the effect of resources on enrolment and attainment.

The 'Coleman Report' (Coleman, *et al*., 1966) submitted in response to the US congress mandate in 1964 for the conduct of a survey 'concerning the lack of availability of equal educational opportunities for individuals' started the intense investigation of the effects of school resources on pupils' attainment. There has however been much debate in the body of literature on the relationship between students' performance and school resources. Whereas some researchers argue that 'there is no strong or consistent relationship between variations in school resources and student performance' (Hanushek, 1997, Glewwe, Hanushek, Humpage & Ravina, 2011) others are of the opinion that there exists a strong relationship between school resources and students attainments (Hedges, Laine & Greenwald, 1996; Krueger, 2003; Pan, Rudo, Schneider & Smith-Hansen, 2003). Nascimento (2008) is of the opinion that although school resources significantly influence student attainment, such degree of influence is dependent 'on the sample taken, the level of aggregation of the data, and methodology used' (p26).

The engagement of science students with laboratory experiences has been argued to have promoted students' understanding of scientific concepts and acquisition of practical and problem solving skills (see for instance, Tobin, 1990; Blosser, 1990; Hofstein & Mamlok-Naaman, 2007). Savasci & Tomul (2013) are of the opinion that 'educational resources are of vital importance in terms of its role in attaining educational aims and objectives' and 'that educational resources play a significant role in order to provide equal opportunities for students by diminishing the effect of socioeconomic factors on academic attainment' (p114). The idea of educational resources providing equal opportunities is very apt especially for public schools in most developing countries like Nigeria, where the affluent afford to send their children and wards to expensive schools both within and outside the country to obtain quality education while the poor that could not afford to send their children to such expensive schools patronize the public schools that are generally ill-equipped and plagued with regular closures as a result of teachers' strike actions. Most of such schools with adequate resources in Nigeria are usually not within the reach of the poor as they charge as much as One Hundred and Fifty Thousand Naira (=N=150, 000) to Six Hundred Thousand Naira (=N=600,000) a term when graduates in the public service earn just about Thirty Thousand Naira (=N=30,000) to Sixty Thousand Naira (=N=60,000) a month in a country with a minimum wage of just Eighteen Thousand Naira (=N=18, 000) per month. For instance, Bello (2012) studied the effect of physics laboratory availability and utilization on academic attainment of senior secondary physics students in Nigeria and reported that parents have a preference to send their children to schools that are better equipped with adequate laboratory and teaching facilities and that federal government owned schools and private schools are more equipped that public schools that are attended by a greater proportion of school age children. Similarly, Anyanwu &Erhijakpor (2007) studied the effect of government expenditure on educational enrolment in Nigeria, South Africa, Algeria and Egypt at primary and secondary schools level and reported that expenditure had a positive and significant correlation with students' enrolment. Nascimento (2008) cited Albernaz, Ferreira & Franco (2002) whose study revealed positive effects of school resources on students' academic attainment in Brazil. In Nigeria, Meremikwu & Enukoha (2010) investigated the effects of instructional aids and school variables on pupil's mathematics attainment and discovered that school resources were 'statistically significant in explaining pupils' mathematics attainment' (p.278). A similar study by Jaiyeoba & Atanda (2011), on the effect of school quality factor on students' mathematics attainment also reported that instructional materials significantly affect students' attainment in mathematics. Adesoji & Olatunbosun (2008) conducted a study on student, teacher and school environmental factors to provide causal explanation of secondary school students' Chemistry attainment in Nigeria. The study adopted the ex-post factor research method using 621 SSS III chemistry students and 27 chemistry students in Oyo State of Nigeria. They used Chemistry attainment tests, questionnaires and Laboratory adequacy inventory as instruments. Their result showed that students' attainment in chemistry is jointly determined and significantly influenced in relative order of importance by school location, laboratory adequacy, and teachers' attitude to chemistry teaching and teachers' attendance at chemistry workshops. Adesoji & Olatunbosun (2008) concluded that 'school environment and teacher-related factors exert potent and positive influence on students' attainment in chemistry' (p.31).

Despite the relevance of adequate teaching and learning resources for the motivation of learners' interest and enrichment of their learning experience in schools, several scholars have highlighted the lack of provision of these facilities in most developing countries (Centre for Science Education, n.d; Black et al., 1998; Onipede, 2003; Magno, 2007; Edomwonyi-Otu & Avaa, 2011; Ejidike & Oyelana, 2015). For instance, Magno (2007) investigated the problems of science education in developing countries with a focus on Asia and reported that:

> "In many developing countries, the spread of the practical work approach is hindered by several factors. Among the reasons mentioned by many teachers are inadequate background knowledge about the topic; too many topics to cover; lack of science equipment, laboratory rooms, laboratory tables, and other facilities such as running water and electricity…" (p.52).

The problem of electricity in developing countries as mentioned by Magno (2007) appears to be complex as it affects the industrial and economic lifestyle of these nations. Most of these nations ultimately rely on the importation of laboratory facilities from foreign nations at very exorbitant costs that their economies could not sustain as local industries lack both the technical know-how coupled with poor power supply. This may partly explain the difficulty of the supply of laboratory facilities to schools in developing countries like Nigeria. Several studies in Nigeria have shown that most public schools lack basic infrastructure for effective teaching and learning especially in the sciences (Omosewo, 1995; Onipede, 2003; Adeyemi, 2008; Stephen, 2011; Bello, 2012).

On school resources for the teaching and learning of physics and generally, all science subjects, the place of computers and use of online simulations for the effective teaching and learning cannot be over-emphasized. In Nigeria, the government's concern for the effective teaching and learning in schools is expressed in the National Policy on Education under 'Educational Services'. Section 11 of the policy stated the goals of educational services that are expected to be provided by the government.

"The goals of educational services shall be to –

(a) develop, assess and improve educational programmes;

(b) enhance teaching and improve the competence of teachers;

(c) make learning experiences more meaningful for children;

(d) make education more cost effective;

(e) promote in-service education; and

(f) develop and promote effective use of innovative materials in schools" (FRN, 2004, 52).

It is clear from this policy statement that the main goal of the educational services is that of improving the learning experiences of students by enhancing the competence of teachers and promoting the utilization of innovative teaching and learning materials for students' meaningful learning experiences in schools. The Federal Government in the policy document also stated how these lofty goals of educational services would be achieved. Some of the strategies according to the policy (FRN, 2004:54) are:

> “A Network of Educational Services Centres in Nigeria (NESCN) shall be set up to provide a forum of exchange of ideas on the development and use of innovative materials for the improvement of education. All states, Teachers Resources Centres, University Institutes of Education, and other professional bodies shall belong to the network of Information and Communication Technology (ICT)… Government shall provide facilities and necessary infrastructure for the promotion of Information and communication Technology (ICT) **at all levels of education**” (emphasis is mine)

It may be interesting to mention here that in a bid to integrate ICT in schools in Nigeria, the Federal Government developed the National Policy on Computer Education in 1988. Part of the objectives of the policy was to “bring about a computer literate society in Nigeria by the mid-1990s” and “to enable present school children to appreciate the potential of the computer and be able to use the computer from Junior Secondary School (JSS) One to Senior Secondary School (SSS) Three” (Jegede & Owolabi, 1998: 3). Surprisingly, close to 3 decades after the national policy on computer education and over one decade after the revised policy on education in Nigeria, available evidence in literature suggests that computers and ICT facilities may not have been provided by government ‘at all levels of education’. According to Jegede & Owolabi (1998), computer education was scarcely offered in public secondary schools in Nigeria and it was limited to federal government owned colleges. Aduwa-Ogiegbaen & Iyamu (2005) alleged that implementation of the policy on computer education and the provision of educational services as contained in the national policy on education was the mere distribution of computers in some schools. In a recent study on the challenges of teachers’ use of e-learning in secondary schools in Nigeria, Nwana (2012) reported some of the challenges as “acute shortage of e-learning materials such as on-line/internet-connected computers, e-mail facilities, multimedia television, multimedia computer and digital library” (p. 1). Despite the implementation challenges of introducing innovative technologies for the promotion of meaningful learning experiences of school children in Nigeria, it is clear that it is the government’s belief that the introduction of computers and ICT for class instruction would revolutionize the teaching and learning practice in Nigeria and ensure effectiveness in the school system.

Several studies have reported the effectiveness of Computer Assisted Instructions (CAI) in physics classrooms on students’ cognitive development and academic attainment (Bayraktar, 2001; Cepni, Tas & Kose, 2006; Vogel, Vogel, Cannon-Bowers, Bowers, Muse & Wright, 2006; Adeyemo, 2010b; Smetana & Bell, 2012). For instance, Adeyemo (2010b), investigated the effects of the use of information and Technology Communication (ICT) on the teaching and learning of physics in secondary schools in Nigeria and reported that the use of ICT significantly impacted on the teaching and learning of physics and that “the introduction of ICT makes learning of physics so interesting for the students” (p. 48). The implication of the above conclusion is that students get inspired, motivated and so pick interest in the subject when ICT is incorporated into the teaching and learning of the subject. Although Adeyemo (2010b) did not explain the link between the use of ICT and students’ understanding, it is likely that the use of ICT to illustrate and demonstrate certain abstract concepts with electronic simulations could provoke interest in the learners. There is evidence in literature that what learners find interesting, they are more likely to comprehend and so make improvement in both their learning and understanding (see for instance, Williams *et al*., 2003). Also, Smetana & Bell (2012) carried out a review of literature on the effect of computer simulations on science instruction and learning. Their review involved 61 articles published in refereed science education and educational technology journals between 1972 and 2010. They reported that “The overall findings suggest that simulations can be as effective, and in many ways more effective, than traditional (i.e. lecture-based, textbook-based and/or physical hands-on) instructional practices in promoting science content knowledge, developing process skills, and facilitating conceptual change” (p. 1337). Similarly, Rutten, van Joolingen & van der Veen (2012) reviewed quasi experimental studies in literature within the period of a decade on what learning effects computer simulations have in science education and concluded that computer simulations effectively used by teachers enhanced conventional class instructions. They attributed the success of the effects of computer simulations on learning in science classes, to the “lnterplay between the simulation, the nature of the content, the students and the teacher” (p. 151). The point here is that for computer simulations to achieve the desired objectives of enhancing students’ learning, the teacher must be trained and skilled in the selection of such simulations that perfectly align with the content and learning objectives. The implication of these findings is that the use of computer assisted instruction and simulations for the teaching of physics and science in general, not only captures the interest of the students, but could also motivate and enhance their cognitive understanding of the concepts of physics. Despite the much acclaimed relevance of computers and computer simulations in science education, evidence from several studies in Nigeria and most developing countries in Africa, show that most schools do not have adequate supply of computers, internet facilities and related accessories for teaching and learning (Aduwa-Ogiegbaen & Iyamu, 2005; Adomi & Kpangban, 2010; Adeyemi & Olaleye, 2010; Nganji, Kwemain & Taku, 2010; Amenyedzi, Lartey & Dzomeku, 2011). For instance, Aduwa-Ogiegbaen & Iyamu (2005) analysed the problems and prospects of the use of Information and Communication Technology (ICT) for teaching and learning in Nigerian secondary schools and lamented that:

> "secondary schools in Nigeria are not given adequate funds to provide furniture, relevant textbooks and adequate classroom let alone being given adequate fund for high-tech equipment. At present the cost of subscribing to the Internet is too high for many of the impoverished secondary schools in Nigeria" (p.104).

According to them, more than 90% of public schools in Nigeria do not have computers as part of classroom technologies for effective teaching and learning. Similarly, Adomi & Kpangban (2010) investigated the "application of ICTs in Nigerian secondary schools" with samples drawn from 2 states in the south-south region of the country. They reported that most schools do not use ICT for their lesson as a result of lack or inadequate ICT facilities in the schools. Another factor that has been put forward for the very low or lack of utilization of ICT in classrooms has been the problem of poor electricity supply in the country. There are still many communities and schools in Nigeria without electricity and where there is supply, it is most times epileptic.

The poor state of ICT usage for classroom instructions in schools seems not to be peculiar to Nigeria. Similar situation have been reported in Cameron and Ghana (Nganji, Kwemain & Taku, 2010; Amenyedzi, Lartey & Dzomeku, 2011) all in Africa. For instance, Amenyedzi, Lartey & Dzomeku (2011) assessed the use of computers and internet as educational resource in senior high schools in Ghana and reported that less than 15% of school teachers use the computer for teaching and learning. They concluded that:

> "integration of ICT in Ghanaian school systems is a major step in promoting innovation. However, the educational system currently is bedevilled with myriads of problems including lack of adequate computers and other ICT tools especially in rural schools, poor internet connectivity, lack of adequate manpower, lack of coherent ICT policy framework" (p. 160).

The common index in the state of computer and ICT usage for the facilitation of teaching and learning especially in the science subjects in some African countries is that most of the public schools are either lacking these facilities or that the facilities are in a poor supply, coupled with the problem of lack of adequate supply of electricity. This explains why most school teachers still hang on to the traditional chalk and blackboard utility for teaching (Aduwa-Ogiegbaen & Iyamu, 2005). The state of availability of computers and ICT for teaching and learning seem to be different for developed countries of the world. For instance, as far back as 2 decades ago, Rosen & Weil (1995) investigated the availability of computer and other variables in public schools in California State in the United States and reported that computers were available in all schools. They also reported earlier studies in the US that showed that all K-6 primary schools in the US were estimated to own nearly 20 computers each, while high schools were estimated to have nearly 45 computers each. This is clearly a marked difference from the report of availability of computers in schools in most African countries.

On laboratories and students' laboratory experiences in school science, the National Science Teachers Association maintained that "for science to be taught properly and effectively, labs must be an integral part of the science curriculum" (NSTA, 2007:1). The implication here is that for students to learn science more effectively, they need to get involved in scientific investigations with appropriate teaching and learning facilities as part of the school curriculum so as to match the theories of science with practical demonstrations. When science is taught and learnt in this way, students have a better understanding of the subject content, develop appropriate scientific reasoning and inquiry skills, enhance their understanding of the natural world of science and general interest and appreciation of science and science learning (NRC, 2006). For instance, Hofstein, Shore & Kipnis (2004), investigated the effect of inquiry-based laboratory on high school chemistry students' learning skills and abilities in Israel and concluded that students improved in their inquiry learning abilities. Similarly, Odubunmi & Balogun (1991) compared the effects of laboratory and lecture teaching strategies on the academic attainment of secondary school students in Integrated Science in Nigeria and reported that whereas high achievers in both group recorded similar attainments, the low achievers in the experimental group that were taught with the laboratory method performed better than those in the control group. The result suggests that the use of laboratory facilities with concrete demonstration of abstract concepts enhances the chance of learning at least, for the low achieving group of students who would necessarily touch, feel and see before effective learning can take place. Evidence in literature also suggests that students find involvement in practical work interesting, enjoyable and that it is a motivating factor to the study of science (White, 1996; Abrahams & Millar, 2008; Abrahams & Reiss, 2012). According to White (1996:761), “laboratories motivate, even excite, students and are a major attraction for them to study science”. Despite the relevance of laboratories in science teaching and learning as posited by some researchers, others are of the opinion that students’ involvement in laboratory work in the study of science contributes little to their understanding of science especially on pencil and paper examinations. (See for instance, Hofstein & Lunetta, 1982; Tobin, 1990; Chang & Lederman, 1994). The conclusions arrived at on the ineffectiveness of students’ laboratory experience by some scholars can truly be said to be ‘disappointing’ in the words of White (1996) and Abrahams & Reiss (2012) as they clearly contradict known theories of learning as those of Bonwell & Eison’s (1991) theory of ‘active learning’, Brunner’s (1961) theory of ‘discovery learning’ supported by the theories of Jean Piaget and Seymour Papert, and Kolb’s (1984) theory of ‘experiential learning’. For instance, Brunner (1961:26) propounded that:

> “emphasis upon discovery in learning has precisely the effect upon the learner of leading him to be a constructionist, to organize what he is encountering in a manner not only designed to discover regularity and relatedness, but also to avoid the kind of information drift that fails to keep account of the uses to which information might have to be put. It is, if you will, a necessary condition for learning the variety of techniques of problem solving, of transforming information for better use, indeed for learning how to go about the very task of learning. Practice in discovery for oneself teaches one to acquire information in a way that makes that information more readily viable in problem solving”.

The position of these learning theories is that students learn better when they interact with materials not only to match or relate theory with practice or experience but that they, in the process acquire inquiry and problem solving skills that would enable him or her to construct knowledge and transform information in variety of ways in preparation for real life and work experiences.

Although the debate on the effect of students' engagement in laboratory work on students' learning and development of inquiry skills is evident in literature, the underlying concern by both groups of scholars as Lunetta, Hofstein & Clough (2007) cited by Abrahams &Reiss (2012) put it is that:

> ''Much more must be done to assist teachers in engaging their students in school science laboratory experiences in ways that optimize the potential of laboratory activities as a unique and crucial medium that promotes the learning of science concepts and procedures, the nature of science, and other important goals in science education'' (p. 433).

The implication here is that teachers need to understand the content of instruction in their teaching that would require the use of laboratory experience to promote students' effective learning and also, that students would have the opportunity in laboratory work to truly interact with materials and construct their own knowledge, imbibe the knowledge of scientific processes and not necessarily bored with the instruction-focused or manual-focused laboratory tasks where students merely verify already known scientific laws and concepts. The involvement of students in laboratory experiences just to verify already known laws and scientific concepts and demonstration, and not in the engagement of scientific inquiry and processes of investigation is what some (Chang & Lederman, 1994; Hofstein & Lunetta, 2004 and Jordan, Ruibal-Villasenor, Hmelo-Silver & Etkina, 2011, for instance), argue that defeat the place of laboratory work in science learning.

Despite the foregoing arguments and findings on effectiveness of school resources and students' attainment, it is part of educational planning for the establishment of schools at every level, that resource - ranging from teaching personnel, teaching assistants, classrooms, laboratory, staffrooms, working spaces, teacher and students' working materials are in place and adequate for the goals and general objectives of education and effective teaching and learning to take place. Unfortunately, in most under-developed and developing nations like Nigeria, where laws and implementations are not strictly complied to, schools are run either by individuals or government without adequate provision of the necessary resources for effective teaching and learning before the take-off of schools. Another very worrisome situation is the qualification of the proprietors of such schools some of whom do not have the basic educational qualification for teaching. The very high rate of unemployment and explosion of population especially of school aged strata of the population in these under-developed nations has seen the 'school business' as a very lucrative one! Shanties and very poorly hygienic environments characterize most schools in such places. The very high rate of corruption has unfortunately made regulatory agencies ineffective, all to the detriment of vulnerable kids as schools get government approval without strict conformity to set down standards. It is hoped that the findings of this research will contribute to address the much decried state of teaching and learning of science and particularly physics in schools in the study area.

2.8 Effect of teacher quality and experience on students' enrolment and academic attainment

One of the research questions for this study seeks to find how teacher qualification and experience relate to the enrolment and attainment of students in physics. Research findings on the effect of teacher characteristics on student enrolment and academic attainment has therefore been reviewed in this section to understand the effect in different educational systems across the globe and also, to provide a good guide for discussion of the findings of the present study on the subject.

A lot of educational policy makers are increasingly using students' attainment and development as a tool for assessing the effectiveness of teachers (McCaffrey, Lockwood, Koretz, Louis & Hamilton, 2004; Zuzovsky, 2005; Buddin & Zamarro, 2009; Darling-Hammond, 2012). Zuzovsky (2005) justified this use of students' attainment in assessing teacher effectiveness when she argued that with cultural differences in ethical, logical and psychological perceptions, "the tendency to evaluate teacher qualities on the basis of student performance is given even greater emphasis" (p. 38). The point here is that different cultures may have their varying standards and perceptions of what is ethical and acceptable even in terms of the general goals of education and what basic infrastructure is provided for effective teaching and learning which portends a difficulty of accessing standards of attainment across cultures or even systems or institutions.

The concern therefore is to see how well learners achieve stated goals as a basis to assess the effectiveness of the teacher. It is therefore important to focus on certain characteristics of the teacher that may enhance his effectiveness by promoting learners classroom experiences.

Darling-Hammond (2012), distinguished between ‘teacher quality’ and ‘teaching quality’. According to her, “teacher quality might be thought of as the bundle of personal traits, skills, and understandings an individual brings to teaching, including dispositions to behave in certain ways” (p.2), while “teaching quality refers to strong instruction that enables a wide range of students to learn”(p.3). The end result expected from every worthwhile educational investment is that students learn more effectively and progress further to achieve success not only in both internal and external examinations, but also outside the four walls of the school. School reforms and educational policy changes are all driven by the desire to better the learning outcomes of students in line with set societal goals. According to Zuzovsky (2005), “With the increased demands for accountability in line with performance standards and with the growing demand for evidence-based policymaking, student attainment is considered an accurate measure of teacher effectiveness and has become a basis for value-added teacher assessment systems” (p. 38).

The place and importance of the teacher in the school enterprise cannot be over emphasized as teachers remain the key asset of the school system (Hanushek, 2011). Teachers are the drivers of the actualization of the national broad policies of any nation. This is so as the educational policies of any nation are a reflection of the needs of that society and the aspiration of its people. In the school, students interact basically with teachers and research has shown some association between teacher quality and students’ attainment. For instance, Rivkin, Hanushek & Kain (2005) reported ‘large differences among teachers in their impacts on attainment’ and that ‘high quality instruction throughout primary school could substantially offset disadvantages associated with low socioeconomic background’ (p.419). Many researchers have therefore stressed the necessity of improving teacher quality and interpersonal behaviour so as to enhance students’ performance in schools (Brok, Brekelmans & Wubbels, 2004; Hanushek & Rivkin, 2006; Adolphus & Torunarigha, 2008). For instance, Brok, Brekelmans & Wubbels (2004), reported that “between 7 and 15% of the variance in student outcomes is related to differences between schools, teachers, and classes” (p. 407) and that difference between teachers account for most of the percentage. It is therefore important to identify those qualities of teachers that significantly influence learner outcome. Not only in their identification, but also that teachers in training would need to know these qualities and conscientiously inculcate, develop and build on those qualities so as to improve in the learning outcomes of students.

Schooling is one of the most vital endeavours of every individual that brings together both teachers and students in a learning environment with the later at the centre of instruction. Research evidence shows that the quality of education people receive is highly dependent of the quality of the teacher in terms of his/her content knowledge, academic/cognitive level, quality of instruction, classroom management, teacher beliefs and professional behaviours (Coe, Aloisi, Higgins & Major, 2014; Mincu, 2013; The Sutton Trust, 2011; Metzler & Woessmann, 2010, Darling-Hammond, 2000). Darling-Hammond reviewed the effect of teacher quality on student attainment from a survey of data on policies of 50 states in the United States of America and reported that "the percentage of teachers with full certification and a major in the field is a more powerful predictor of student attainment than teachers' education levels (e.g., master's degrees)" (p.32). The implication here is that, what is important in the quality of a teacher that positively impacts on his teaching and that enhances effective student learning is not the chain of degrees and certifications the teacher has acquired that are not the subject he teaches but those that are relevant to his teaching subject. For instance, a biology teacher who has a Master's degree in biology with appropriate certifications in CPDs in effective teaching on the biology curriculum may not be as effective in teaching physics as one who has a Bachelor degree in physics with adequate CPD workshop and training certifications in physics. Similarly, Metzler & Woessmann (2010) investigated the effect of the subject knowledge of teachers on their students' attainment among 6th grade Peruvian students on mathematics and reading, and reported that "a one standard-deviation increase in teacher subject knowledge raises student attainment by about 10 percent of a standard deviation." (p. 20). What this means is that teachers with better knowledge of the subject content are most likely to support their students' understanding with appropriate classroom activities than those with less knowledge and mastery of the subject matter.

It is a common observation that most parents and students are attracted to schools with high quality teachers where their students make consistent good grades in external examinations. Placements into such schools are usually competitive with the 'most able' students gaining places while the 'less able' are filtered to source for placement in schools with 'less able' teachers. This scenario complicates the research results on the effectiveness of teacher characteristics on students' attainment. It is also observed that most of the well 'sought for' and able teachers move to 'good' schools with higher pecuniary offers and more able students. Hanushek, Kain & Rivkin (2004) captured these concerns and showed that 'teachers switching schools or districts tend to move systematically to places where student attainment is higher' and that 'this movement suggests the possibility of a simultaneous equations bias – that higher student attainment causes more experienced teachers or at least that causation runs both ways' (p.1059). Whatever the concerns may be, generality of researchers seem to find a place in assessing the effectiveness of teachers, educational policies, reforms, investments and interventions by the learner outcomes or students' attainments. In this study therefore, some teacher qualities elicited from research instruments and methods are investigated and correlated with students' attainment.

2.9 Professional development and teacher effectiveness

Teachers' professional development in areas of content, pedagogy, use of technology, assessment and feedback, lesson preparation and presentation are perceived as relevant to the quality and effectiveness of the teacher. In this section, relevant research findings in literature on the place and effect of teachers' continuing professional development has been reviewed to have a good understanding of current research findings, give focus to the study and adequate guidance to the discussion of findings on the subject for the present study.

The place and role of teachers as a valuable resource in the school as a system of educational activities cannot be overemphasized. In general, studies have shown that certain factors within the teacher's control significantly influence the academic attainment or progress of his pupils (Mcber, 2000; Harwell, D'Amico, Stein & Gatti, 2000; Rivkin, Hanushek & Kain, 2005; Cox, 2015). Some of these factors according to Mcber (2000) are the teacher's teaching skills, his professional characteristics and the classroom climate which together accounted for "well over 30% of the variance in pupil progress" (p.9). Some of these skills in teaching and professional characteristics are developed in teacher training and re-training activities in organized Continuing Professional Development (CPD) programmes by relevant professional bodies and institutions.

Parents and sometimes, students in certain allowable circumstances use teacher quality differences among teachers to request for class placement with specific teachers (Rivkin, Hanushek & Kain, 2005). The teacher plays several roles in the context of the school system. Some of the roles of the teacher have been summarized by Cox (2015):

> “The role of a teacher is to help students apply concepts, such as math, English, and science through classroom instruction and presentations. Their role is also to prepare lessons, grade papers, manage the classroom, meet with parents, and work closely with school staff. Being a teacher is much more than just executing lesson plans, they also carry the role of a surrogate parent, disciplinarian, mentor, counsellor, book keeper, role model, planner and many more”

As can be seen, the teacher has very many roles from the stage of lesson preparation, selection of appropriate delivery techniques, lesson presentation and classroom management, to that of skills in effective assessment and feedback to pupils, parents and school authorities, not excluding some other roles that posit the teacher as a role model, counsellor, facilitator and even a surrogate parent. These enormous task bequeathed on the teacher demands that the teacher is not only well trained or satisfy some basic Teacher Standards in his initial qualification process, but that the teacher whilst in service is prepared adequately with training and re-training programmes that would sufficiently support the teacher in demonstrating enhanced skills and knowledge development in those Teacher Standards that would enable him actualize his classroom roles and expectations effectively. Some scholars have advocated that teachers’ continuing professional development if appropriately executed would improve teachers’ quality of instruction, lesson delivery skills, subject content knowledge and confidence which could in turn result in school pupils obtaining higher academic attainments (Harwell, D’Amico, Stein & Gatti, 2000; Knapp, 2003; Richards & Farrell, 2005; Kunz, Nugent, Pedersen, DeChenne & Houston, 2013).

There is empirical evidence in literature that supports the positive effect of teachers’ participation in continuing development on both the teacher’s efficiency and pupils’ academic attainment. For instance, Kunz *et al.*, (2013) investigated the differences between rural science teachers who received professional development in guided scientific inquiry and those who did not receive any form of professional development and reported that:

> “Teachers’ pedagogical content knowledge (PCK) of guided science inquiry significantly increased from 34% correct before the summer portion of the guided science professional development institute (i.e., Summer Institute) to 58% correct immediately after the Summer Institute (p=.000). Similarly, teachers’ scientific inquiry knowledge (SI) significantly increased from 69% correct prior to the

> Summer Institute to 80% correct immediately after the Institute (p=.002). The growth of teachers' classroom inquiry knowledge (CI) was not statistically significant (from 68% to 72% correct, p=.125)" (p.6).

The results above show that teachers' participation in professional development programmes significantly enhanced their pedagogical content knowledge (a measure of their instructional strategies) and scientific inquiry knowledge (a measure of teachers' knowledge of the nature of science and inquiry in science) with an improvement (from 68% to 72%) in the teachers' classroom inquiry knowledge which measured teachers' scientific questioning skills and abilities, priority to evidence and formulating explanations (Kunz, *et al.*, 2013). Similarly, the study by Yoon, Duncan, Lee, Scarloss & Shapley (2007) that reviewed studies on the effect of teacher professional development on students' attainment, reported that professional development of teachers enhances their skills and knowledge which ultimately bettered their classroom interaction and teaching skills. On the link between professional development of practicing teachers and students' attainment, Yoon *et al.* (2007) reported that:

> "Professional development affects student attainment through three steps. First, professional development enhances teacher knowledge and skills. Second, better knowledge and skills improve classroom teaching. Third, improved teaching raises student attainment. If one link is weak or missing, better student learning cannot be expected. If a teacher fails to apply new ideas from professional development to classroom instruction, for example, students will not benefit from the teacher's professional development" (p. 4).

Yoon *et al.* (2007) also reported studies which showed that "students would have increased their attainment by 21 percentile points if their teacher had received substantial professional development" (p.2) and that teachers who get involved in least amount of professional development of between 5 – 14 hours did not show any statistically significant effect on the attainment of their students.

The foregoing therefore underscores the necessity and importance of quality continuing professional development programmes for in-service teachers – A professional development programme that would expose and engage teachers with quality time and duration on subject content knowledge, pedagogy, classroom management, teacher standards, integrating information technology into subject content, improving students' critical thinking and inquiry skills and effective assessment and feedback techniques. Such an efficient and effective professional development programme would then not be a one-day, one-off programme if the much desired goals of the programme must be achieved. On the criteria for a good quality teacher professional development programme, Yoon, *et al.* (2007), cited the No Child Left Behind (NCLB) Act of the United States which defined five criteria:

> "(1) It is sustained, intensive, and content focused—to have a positive and lasting impact on classroom instruction and teacher performance.
>
> (2)It is aligned with and directly related to state academic content standards, student attainment standards, and assessments.
>
> (3)It improves and increases teachers' knowledge of the subjects they teach.
>
> (4) It advances teachers' understanding of effective instructional strategies founded on scientifically based research.
>
> (5)It is regularly evaluated for effects on teacher effectiveness and student attainment" (p.1,2).

In the light of the NCLB Act, it is important to stress that the sort of professional development programme that would have a substantial impact both on the teacher and the school system, is one that is content-focused, aligned with established teacher standards, professionally useful to the teacher in terms of the enhancement of his skills and knowledge, sustained over time and is regularly appraised for its effectiveness. Considering the importance of teacher training and re-training, it is imperative that school administrators and policy makers conscientiously plan, encourage and support both inexperienced and experienced teachers to get engaged with regular quality professional development programmes so as to enhance their knowledge and skills and improve the academic attainment of their students.

2.10 School climate and students' enrolment and academic attainment

The school climate and the general quality of school life with their effect on enrolment and attainment are of interest to the present study as evident from the objectives and research questions. In this section, some studies on school climate and how that affects students' school attendance and academic attainment has been reviewed. The review has contributed to understand current issues on the subject and also, to provide necessary guide on the subject for the discussion chapter.

The quality of school life and character of school pupils and staff among themselves, with the facilities and the environment that creates, has been shown to significantly affect students' learning and attainment (Marshall, 2004; Thapa, Cohen, Guffey & Higgins-D'Alessandro, 2013). School environments may vary significantly sometimes depending on the prevailing socio-economic situations, culture and occupation of the people, legal systems operational in the society and how well these laws are respected, enforced and adhered to. School learning environments that are not friendly or hospitable may not encourage effective teaching and learning which in the long run could negatively affect students' attendance to school and attainment (Macneil, Prater & Busch, 2009). Loukas (2007) opined that it is difficult to proffer a succinct definition of school climate and that there is a consensus among scholars that it has physical, social and academic dimensions. A very broad and all-encompassing definition and description of school climate was offered by the National School Climate Council (2007) of the United States of America:

> "School climate refers to the quality and character of school life. It is based on patterns of school life experiences and reflects norms, goals, values, interpersonal relationships, teaching, learning and leadership practices, and organizational structures. A sustainable, positive school climate fosters youth development and learning necessary for a productive, contributing and satisfying life in a democratic society. This climate includes norms, values and expectations that support people feeling socially, emotionally and physically safe. People are engaged and respected. Students, families and educators work together to develop, live and contribute to a shared school vision. Educators model and nurture attitudes that emphasize the benefits and satisfaction gained from learning. Each person contributes to the operations of the school and the care of the physical environment" (p.4).

The baseline of the concept of school climate is that of a shared responsibility among students, parents, teachers, school proprietors and school administrators; who engage and support one another for the sustainable development of the school environment and for the fostering of satisfactory, productive and effective teaching and learning activities. It is therefore important for the attainment of desired educational goals that learning environments are safe, conducive and inviting with students freely engaging in their work, supportive of one another and interacting positively in inter-personal relationships without fear or intimidation. This kind of classroom or school climate and environment will no doubt encourage effective teaching and learning.

Studies have shown that positive and sustained school climate promotes students' learning and ultimately enhances academic attainment (McBer, 2000; National School Climate Council, 2007; Thapa, Cohen, Guffey & Higgins-D'Alessandro, 2013; Cohen, 2014). More specifically, a positive school climate has been found to improve students' attainment, graduation rates and retention of teachers and students in schools (Thapa, *et al.*, 2013), encourage the optimum use of learning opportunities that promotes students' participation to learn (McBer, 2000; NSCC, 2007) and also, that positive school climate has been recognized as an intervening variable between the quality of school facilities and attainment of students (Uline & Tschannen-Moran, 2008). It is obvious that a positive school climate that supports effective teaching and learning environment where students, teachers and administrative staff respect and give regards to set norms would be devoid of violent acts and bullying with a high sense of communality and acceptable use of school facilities which would support teaching and learning. On schools with unfriendly learning environment, Macneil, Prater & Busch (2009) argued that:

> "Unhealthy schools lack an effective leader and the teachers are generally unhappy with their jobs and colleagues. In addition, neither teachers nor students are academically motivated in poor schools and academic attainment is not highly valued" (p 75).

OECD (2013), in its report of the results of the 2012 PISA assessment that involved 65 countries and economies stated that:

> "if offered the choice of schools for their child, parents are more likely to consider such criteria as 'a safe school environment' and 'a school's good reputation' more important than 'high academic attainment of students in the school'" (p.18).

The report also stated that secondary schools with higher records of indiscipline and such related school climate are more inclined to have a good proportion of disadvantaged students with a more diverse socio-economic student population and that such schools are also characterized by the shortage of qualified teachers. It is no doubt that teaching and learning in such schools where qualified teachers are lacking and where parents would normally not prefer their children to attend may be hampered with resultant low academic attainment. The PISA 2012 assessment, investigated aspects of the learning environment that involves student truancy and school climate and reported that “systems with larger proportions of students who arrive late for school and skip classes tend to show lower overall performance” (OECD, 2013:18).

From the foregoing, it is imperative that school managers deliberately pursue the advancement of a healthy and friendly school climate which has been proved to enhance the morale of teachers and students with the effect of improving students’ participation in the school community and attainment (Macneil, Prater & Busch, 2009). Although several studies have associated positive school outcomes to a healthy school climate, not many have discussed how school climate actually affects student outcomes. Loukas (2007) stressed that to plan and execute effective interventions that would improve the school climate, it is imperative that we do not only know about the fact that a good school climate results in students and teachers willingness to be in school and also improved student outcomes, but that the mechanism and interaction of factors that underlie the relationship is properly understood. School connectedness – the perception of students having a sense of belonging and association with other members of the school community - has been identified as one of the processes that could explain the effect of school climate on students’ learning outcomes (Loukas, 2007). Expatiating upon the mechanism of association between the variables of school climate and student outcomes, Loukas (2007) explained that:

> “high-quality school climates cultivate a connection to the school and in this way protect youths from negative outcomes. That is, quality of school climate impacts student feelings of connectedness to the school and, in turn, the level of connectedness is directly predictive of how students behave and feel”(p.2).

The highlight of her explanation is that a safe and friendly learning environment would encourage pupils to want to belong to the school as a teaching and learning community and longing to see each other on the next school day in a friendly atmosphere with teachers and students supporting one another. Students in such an atmosphere make healthy school associations with their peers and teachers with a positive drive to learn. Students would normally learn better in such climate and so are most likely to make positive improvement in their learning outcomes.

2.11 School location, student enrolment and academic attainment

Research findings on school location and how that affects student enrolment and academic attainment has been reviewed in this section. Although there was no research question that was formulated to directly investigate this in the present study, the review of literature has contributed to shape the study and the presentation and discussion of findings on contextual data as presented in chapter 4.

The place where a school is located is referred to as the school location. PISA of the OECD defined a school location as “the community in which the school is located” and classified school locations in terms of their population with communities with a population of less than Three thousand people classified as villages, small towns with a population of between Three thousand and Fifteen thousand, towns with populations of between Fifteen thousand and One hundred thousand and a city with populations of between One hundred thousand and One million. (OECD, 2007:697).

In most developing countries with few amenities, unemployment, underemployment and lack of adequate infrastructure for meaningful living in the rural areas, people migrate to the city centres in search for better economic and living conditions such as employment and access to better medical facilities (Fischer, 2009). As a result, the population in the rural areas is reduced while the urban areas witness increase in population and possibly, overpopulation. It is therefore common to witness high or over population in schools in urban areas while those in the rural areas are characterized with low population. In this section, literature on the implication of all these on the quality of students, teachers and their possible effect on students’ academic attainment is reviewed.

In view of the importance of school location in teaching and learning and possible effect on students’ attainment, some researchers have investigated the link between school location and learners’ motivation and attainment as documented in literature (Osokoya & Akuche, 2012; Owoeye & Olatunde, 2011; Yusuf & Adigun, 2010; Xu, 2009; Gordon & Monastiriotis, 2006). In Nigeria, Osokoya & Akuche (2012) investigated the effects of school location on the learning outcomes of students in physics and reported that there was a significant effect of school location on students' attainment. According to them,

> "Distribution of teachers in the rural schools is not comparable with the urban schools. The number of teachers in rural schools is usually low because teachers do not readily accept postings to rural areas, because rural communities are characterized by low population, monotonous and burdensome life. Most teachers prefer to stay in the schools in urban areas because of the benefits and comforts of the city which include good roads, satisfactory means of communication, availability of books and teaching materials, etcetera. Highly qualified teachers also prefer to stay in city schools" (p.242).

The above revelation may well explain the outcome of their investigation that pupils in schools located in the urban areas achieve better than their counterparts who school in rural communities in the country. The situation where more qualified and experienced teachers are concentrated in urban schools leaving the mostly new and inexperienced teachers in the rural schools flouts the right of young children in the rural communities to quality education as enshrined in the national policy on education:

> "every Nigerian child shall have a right to equal educational opportunities irrespective of any real or imagined disabilities each according to his or her ability" (FRN, 2004:7)

And that the philosophy of education is based on:

> "the provision of equal access to educational opportunities for all citizens of the country at the primary, secondary and tertiary levels…" (FRN, 2004:7).

The forgoing presents the problem of policy formulation, implementation and practice in Nigeria. With the expected fewer class sizes in the rural areas, there is the possibility of rural students competing favourably with their urban counterparts if exposed to 'equal educational opportunities' as quality of teachers, facilities and other amenities. In the United States, Xu (2009) investigated the effect of school location, attainment of students and homework management and reported that middle school students in urban areas were more self-motivated during homework than their counterparts in rural middle schools. Justifying his conclusion, on the less initiative of rural middle school students during their homework, Xu (2009) explained that rural students demonstrate less importance on academics and homework as they are more hesitant about continuing their schooling from high school to college and that the explanation was consistent with research findings that the "educational aspiration of students may influence the strategies they use to engage in studying and the level of effort they devote to that work" (p. 38). Considering the evidence in literature that suggests that students' educational aspiration influences their learning efforts and that there is inequality in the aspiration of students in rural and urban areas, government and all stake holders in the education industry need to bridge the gap in terms of supply of teachers, provision of adequate teaching and learning facilities and amenities, so as to be true to be providing 'equal opportunities' to all, as stated in the national policy of education in Nigeria.

2.12 Issues of gender in science enrolment and attainment

In this section, research findings on gender in science enrolment and attainment have been reviewed. The review has brought to the fore current research findings on gender in science and has thus, informed the investigation of effects of gender on teacher characteristics and school resources in science as presented and discussed in chapters 6 and 7.

The space of science education discussions on gender representations in science and science related fields have been on for several decades with little or no difference on the ratio of boys to girls in science dominated classes in many countries. Most science, technology, engineering and mathematics classrooms continue to be dominated by males than females (Reid & Skryabina, 2003; Bettinger & Long, 2005; Institute of Physics, 2011, 2012). In physics particularly, the Institute of Physics (2011) reported that only about 20% of physics A-level students in the UK were girls and that the percentage has not changed for 25 years.

The Institute of Physics has been at the forefront in promoting research and support for increased female representation in physics in the UK. The relatively fewer numbers of girls are performing as good as their male counterparts in the subject (IOP, 2012; Blickenstaff, 2006). The question that many would ask is: if girls do well in physics, why is it that they do not progress with the subject post-16? Blickenstaff (2006) argued that girls choose not to continue with the study of science as a result of the lack of encouragement and support they receive from science teachers who are predominantly males. For instance, he reported that girls complain of the unwholesome behaviour of boys in disrupting classes and other learning activities and that "teachers tended to be overly generous in their predictions scores on national exams in science, while tending to underestimate girls' scores on the same tests" (p.380). In the view of Blickenstaff, this behaviour of boys in a male dominated class environment coupled with the supposed teachers' low expectation of girls' performance in science, lack of adequate encouragement and support in science classes could no doubt dissuade them to continue with science related disciplines in post-16 classes. The Institute of Physics (IOP) also holds a similar position when it stated that:

> "the low numbers of girls choosing to take A-Level physics is a continuing cause for concern. It means that girls who would enjoy and excel at A-level physics are being denied the opportunity because their experience of physics up to age 16 is not as encouraging or positive as it should be" (IOP, 2012, p.5).

The Institute of Physics in the UK, National Science Foundation in the United States and many other organizations have invested much into research in a bid to gain the interest of female students with stimulating experiences that could encourage their participation not only in physics but in all STEM related disciplines.

As a way of motivating female students into science disciplines, Bettinger & Long (2005) and Blickenstaff (2005) advocated that more females be encouraged to teach science so as to serve as role models. This in their view would encourage, motivate and challenge female students to choose science related courses and disciplines and also eliminate the male dominated biases that female students face in such classes.

2.13 Summary of literature review

Literature on theoretical and empirical reports and findings has been reviewed in this study. From the theoretical perspective, students' attainment has been found to be influenced by student ability and prior attainment, motivation, learner's age/developmental level, quality and quantity of instruction, psychological learning environment such as classroom and home environments, peer group and exposure to mass media outside the school (Walberg *et al.*,1981; Reynolds & Walberg, 1992).

Several studies on school effectiveness and factors that contribute to or affect the learning outcomes of students have been reviewed in this research. Whereas some researchers (Hanushek, 1994a, 1994b, 1997, 2006; Glewwe, Hanushek, Humpage & Ravina, 2011) have argued that variations in the school resources do not significantly affect student attainment others like Heyneman & Loxley (1983), Fuller (1986), Hedges, Laine & Greenwald (1994a, 1994b) Greenwald, Hedges & Laine (1996) and Krueger (2003) have maintained that school-based factors strongly affect students' school attainment, especially in developing economies.

However, an overview of the reviewed studies reveals that most of the studies on factors affecting students' choice and attainment in general are foreign and not conducted in Nigeria. Also, only few studies have been found to focus on school-based factors and physics enrolment and attainment in particular. It therefore became necessary to investigate the effects of school-based factors on the enrolment and attainment of physics students in a developing country like Nigeria.

Chapter 3: Research Methodology

3.1 Introduction

This study is an investigation of school-based factors that affect the enrolment and attainment of senior secondary school physics students in Rivers State, Nigeria. The research methodology or design and methods employed for the collection of data are discussed in this chapter. Descriptive and analytical survey and case study designs have been utilized for the study. For the collection of data, questionnaires, interviews, observations, and secondary data acquired from the West African Examination Council (WAEC) in Nigeria and the schools involved in the study together with the Physics Attainment Test (PAT) designed by the researcher, constitute the methods of data collection for the study. The details about the procedure for the pilot study and discussion of the outcomes of the pilot and initial analysis of the secondary data on students' attainment in physics and science subjects generally will also be discussed. Next is the section on the procedure for the collection of data for the main study. The chapter closes with the section on the data analysis methods and validation of the study.

3.2 Background and research focus

The low enrolment and performance of students in physics in particular and science more generally in Nigeria has been a major concern to researchers, parents and other stake holders (Oladejo, *et al.*, 2011; Bello, 2012). Over the years, there has been no identifiable national intervention to particularly stem this tide of low enrolment and dismal performance in the science subjects in Nigeria. Available literature also suggests that most studies on performance and enrolment in physics in particular, and science subjects generally, in Nigeria adopt questionnaires to elicit information on the state of teaching and learning, and tests to compare academic attainment. The use of questionnaires generate much quantitative data but is quite inadequate to understand the emotions and feelings of the participants who give very limited amount of information with little or no explanations (see for instance Bello, 2012; Omosewo, Ogunlade & Oyedeji, 2012; Oladejo *et al.*, 2011; Omosewa, 2003). This study employed interviews and observations in addition to questionnaire methods to dig deep into understanding the state of the teaching and learning of physics. Also, not many studies in Nigeria have critically examined the school system to identify how school-based factors affect the enrolment and performance of students in physics or science in general. It is no wonder that there has not been any national intervention to address the poor state of science teaching and learning in Nigeria. None of the education reforms in Nigeria has particularly and practically addressed the poor state of science teaching and learning in Nigeria as it is presently. Some of the educational reforms in Nigeria are the Regional compulsory and free primary education of the Western Region in 1955, Universal Primary Education (1976), National Policy on Education (1977, 1981, 1998, 2004 and 2007), 6-3-3-4 system of education (1981), National Science and Technology Policy (1986), Nigeria National Computer policy (1988) and more recently, the Universal Basic Education (1999) (Gbamanja, 1999; Ogunleye, 1999).

This study aims to provide a thorough investigation of school-based factors and how they might affect the teaching and learning of physics in secondary schools in Nigeria by combining both the descriptive –analytical and case study approaches. It is hoped that the understanding of the interaction of these school factors with students and teachers will benefit school managers, authorities and all stake holders to pursue policies that will reverse the trend of low enrolment and performance in physics and science in general in Nigeria.

3.3 Research design

This study had made use of mixed methods to comprehensively investigate school-based factors that affect physics students' enrolment and achievement in Nigeria. Creswell (2012) defined mixed method as 'a procedure for collecting, analysing, and "mixing" both quantitative and qualitative methods in a single study or a series of study to understand a research problem' (p.535). This approach has been chosen to deal with the research questions in an in-depth manner with the collection of data in varied forms as to present a comprehensive picture of the issues under investigation. Particularly, this research adopted the descriptive survey together with the case study design. As a survey, questionnaires and tests shall be used to obtain information from schools in the area of study with the aim of establishing the status quo in the various schools, making comparisons and drawing some assumptions about the observed conditions without manipulating any variable in the study. The term 'survey' can be used in different ways, but generally, it entails the generation of data through the collection of information from a sample of respondents through their voluntary response to questions. Nwankwo (2010:72) defined descriptive survey as:

> that in which the researcher collects data from a large sample drawn from a given population and describes certain features of the sample as they are at the time of the study and which are of interest to the researcher, however, without manipulating any independent variables of the study.

A survey design utilizes tools to collect information about individuals, groups, systems or institutions and is commonly used in education and social science research. According to Bachman & Schutt (2014), the versatility, efficiency and generalizability of the survey research has lent itself to be commonly used by researchers.

Questionnaires for physics teachers, and physics and non-physics students, together with SSCE physics results and the researcher-made 'Physics Attainment Test' (PAT) were utilized to elicit data for the survey. As Bell (2008) put it, 'Surveys can provide answers to the questions - what? Where? When? and how?, but it is not so easy to find out Why?' (p14). So as mentioned earlier, the case study was adopted together with the survey to have a deeper understanding of the issues under study and to give answers to the 'why' questions as regards school-based factors that affect physics enrolment and performance. This type of research addresses the 'what' of numerical and quantitative data from questionnaires and the 'how' and 'why' of qualitative data from interviews and observations (Cohen, Manion & Morrison, 2011; Johnson, Onwuegbuzie & Tuner, 2007). Interviews with physics teachers and physics and non-physics students and physics classroom observations were used to generate qualitative data for the case study.

3.4 Methods used in the investigation

Under this section, the tools or instruments that are used for the collection of data are described. Questionnaires, interviews, classroom observations, Physics Attainment Test (PAT) and secondary data are the methods of data collection for the study.

3.4.1 The questionnaires

Three questionnaires were developed for use in the study. They are the Questionnaire for Physics Teachers (QPT), Questionnaire for Physics Students (QPS) and the Questionnaire for Non-Physics Students (QNPS). The questionnaires are intended to elicit information from respondents that would generate data for statistical analysis to answer research questions. Professional physics teachers in Nigeria also validated the questionnaires that the questions measure what they were supposed to measure. What follows is a brief description of each of the questionnaires.

The *Questionnaire for Physics Teachers (QPT)* (see Appendix A) is a 22-item instrument initially designed and developed with questionnaire items adapted from the Trends in International Mathematics and Science Study (TIMSS) Advanced 2008 'Teacher Questionnaire' and the OECD's PISA 2012 'School Questionnaire'. Items from these instruments were adapted mainly because of the reliability and validity of those instruments used in international study. In adapting the questionnaires, only relevant aspects that could generate data on school-based factors have been included in the QPT; aspects of the original instrument that were not investigated in the present study were excluded. For instance, questions that look at parental level of education and status were not included in the QPT as those factors are not investigated in the study. Also, consideration for the reasonable time that teachers would need to complete the questionnaire without much distraction to their normal school responsibilities, together with the goal of making the instrument relevant and suitable for use in the Nigerian context necessitated the shortening of the number of items and the modification of some of the original items on the TIMSS and PISA questionnaire. For instance, Question 7 that had to do with the teachers' qualification was adapted to reflect the possible teacher qualifications in Nigeria. The Questionnaire for Physics Teachers (QPT) fielded questions about the school, teacher characteristics and qualification, availability and utilization of resources for teaching Physics, teachers' professional training and activities in the school and the school climate which have been identified in literature to have some effect on students' enrolment and attainment (Hanushek, 1997; Williams, Stanisstreet, Spall, Boyes & Dickson, 2003;Gamoran & Long, 2006; Yu, 2007;Nascimento, 2008; Lips, Watkins & Fleming, 2008; Bello, 2012; Aina & Akanbi, 2013). A copy of the Questionnaire for Physics Teachers (QPT) is attached as Appendix A.

The *Questionnaire for Physics Students (QPS)* (see Appendix B) is a 12-item instrument with most questions adapted from TIMSS 2008 and UPMAP 2008 (Understanding Participation rate in post-16 Mathematics And Physics) instruments for physics students. The UPMAP study investigated the influence of factors such as home, school, out-of-school and individual on students' participation in mathematics and physics after the compulsory years (post-16) of secondary education in the UK. As explained earlier, the major reason for adapting these instruments is that such instruments have established reliability and validity. In adapting the instruments, only questions that are related to school-based factors in line with the focus of the study have been carefully considered for inclusion in the QPS. For instance, questions about the home of school pupils – quantity of books, magazines and newspapers, parental level of education, etc were not considered for inclusion in the QPS as those areas are not of primary interest of investigation in the present study. The number of questions was also curtailed with some items modified and made relevant and suitable for use in the Nigerian context. The instrument seeks to elicit information in line with research objectives, about the school, students' choice of physics, students' experiences in physics classrooms, their perception about their physics teacher and their school climate. A copy is attached as Appendix B.

The *Questionnaire for Non-Physics Students,* QNPS, (see Appendix C) is a One-page 5-item questionnaire intended to elicit information from non-physics senior secondary school students on the experiences in science classes during the compulsory years of schooling and what school-based factors that might have informed their decision not to choose physics. The questionnaire items for this instrument were developed by the researcher from some original items from the TIMSS questionnaire for physics students that were reversed and modified for non-physics students who were included in my study. Both the reversed and other items added by the researcher to align the instrument to the Nigerian context, were informed by evidence in literature on possible factors that could influence students' choice of subjects. For instance, whereas the question: "The way physics contents in Basic science was taught motivated me to choose physics" was used for the QPS, it was reversed to "The way physics contents in Basic science was taught made me NOT to choose physics" for the Non-physics students. A copy is attached as Appendix C.

3.4.2 Interview schedules

Questionnaires are generally considered inadequate to capture certain forms of information like changes in behaviour and emotions. There is also the problem of limited amount of information with no explanation of views as respondents' thoughts are not explored. Interviews are therefore proposed to obtain detailed and qualitative information from respondents on topical issues in line with research objectives. As Bell (2008) put it, 'one major advantage of interview is its adaptability. A skilful interviewer can follow up ideas, probe responses and investigate motives and feelings which the questionnaire can never do' (p.157).

Two semi-structured interview schedules have been planned for this study – The Interview Schedule for Teachers (ISfT) (see Appendix D) and the Interview Schedule for Students (ISfS) (see Appendix E). The ISfT is made up of 9 questions and intended to last between 45-60 minutes, while the ISfS is composed of 8 questions and is designed to add some 'flesh' to the information expected from the questionnaires, secondary data and classroom observation. All questions on the schedules (ISfT and ISfS) were well thoughtout questions developed by the researcher from an extensive search of the literature on possible school-based factors that could influence students' enrolment and attainment in physics. The schedules were designed to elicit information from respondents on relevant school-based factors that could influence students' choice of physics and their attainment. For instance, questions on the state of teaching and learning of physics in their schools, availability and utilization of physics teaching and learning resources and their classroom experiences were asked. The ISfT was used for only Physics teachers, while the ISfS was used for the focused group interviews composed of both physics and non-physics students who are in the final year of secondary education in selected schools.

3.4.3 Classroom observation

It is considered important to obtain information on what actually goes on in physics classrooms. The collection of data by observation in addition to those collected by questionnaires and interviews further strengthens and enriches the data base (Simpson & Tuson, 2003). The teacher and students will form the focus of the observation. On the part of the teacher, aspects considered for observation include his (or her) social/personal interaction with students, teaching strategies, resource utilization, teacher-talk time, teacher demonstrations, role while students work, question types and styles. Students participation (students-talk time), involvement in hands-on activities, demonstrations and forms of involvement in class were focused on during the observations. The main instrument used for the class observation was the 'Science Classroom Observation Worksheet' (SCOW), developed by the RMC research corporation in collaboration with the Leadership and Assistance for Science Education Reform (LASER) of Washington State. The Science Classroom observation Worksheet was designed for use by researchers to gather quantitative data 'to determine the degree to which students are engaged' in effective science learning experiences 'as a result of the science instructional practices within the school' (p.3). The instrument has been adopted for use in this study basically because of it established content validity and reliability of over 0.9. The instrument was used to observe single lessons across many teachers. The instrument was designed to assess the evidence of 4 broad traits considered for an effective science teaching and learning – learning objectives, developing understanding, sense-making and classroom culture. Another instrument – The Classroom Observation Schedule (COS) that was developed by the researcher was also used alongside the SCOW for the classroom observations. The instrument is time based and was intended to record both teachers and students activities for the duration of the class period. The Classroom Observation Schedule and the Science Classroom Observation Worksheet are attached as Appendix F1 and F2 respectively.

3.4.4 The Physics Attainment Test (PAT)

The PAT was introduced into the study considering the analysis of the performance data of students in the Senior School Certificate Examinations (SSCE) conducted by the West African Examination Council (WAEC). The results as shown in Table 1(b) show no trend over the years with a wide variation in attainment among schools. There is also the issue of creditability in the conduct and attainment of candidates in the examinations in Nigeria with reports of wide spread examination malpractice. The PAT was therefore designed to be conducted under strict examination conditions by the researcher to ascertain the level of attainment of students in physics in secondary schools in the study area. The PAT is also intended to cross-check the students' performances in the various schools and to compare same with the SSCE performance ratings of the schools.

The Physics Attainment Test (PAT) is made up of 6 questions drawn from past University of Cambridge International General Certificate of Secondary Education (IGCSE) October/November 2012 physics examination question paper and General Certificate of Secondary Education (GCSE) November 2012 and January 2013 physics examination question papers. Questions were adapted from these examinations for some reasons. One, the examinations are internationally recognized with candidates from most countries including Nigeria, writing the examinations. Two, the examination questions are standardized and attainments recognized by most universities and employers of labour across the globe as a reliable evidence of attainment. The items of the examinations are therefore deemed highly valid and reliable. Three, to see how well physics students in Nigeria would fare in the test relative to students' performance in the SSCE and lastly, to make possible international comparisons of students' physics performance. In selecting questions from these instruments for the Physics Attainment Test, PAT, items with terminologies and objects that are not common in the Nigerian context were not included. For instance wind turbines, washing machines and sun beds are not common terms most Nigerian school children would be familiar with and so questions with such items have not been used even when the physics concepts may have been contained in the senior secondary school physics curriculum that is used in Nigeria. The 6 questions in the PAT cover content in 3 of the 5 core content areas of the senior secondary physics curriculum – 'interaction of matter, space and time', 'conservation principles' and 'fields at rest and in motion'. The coverage was considered adequate to test for a general knowledge of the subject for students in the senior secondary class 3 in Nigeria. Consideration to construct a test that would take students about 45 minutes also informed selection of few numbers of the questions. The PAT is attached as Appendix G

3.4.5 Use of secondary data

The National and Rivers State enrolment and performance data in the Senior Secondary Certificate Examination (SSCE) for all three cores sciences – Biology, Chemistry and Physics for the period 2004 – 2013 were collected from the West African Examinations Council (WAEC). A summary of the enrolment and performance is shown in Tables 1a, 1b, 3.7, 5.1, 5.7 and 5.12. Data for the three sciences was collected to compare the popularity of the sciences among students and performance in the subjects. For the main study, only enrolment and performance data in physics were obtained from the participating schools. Schools in local government areas with performance above and below the state average were selected for the study. The intention is to examine and compare the school-related factors in schools where students do well with those where students do not do well.

3.5 The pilot study

A survey research design was used for the study. Both qualitative and qualitative techniques were used to obtain data from the piloting of the instruments. Two teachers were recruited as research assistants and utilized in administering the instruments to both physics teachers and SS3 physics and non-physics students in three local government areas of Rivers State, Nigeria. The pilot was conducted between June and July, 2014. 13 physics teachers, 16 physics students and 12 non-physics students drawn from 4 schools in the study area were used for the pilot. (see Table 3.1)

Table 3.1: showing respondents for the pilot study

	Teachers		Physics Students		Non-physics Students		Total
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	
Rural	4	1	4	4	3	3	19
Urban	7	1	3	5	3	3	22
Total	11	2	7	9	6	6	41

3.5.1 Purpose of the pilot

A pilot study could be referred to as a mini version of a full-scale study and or a pre-testing of a research instrument. For this research, the research instruments – Questionnaires for physics teachers and physics and non-physics students together with the interview questions were pre-tested and critiqued by colleagues teaching physics in schools selected for the pilot in Nigeria. The main objectives of the pilot were:

1. Assessing the adequacy of the research instruments in answering the research questions.
2. Identification of unclear and ambiguous items in the instruments.
3. Determining the effectiveness of the sampling technique.
4. Identifying likely logistic problems that may occur during the main study.
5. Collecting preliminary data and determining effectiveness of proposed analytical processes.
6. Establishing the feasibility of the study.
7. To use information from the pilot to further refine the research instruments for the main study.

3.5.2 Selection of participants for the pilot

Students and physics teachers from schools in 2 rural and 2 urban areas of Rivers State were used for the study. This is done since the study is interested in the pattern of enrolment and attainment of physics students in terms of school location, school type and gender. No single-sex school could be accessed for the pilot, partly due to initial difficulty in accessing schools as at the time of the pilot as students were busy with their final SSCE examinations. Incidentally all schools that allowed the use of students and teachers for the pilot were co-educational. All physics teachers in the schools used participated in the pilot while between 3 – 5 physics and non-physics students were randomly selected by the teachers for the pilot. Out of the 13 teachers used, 7 responded to the teachers' questionnaire and interview questions while 6 critiqued all the instruments. This was so done to reduce the burden on the teachers and save them some time to also attend to their normal responsibilities in the school.

3.5.3 Pilot procedure and activities

Two teachers in Nigeria were instructed via telephone, skype and e-mail on the procedure and expectations for the conduct of the pilot study. Permission was sought from school heads and physics teachers and thereafter, the physics teachers in schools were permission was granted were briefed on the pilot study. Each teacher was given the covering note to read and thereafter the consent form to indicate their acceptance to participate in the pilot. Physics teachers were then given the 'Questionnaire for Physics Teachers' (QPT) to respond to. They were thereafter given the 'Interview schedule for teachers' (ISfT) to respond to the questions in blank sheets supplied to them. The physics teachers recruited both physics and non-physics students for the pilot. Each participating student was handed down the covering note to intimate them of the objectives of the study and what was expected of them as participants in the pilot. The consent forms were then given to each of them to indicate their willingness to participate in the pilot. All students selected by their teachers accepted to participate in the pilot. Students separated into the physics and non-physics groups were then given their respective questionnaires (Questionnaire for Physics Students, QPS and Questionnaire for Non-physics Students, QNPS) to respond to. After completing the questionnaires, the students were then issued with the 'Interview schedule for students' (ISfS) for them to respond to on blank sheets that were made available to them. Other Physics teachers were given a copy of all the instruments – QPT, ISfT, QPS, QNPS and the ISfS for critiquing. They were each given copies of the 'Piloting research instrument (Remarks form)' to critique the instruments. The breakdown of participants in the pilot is shown in Table 3.1 below. The report on the critique of the instruments and preliminary data obtained in the pilot are discussed in the sections that follow.

3.5.4 Responses from physics teachers on the QPT

Five (5) Physics teachers critiqued the QPT. Their suggestions and queries on some of the items in the questionnaire are summarized in the Table 3.2 below. The suggestions and observations on the instrument were used to refine the QPT for the next stage of the research. 100% of teachers who returned the remarks form indicated 'Yes' to the question 'Are all the words understood?' and expressed that the length of questions "are okay".

Table 3.2 Teachers' critique and suggestion on the Physics Teachers' Questionnaire

Questionnaire item	Critique/suggestions	Researcher's Remarks
2	That 'City' be replaced with 'Urban'	Noted for correction as the term is more commonly used with 'rural'
6b	That the question be changed to read "for how many years would you have taught Physics by the end of *this* school year"	Noted for correction
7	Change "what" to "which" qualification (s) do you currently hold	Noted for correction
8	That the first question should have been to "ask if there are any apparatus in your school" before asking to know the extent of availability.	Noted. Questions 18 and 19 will be reposition to come before Q8.
9	That a question on the preparations before commencement of the Physics class be included	Suggestion does not follow the essence of the question which attempts to identify interactions and collaboration among teachers.
15	That it should read "During Physics lessons, how often do you use a computer as a teaching aid or instructional material?	Noted for correction.
16	Separate the question for (a) Calculators (b) Computers	Noted for correction
19	That the word "seldom" in the question be changed to "everyday or during every physics lesson"	The suggestion may imply misunderstanding of the term and so would be changed to "rarely".
21	That the options 'A little' and 'some' be merged to read 'A little or some'	Noted for correction
24	That options 'a' and 'b' mean almost the same and so should be merged	Noted for correction

3.5.5 Responses from physics teachers on the QPS and QNPS

Teachers were requested to critique the Questionnaires in line with the objectives of the study. The responses and suggestions from physics teachers on the appropriateness of the instrument to meet the research objectives are presented in the table below.

Table 3.3 Teachers' critique and suggestion on the Questionnaire for Physics Students

Questionnaire item	Critique/suggestions	Researcher's Remarks
6g	That the question should read 'I always know what I am doing when studying Physics'	Noted for correction
6h	That the question should read 'I always learn new skills and ideas when studying Physics'	Noted for correction
10	That the question should have been 'in doing physics homework, how often do you study and practice each of the following as indicated in the item statements?'	Suggestion not considered but option (a) to be adjusted to read 'solving problems/question sets'
12c	That 'sets' be replaced with 'gives'	Noted for correction
12g	That 'physics ability' be replaced with 'abilities in Physics'	Noted for correction with the removal of 'the' in the sentence which was an error.
12h	That the statement read 'My Physics teacher is good at **teaching** Physics' instead of 'explaining physics'.	Noted for correction as the word 'teaching' may make more sense to the pupils.
12k	That the statement read 'If I need extra help, I always get it from my Physics teacher'	Noted for correction
13	That 'Physics teacher' in the question to read 'school environment'	Noted for correction.
14 (d) & (g)	That instead of using business and social sciences, courses in environmental sciences should be used.	Noted for inclusion as students choosing Physics at this level are not likely to prospectively pursue careers in business and social sciences.

Seven physics teachers critiqued the QPS. Other than making comments on the instrument, only 3 of the teachers responded to the remarks form by assessing the appropriateness of the instrument. All 3 teachers expressed that the questions in the instrument measure what they are intended to measure.

The suggestions and observations of physics teachers on the Questionnaire for Non-Physics Students (QNPS) are presented in the table that follows.

Table 3.4 Teachers' critique and suggestion on the Questionnaire for Non-Physics Students

Questionnaire item	Critique/suggestions	Researcher's Remarks
5	That the statement 'There was no physics laboratory in my school for practical work' be added	Considered for inclusion
5	That the statement 'There was no qualified physics teacher in my school, so the basic science teacher was used for Physics in the senior secondary classes' be added.	Considered for inclusion
5f	That the statement be changed to read 'My parents advised me not to choose physics'	Not considered as it does not seem to simplify the meaning of the statement
5i	That the statement should read 'My Physics teacher advised I should not do Physics because he/she thought I couldn't'	Noted for correction
5k	That the statement read 'My physics teacher did not show interest in the subject	Noted for correction since these are Non-Physics students.

Seven (7) Physics teachers critiqued the Questionnaire for Non-Physics students. Apart from making suggestions and remarks about the statements on the instrument, only 5 remarked on the appropriateness of the instrument. All 5 agreed that respondents will interpret the questions the same way. 3 of the teachers agreed that the questions measure what they were supposed to measure. All 5 teachers were of the opinion that all the words of the instrument are understandable and were also satisfied with the length of the questions.

3.5.6 Piloting the interview schedules for teachers and students

The questions on the interview schedule were only piloted for physics teachers to contribute to the appropriateness of the questions and whether the questions could elicit necessary information to meet the research objectives. The interviews are designed to triangulate the data and information expected from the questionnaires and observations. Only the interview questions were piloted as the researcher could not to travel to Nigeria where the main study was conducted.

The suggestions and views of physics teachers on the instruments are presented in the table below.

Table 3.5 Teachers' critique and suggestion on the Interview Schedule for Teachers

Interview Question no.	Critique/suggestions	Researcher's Remarks
01	That the question read 'What has been your observation in the Physics results of past senior secondary school students?'	Considered to modify the question to specify 'Physics results' instead of 'results of physics students'.
03	That 'Physics teaching and learning' be changed to 'teaching and learning of Physics'	Not considered necessary as suggestion does not simplify understanding.
06	That 'participatory manner' in the question be changed to 'participatory learning'	Noted for correction.
07	That the question should read 'Is there any factor that has hindered (incapacitated) the effective teaching and learning of Physics in your school?'	Noted for correction
09	That the question be replaced with 'Do you have any point(s) to raise or contribution to make? Do you have any question?	Noted for correction

Five (5) Physics teachers critiqued the Interview Schedule for Teachers. Apart from offering suggestions to the improvement of the instrument, only one of the 5 teachers evaluated the appropriateness of the schedule and was of the opinion that the questions measure what they are supposed to measure, all words of the questions are understood and that all respondents will interpret the questions in the same way.

Like the schedule for the teachers, only the questions of the ISfS were piloted as the researcher could not travel to Nigeria where the main study was conducted. It was hoped that the suggestions from Physics teachers on the questions will contribute to the development of a good instrument that could elicit information to meet the research goals. The suggestions and critiques of physics teachers on the ISfS are presented in the table that follows.

Table 3.6 Teachers' critique and suggestion on the Interview Schedule for Students.

Interview Question no.	Critique/suggestions	Researcher's Remarks
02, 03	That the word 'most' be used instead of 'many'	Noted for correction
05	That the question read 'Is there physics laboratory in your school?'	Not considered necessary as that does not affect the understanding of the question.
06	Most spotted the omission of the word 'you' between the words 'do' and 'utilize'.	Noted for correction
08	That the question read 'Is there any issue you think we should have discussed that has not been raised?'	Considered to remove the personal pronoun 'I'.

Four (4) Physics teachers critiqued the Interview Schedule for Students. Only 2 of the 4 returned the Remarks form that asked for their assessment of the instrument. All 2 agreed that the words of the instrument are understandable and that respondents are likely to interpret the questions in the same way.

3.6 Modification of research instruments and strategy

The instruments for data collection were modified following the comments and suggestions of physics teachers during the pilot. The areas of correction and modification can be seen at the 'Researcher's Remarks' column of Tables 3.2–3.6. The suggestions and comments of the teachers bother on appropriateness of the language, response choices, clarity of the instructions and questions, length of the questionnaires and the questions both for the questionnaires and the Physics Attainment Test (PAT). Teachers in Nigeria were deemed most appropriate for the piloting as they are on the ground and have a good knowledge of their students' level of understanding. In terms of the level of the questions, teachers know areas of the curriculum they have covered and so are trusted to ascertain whether or not questions are within reach of the average student in their schools. The modified instruments are attached as appendices.

Also, following the data obtained from West African Examinations Council (WAEC), it is now thought that using schools with known performance above and below the State average and having a case study of the school-based factors in the different schools and making comparisons will better serve the purpose of the research. The analysis of the performance data of the schools both nationally and for the state do not show any trend with wide variation even within the same local government area in the state. It is therefore thought that an independent test designed by the researcher and administered to students would be useful as an added tool to better understand the performance of students in the schools while making comparisons with the WAEC conducted Senior Secondary Certificate Examination (SSCE) results of the schools. The Physics Attainment Test (PAT) with questions adapted from the International General Certificate of Secondary Education (IGCSE) and the General Certificate of Secondary Education (GCSE) was therefore designed to cross-check the school performances and compare with the SSCE based ratings of the schools. Questions from IGCSE and GCSE were adapted as the examinations are taken in many countries around the world including Nigeria and their results are widely acceptable as reliable assessment of students' attainment by most universities in the world as explained earlier in this chapter.

3.7 Selection of sample for the main study

The physics performances data for 10 years obtained from the West African Examination Council (WAEC) was used to determine the selection of schools for the main study. The result of the mean physics attainment for the 23 Local Government Areas, LGAs of Rivers State is presented on Table 3.7 below. For the purpose of anonymity, the actual names of the LGAs have not been used. They have simply been code named LGA1, LGA2 … LGA23.

Table 3.7: 10- year Mean % A-C grade passes in the 23 Local Government Areas of Rivers State

LGA's	Mean % A-C grades	Standard Deviation.
LGA1	30.9	31.7
LGA2	34.6	23.7
LGA3	39.0	20.1
LGA4	42.9	19.7
LGA5	44.0	14.4
LGA6	44.8	15.1
LGA7	46.3	18.1
LGA8	46.3	21.8
LGA9	46.5	17.6
LGA10	48.4	20.0
LGA11	49.6	22.0
LGA12	50.2	19.2
LGA13	52.7	15.0
LGA14	54.8	20.3
LGA15	57.3	17.7
LGA16	58.5	16.6
LGA17	58.8	27.0
LGA18	61.2	20.2
LGA19	61.3	17.5
LGA20	62.9	18.5
LGA21	65.4	22.5
LGA22	65.8	23.8
LGA23	66.7	18.3

Analysis of the results from the 23 local government areas of Rivers State where the study is planned to be carried out shows a high variation (SD lies between 14 and 32) in mean percentage A-C grades. The mean % A-C level passes for the 10-year period for Rivers State is 60.2.

The purposive sampling was utilized to select schools in the high and low performing local government areas of the state in physics having a boy, girl and co-educational school. This school selection criteria is so adopted to capture the three school types in the system and also, to explore the possibility of interesting outcomes of gender and physics enrolment and performance. Consequently, LGA21 with 65.8% of A-C grade pass was selected among the high performing LGA's while LGA4 with 42.9% was chosen from among the low performing local government areas. These two LGA's are the only ones having the 3 types of schools – Boys', Girls' and mixed or co-educational in Rivers State. In LGA4, the school populations were generally small, so a second mixed school was added to the study. The same could not be done for the boys' and girls' as there was only one each of such type of schools in the area.

During the visits to schools in both LGA's, the researcher observed that all the schools visited do not have functional laboratories and resources for teaching physics. Added to this, most teachers in both local government areas, possibly because of their location in rural or semi-rural (LGA21) were observed to be truant and irregular in school. Informal conversation with some principals suggests that some teachers get absent from school for as long as 1 month without permission. Lesson time-tables were not followed in some cases as physics teachers could not be seen in school. The researcher therefore thought of, and included a specialist science college situated in LGA16 with established and functional physics, chemistry and biology laboratories. Teachers in this school are also known to be under strict supervision and monitoring. This was so considered to compare performance in the light of resource availability, utilization and teacher characteristics.

All the physics teachers in all schools selected constituted the sample for the study. The senior physics teacher of the SSS 3 class was purposively selected in each of the schools for the interview. This was so considered as the teacher was the most experienced and could draw from years of experience in teaching and classroom interaction to offer very valuable contributions in line with the research objectives. For the class observation, physics teachers were randomly selected for observation with the few schools having more than one physics teacher. This is so considered to eliminate bias and as the population was finite and homogeneous. All physics and non-physics students willing to participate were chosen for the study. Focused group interview was used for the students. In each of the 8 schools, quota sampling was used by the teachers to select 5 students of high, average and low abilities to constitute the focus group. 2 of the 5 students were non-physics students. In some schools, the students' focus group went as much as 8 either because the number of students in the school was few and so were all recruited or in large populated schools, a few students not selected by the teachers and who were eager to participate in the interview were allowed to join. In all 116 non-physics students, 248 physics students and 14 physics teachers participated in the study.

3.8 Validation of research instruments

It is important in any research that instruments that are used to generate data or make measurements are adequately validated to reduce errors both in the results and in the inference or interpretation that could emanate from them. According to Kimberlin & Winterstein (2008), the validity and reliability of research instruments are the main indicators of the quality of the research instrument. Nwankwo (2010) outlined three basic components in the validation process of non-cognitive instruments for use in any research. They are: "ensuring the validity of the instrument, establishing the reliability of the instrument and pilot-testing or trial testing of the instrument" (p. 139). In the sections that follow, the validity and reliability of the instruments used in this study shall be presented.

3.8.1 Validity of the instruments

The validity of an instrument refers to the extent to which a research instrument measures what it is supposed to measure. There are several types of validity. Some of which include face, content, predictive, concurrent, construct, criterion-referenced, external and internal validity (Kothari, 2004; Nwankwo, 2010; Cohen, Manion & Morrison, 2011; Creswell, 2012). According to Nwankwo (2010), "the two basic types of validity generally determined by researchers for their non-cognitive research instruments include face and content validity" (p.140). The non-cognitive instruments used for this study are questionnaires, interview and classroom observation schedules. The PAT was the only cognitive instrument that was used in this study. The validation of the research instruments – questionnaires, interview schedules, classroom observation schedule and the PAT for this study began with the supervisors and members of the Thesis Advisory Panel (TAP) at the initial stage of the development of the instruments. The suggestions, corrections and criticisms informed the production of the first set of instruments. These first set of instruments were further validated through piloting with experts and physics teachers in Nigeria. This was so done as the study is carried out in Nigeria and the valuable experience of teachers and experts with classroom experience in the country was needed to ensure the development of worthwhile instruments in line with the research objectives. The criticisms, comments and suggestions from these physics teachers and science educators were utilized in the development of the final sets of instruments. The non-cognitive instruments were adjudged by the experts and physics teachers to be suitable as to elicit relevant information for the study of school-based factors that affect the enrolment and attainment of physics students in Nigeria.

Physics teachers also affirmed that the contents of the PAT test was adequate in scope for measuring the attainment physics students for the Senior Secondary School III class.

3.8.2 Reliability of the instruments

The reliability of an instrument refers to the ability of the instrument to yield consistent results when used to measure a given variable over repeated times. It is the extent to which a research instrument can be relied upon to obtain the same result with repeated trials (Kothari, 2004; Weiner, 2007; Nwankwo, 2010; Cohen, Manion & Morrison, 2011; Creswell, 2012).

There are three main types of reliability. These are stability measures, measures of equivalence and measures of internal consistency. Nwankwo (2010) opined that for instruments that are non-cognitive, "the most convenient reliability estimates could be: measures of stability through test-retest method, measures of internal consistency through the split-half method *and the* measures of internal consistency through the coefficient alpha developed by Cronbach" (p158,159). For the reliability of cognitive tests or instruments, test-retest, alternate forms and split-half methods can be used for the measures of stability, equivalence and internal consistency respectively (Kothari, 2004; Nwankwo, 2010; Cohen, Manion & Morrison, 2011).

For this study, test-retest has been adopted as the most appropriate method to determine the reliability of the instruments. This is because for the questionnaires, teachers and students were expected to make responses for instance, whether or not certain practices hold in the physics classrooms and the extent to which they occur. As such varying degree of responses is expected depending on the circumstance in the different school. It is therefore not necessary to talk about the internal consistency of a cluster of questionnaire items in relation to a construct or measuring the homogeneity of items of an instrument.

A school in the study area but not included in the main study was used for to test for the reliability of the research instruments. The instruments – Questionnaire for Physics Teachers (QPT), Questionnaire for Physics Students (QPS), Questionnaire for Non-physics Students (QNPS) and the Physics attainment Test (PAT) were administered to the respondents and repeated after a time laps of 2 weeks. 12 physics students, 14 non-physics students and 3 physics teachers were involved in the determination of the reliability of the instruments. The Pearson product moment correlation was used to compare the test and retest outcomes of the respondents. The Pearson product moment was used and not the Spearman rho rank correlations as the responses were converted to scales for the questionnaires whilst the PAT scores were computed in percentages which are scale data. The correlation coefficients obtained for the instruments were r = 0.891 for the QPS, r = 0.811for the QNPS, r = 0.819 for the QPT and r = 0.753 for the PAT. The p-values for all were less than 0.05 which implied that the correlation coefficients were statistically significant. The instruments were therefore considered reliable and used for the collection of data in the main research.

3.9 Procedure for data collection for the main study

The criteria for the selection of schools for the study have been explained earlier in this chapter. In this section, the procedure for the selection of participants is explained. An approval to involve schools in the Rivers State was secured from the Senior Secondary Schools' Management Board (SSSMB). In all schools, a minimum of 4 visits were made for the collection of data. The process of data collection is shown in Fig.3.1.

Introduction/Distribution of consent

⇩

Retrieval of consent forms/Administration of Questionnaires

⇩

Class Observation/Conduct of Interviews

⇩

Conduct of the PAT

Fig. 3.1: Process of data collection

On the first day, the research introduced himself to the principal and through the principal to the physics teacher(s). On that same day, where the outcome was positive after the introduction as in most of the schools, the researcher addressed the students and physics teachers and then, the participant and parental consent forms and letters were distributed to the physics teachers and students. In another visit, the consent forms were retrieved and students whose parents assented their inclusion into the study were administered the questionnaires. Like explained earlier in this chapter, all students who accepted to participate were recruited for the study. This was to ensure a wider participation of the subjects and validity of the study. All physics teachers in all schools accepted to participate in the study. On the third visit generally, the physics classroom observation was held after which the students and teachers interviews were conducted. The physics classroom observation was done in 7 of the 8 schools involved in the study. In one of the schools, the teacher was evasive despite several persuasions to have him observed. He appeared not too confident to be observed having confessed that he was just ‘assisting to teach physics’ and that he was not a qualified physics teacher.

The physics teachers were relied on to select between 5 and 8 students of low, average and high ability for participation in the focused interview of physics and non-physics students. Of the number, between 3 and 5 were physics students while 2 – 3 were non-physics students. However, in schools with very few physics students (<10), all of them where involved in the interview. The rationale for the choice of physics and non-physics students has been previously explained in this chapter. The various abilities of the students were considered in the selection to capture the experiences of all students in their physics lessons.

On the 4th visit or last as the case may be, the Physics Attainment Test (PAT) was administered to the students. Not all the physics students opted to write the test in some schools. It is assumed that those who were not too confident of themselves declined to write the test. It is therefore interesting to observe, from Tables 5.4, 5.9 and 5.14 that even those who were somewhat confident performed so poorly in the test. In some schools, the researcher made between 5 – 8 visits to collect all the data due to the truancy of teachers and students. In one school, students were themselves truant and have to be contacted to come to the school for the data collection.

The study was turned down in two schools. In one of the schools, the principal said the school had no physics teacher and so could not allow the study carried out in the school. In the second school, the principal insisted that he was to meet with his teachers before giving me response as to whether or not he would permit the use of the school. After waiting for 2 weeks and not getting a positive response, another co-educational school within the area was approached and used for the study.

3.9.1 The administration of students’ questionnaire for physics and non-physics students

Students whose parents consented to their participation in the study were involved at this stage of the data collection. Before the distribution of the questionnaires, the researcher again addressed the students, highlighting the main aims of the study and soliciting for their honest and objective response to the items in the questionnaire. In some schools, the questionnaires were retrieved on same day, while in some others, where the school time-table could not allow for the exercise, the questionnaires were left with the physics teacher who administered and retrieved them at the convenience of the school. In such cases, the researcher was invited for the next stage of the data collection.

3.9.2 The administration of the teachers' questionnaire

The teachers and students questionnaires were distributed on same day in each of the schools. The researcher also addressed the teachers on the main objectives of the research and solicited for their sincere and objective response to the items so as to make the outcome of the research worthwhile. In schools where some of the physics teachers could not be caught in school, their questionnaires were sent through their colleagues who also returned them as some of the physics teacher could not be reached in the school at all times of the researcher's visit.

3.9.3 The physics and non-physics students' focus interviews

The procedure for the recruitment of participants for the interview has been explained in sections 3.8. The interviews were held in specially arranged venues ranging from classroom, outside - under a tree shade or laboratory. The students were first addressed on the main objectives of the research. They were reassured of the anonymity of their responses and that none will be victimized resulting from their responses as their teachers and school heads will not be privy to their responses. Teachers were politely requested to leave as their presence was deemed to have a likely influence on the responses of the students. Before the commencement of the interviews, the researcher in each case explained the need for the recording of the interviews to capture all views and again reassured participants on the confidentiality and anonymity of their responses. This was done to allay their fears especially from the backdrop of the Nigerian society were people generally get scared of giving oral evidence for fear of victimization. In all, the interview lasted between 12 and 58 minutes in each school, depending on the ability of the students to freely express themselves and respond to prompts and probes.

3.9.4 The physics classroom observations in selected schools

The school principals and physics teachers were aware of the class observation on the very first visit of the researcher. This was done only in 7 schools as has been mentioned earlier.

The ‘Science Classroom Observation Worksheet’ developed by the RMC research corporation in collaboration with the Leadership and Assistance for Science Education Reform (LASER) of Washington State was used for the classroom observation. Major components assessed during the observation include learning objectives, developing understanding, sense-making and classroom culture. Each of the traits of the major components is assessed quantitatively on a 6-point scale of 0 (not observed) to 6 (very evident). The rationale for each rating is stated on the worksheets.

3.9.5 The physics teachers’ interviews

The physics teachers’ interview was held in all 8 schools. This was intentionally planned to hold after a few visits so as to utilize observations during the school visits and classroom teaching, to achieve a well-informed interview. Before the commencement of each interview, the researcher reminded the teachers of the purpose of the research and encouraged them to give honest responses. Teachers were clarified on the need for the recording of the session. In all 8 schools, the physics teachers teaching the SSS 3 class were the more experienced and in-charge of the physics teaching team, where the school had more than one teacher. The SSS 3 teachers were for that reason selected having been considered to have a better teaching experience and can therefore engage better during the interview. The duration of the teachers’ interviews ranged from 7 – 25 minutes depending on the teachers responses to appropriate prompts and probes.

3.10 Data analysis methods

Both primary and secondary data were collected for the study. Instruments that were used for the primary data collection were: questionnaires, the PAT test, interviews and classroom observations. Secondary data were the 10 years (2004 – 2013) SSCE results obtained for all local governments in Rivers State from the West African Examination Council (WAEC) and the 5 years SSCE results of the participating schools in the study. The data analysis tools for each of the sources of data collection are discussed in the following sub-sections.

3.10.1 Questionnaires

Three questionnaires were used for the study – The QPT, QPS and QNPS. All questionnaires contained questions using scales and open questions. Munn & Drever (2004) outlined ‘data preparation’, ‘data description’ and ‘interpretation of the results’ as the key stages of questionnaire data analysis. Responses in all questionnaires were scaled or open type which therefore generated ordinal, nominal and string data. Nominal data derived for discrete variables that denote categories such as gender, school type and yes/no responses together with the ordinal scale data were coded in 'preparation' and entered into the Statistical Package for Social Sciences (SPSS) for the 'data description' or analysis. In coding data from open questions, Munn & Driver (2004) suggested two main approaches (1) 'create a framework in advance' or (2) 'derive it from the data'. Themes emerging from the research questions for the study in chapter 1 therefore formed the framework for the coding of the responses to the open questions.

Descriptive statistics such as mean, percentage, variance and standard deviation were utilized for the questionnaire data analysis while bar charts were used to present and report findings. According to Cohen, Manion & Morrison (2011), descriptive 'statistics make no inferences or predictions; they simply report what has been found, in a variety of ways' (p.606). Correlational analysis was performed using SPSS to determine the degree of association between school-based factors as explanatory or independent variables and performance as dependent or explained variable (MacDonald, 2014; Mukaka, 2012; Cohen, Manion & Morrison 2011). Responses on school-based factors from teachers and students questionnaires generated ordinal data while the Physics Attainment Test, PAT generated scaled data. The data generated from the PAT and those from the questionnaires for teacher qualification, teaching experience, resource availability and resource utilization were not normally distributed as shown in chapter 6. To establish the degree of association therefore among performance, enrolment and school-based factors, the non-parametric Spearman Rank correlation statistic was deemed most appropriate for data that are either scale or ordinal but are not normally distributed (Cohen, Manion & Morrison, 2011, Field, 2013). Factor analysis could not be used for this study as a result of the small sample sizes for the different components of the study. For instance only 8 schools (for analysis involving schools) and 14 teachers for teacher related analysis. Tabachnick & Fidell (2007) suggests that "it is comfortable to have at least 300 cases for factor analysis" (p. 613). They suggested higher factor loadings for smaller sample sizes. The assumption of specific factors from literature such as teacher qualification, experience, resource availability and utilization and not necessarily the assessment of variables that relate to these 'factors' reduces the number of factor loadings for the use of factor analysis.

3.10.2 The Senior Secondary Certificate Examinations (SSCE) and Physics Attainment Test (PAT) results

The SSCE results were secondary data obtained from WAEC and the schools involved in the study as has been explained. The SSCE results are usually released in letter grades of A1, B2, B3, C4, C5, C6, D7, D8 and F9 (see Table 5.2), with A1 being the best grade for percentage scores ranging from 75-100 and F9 the least and fail grade awarded for scores less than 40%. Simple frequency counts and percentages were used to compare performances both within and among zones and the science college. The SSCE grades were converted to percentages using the WAEC grading system for the purpose of comparison with the PAT and entered into the IBM SPSS 22 for analysis. The Pearson correlation was utilized to compare the SSCE and PAT scores. Both the SSCE and the PAT scores were scale data and so, the Pearson correctional analysis was considered adequate to use and not the Spearman rank order correlation which is best used for nominal data (Cohen, Manion & Morrison, 2011).

3.10.3 Interviews

The thematic approach in qualitative research was used in the analysis of the interview data. Drever (2003) outlined three stages in the analysis of interviews, namely data preparation, analysis and summarizing results. At the stage of data preparation, the audio recorded interviews were transcribed and coded deductively in-line with the *a priori* categories emerging from the research questions (Drever, 2003; Cohen, Manion & Morrison, 2011). The transcription was generally made verbatim to retain the 'flavour' of the original information from the interviewees and at the same time, avoiding distortion of facts and researcher's bias (Drever, 2003; Cohen, Manion & Morrison, 2011; Creswell, 2012). The transcribed data were then entered into the QSR NVivo 10 software package for coding and analysis.

3.10.4 Classroom observations

Seven physics lessons were observed in 7 out of the 8 schools involved in the study. The Science Classroom Observation Worksheet (SCOW), adapted from the Science Classroom Observation Protocol of the RMC Research Corporation (2010) was used for the classroom observations. The instrument has a 6-point rating scale from 'not observed', (0) to 'very evident', (6) on four core traits. The instrument therefore generated quantitative data analysed using percentages and means with appropriate graphs to illustrate the evidence of observed traits during the physics lessons. Also, the Classroom Observation Schedule (COS), designed by the researcher to record classroom activities and duration of time such activities take place during the lesson was used for the observation. Field notes were also made by the researcher during the observations. These were intended to generate some qualitative data from the observations.

3.10.5 Coding adopted for schools and interview respondents

A very simply coding system of alphabets and numbers has been adopted for the description of schools and interview respondents. The first alphabet in the code denotes the ‘school’. Alphabets A, B, C, and D have been used to identify schools in this study. The next after the alphabet is a number that denotes the zone in which the school is located. The number ‘1’ stands for schools in Zone 1 while ‘2’ is used to identify schools in zone 2. The science college has been coded “SC’. The last letter is used to identify the respondent. Thus, the letters ‘P’, ‘T’ and ‘N’ have been used to denote ‘physics student’, ‘physics teacher’ and ‘Non-physics student’ respectively. For example, the code ‘A1P’ would stand for ‘school A, zone 1 physics student’ while ‘D2T’ implies ‘school D, zone 2, physics teacher’ and ‘C1N’ is used for ‘school C, zone1, non-physics student’. For students, there is an additional forward slash (/), followed by numbers which indicate the different respondents in that category. For instance, ‘A1P/2’ indicates that that is the second (2^{nd}) physics student and is unique for all participants in the interview. The numbers that follow after the respondent is the line numbers from the interview transcripts.

3.11 Linking research questions, methods and data sources

The table below summarizes at a glance, the link and association among the research questions used in this study, the methods utilized to generate the data and the sources of data.

Table 3.8: Linking research questions to methods and data sources

Sub-Research Questions	Methods used for data collection	Data sources
i. What is the level of enrolment for physics in the Senior Secondary Certificate Examination?	Secondary data, Interviews	School principals, physics and non-physics students, teachers
ii. What is the pattern of attainment of physics students who enrolled in the Senior Secondary Certificate Examination (SSCE)?	Secondary data	School principals
iii. How does teacher qualification and experience relate with the enrolment and attainment of students in physics in the SSCE?	Tests, secondary data, questionnaires, interviews	Physics and non-physics students, teachers
iv. What is the extent of availability of physics resources for teaching and learning in secondary schools in Rivers State, Nigeria?	Questionnaires, interviews, observations	Physics and non-physics students, teachers
v. To what extent are available physics resources utilized for teaching and learning in secondary schools?	Questionnaires, interviews, observations	Physics and non-physics students, teachers
vi. To what extent does the availability and utilization of physics resources influence students' enrolment and attainment in physics?	Tests, Secondary data, Questionnaires, interviews	Physics and non-physics students, teachers
vii. What are the teaching strategies and classroom interactions adopted by physics teachers?	Questionnaires, interviews, observations	Physics and non-physics students, teachers
viii. To what extent does the teaching strategy and classroom interactions adopted by teachers influence the students' enrolment and attainment in physics?	Tests, Questionnaires, interviews	Physics and non-physics students, teachers
ix. To what extent does the school climate affect teaching and learning in the school?	Questionnaires, interviews, observations	Physics and non-physics students, teachers

3.12 Validation of the study

The validity of a research is considered very important as it tells the worth or otherwise of any piece of research. Validation of the study here, goes beyond the traditional definition of validity- that an instrument 'measures what it purports to measure', to address issues like 'honesty, depth, richness and scope of data achieved, the participants approached, the extent of triangulation and the disinterestedness or objectivity of the researcher' (Cohen, Manion &

Morrison, 2011). In a study that involves the use of questionnaires, for instance where respondents report about themselves and classroom practices, it is important that steps to mitigate the problem of social desirability bias of respondents are incorporated in the research management plan. Social desirability bias is a situation where questionnaire respondents in self-reporting, get tempted to lie, deceive or give socially desirable responses instead of stating what they truly do, practice, think or believe (Jo, Nelson & Kiecker, 1997; Revzina, 2008; Lelkes, Krosnick, Marx, Judd & Park, 2012). This is particularly typical when the respondents perceive that their personality and worth is being investigated or where questions bother on the attainment of their students, for instance, they conclude that their own effectiveness is being investigated. Under such scenario, some teachers cheaply fall into the temptation of lying with dishonest response. To address the issue of social desirability bias, some researchers in social science have advocated the use of 'triangulation' of methods to obtain research outcomes with much confidence as result of increased validity in the use of more than one method of data collection (Mathison, 1988; Holtzhausen, 2001; Bryman, 2012; Creswell, 2012; Wilson, 2014). Creswell (2012) defined triangulation as "the process of corroborating evidence from different individuals (e.g., a principal and a student), types of data (e.g., observational field notes and interviews), or methods of data collection (e.g., documents and interviews) in descriptions and themes in qualitative research" (p.259). To validate this study, I have used triangulations in corroborating responses from teachers and students, and methods of data collection as the use of questionnaires, individual and focus group interviews, classroom observations, field notes, tests and secondary data to holistically investigate school-based factors that affect the enrolment and attainment of physics students.

It is however important to mention here that self-report data from respondents' questionnaires and interviews have been used in the study. For instance, claims by teachers on their qualifications and years of teaching experience were not verified by the researcher. Also, this study has been conducted in a system with problems of examination malpractice as discussed earlier and for which the PAT was introduced into the study. Although these were adequately mitigated by the researcher, the possibility of lowering the validity of the study may not be ruled out.

3.13 Research ethical considerations and standard

Securing informed consent in social science research, medical and most professional practices is "a standard feature of ethical procedure" (Homan, 2001:330). This involves making the human participants in a study aware of the nature of the study, what would be involved in their participation, how the data would be managed and assurances that their participation is voluntary.

For the present study, ethical approval from the Department of Education Ethics Committee was sought and obtained before the start of the research (see Appendix M). Following the approval of the department's ethics committee, permission was requested for and obtained from the Rivers State Senior Secondary Schools Board (charged with the responsibility of managing all senior secondary schools in Rivers State) to conduct my research in schools in Rivers State (Appendices J & K). Permission was also sought and obtained from the school principals before accessing and recruiting teachers and students for the study.

Prospective students and teachers for the study were addressed by the researcher and informed of the nature of the research and what would be involved in their participation. They were assured of the confidentiality and anonymity of their responses both in the questionnaires and interviews. Students and teachers were then issued with the participants' consent form to "opt in" (see Appendix L). All students were given the consent forms (which also gave details of the study) to take home to their parents and return. All physics teachers in the 8 schools and students whose parents "opted in" were recruited for the study. In all, the study adhered to the principle of voluntary consent and the approved ethical standards of the department of Education ethics committee.

Chapter 4: Contextual data from schools

4.1 Introduction

This chapter is the first of three chapters of data presentation. The chapter conveys contextual qualitative data obtained from the schools involved in the study. The chapter contains a brief description of the characteristics of the selected schools in each of the zones. A school-by-school contextual description is presented for schools in zone 1, followed by zone 2 and finally the science college. The description includes observations by the researcher and some reports from both students and teachers in the schools.

4.2 Brief description of characteristics of selected schools

In this section, a brief description of the characteristics of the selected schools for the study is presented. The criteria for the selection of the 8 schools used for the study have been explained in chapter 3. For the purpose of anonymity, School A, B, C and D have been used in place of the actual school names. Also, Zone 1 and Zone 2 have been adopted for the local government areas while 'Science College' is adopted for the science school. The school code, school A1 therefore refers to the school A in zone 1. A summary of the characteristics of each of the schools in the zones that has been involved in this study is presented in Table 4.1. Details of the contextual data from the schools are presented below in the sub-sections that follow.

Table 4.1: Some characteristics of participating schools

School Code	School type	Location	Population of students in SS3 class	Population of Physics students	Any physics laboratory*	Number of physics teachers
A1	Mixed	Rural	26	9	None	3
B1	Mixed	Rural	36	15	None	1
C1	Girls	Rural	72	12	None	1
D1	Boys	Rural	31	10	None	1
A2	Boys	Urban	116	50	None	2
B2	Mixed	Urban	249	72	None	2
C2	Girls	Urban	98	35	None	1
SC	Mixed	Urban	172	172	Yes	3

(* Equipped laboratory for the study of physics)

4.2.1 Schools in zone 1

Zone one is one of the low performing local government areas in the SSCE physics from 10 years record from WAEC. The zone had one single-sex school each for boys and girls. The population of students in all schools in this zone is characteristically very low. This may be as a result of the rural nature of the local government and schools located in almost every community to meet the educational needs of children and youths in the communities. As explained earlier, 4 schools from the zone were used for the research. All schools in the zone are located in the rural area as the zone is one of the rural local government areas of the state.

School A1 in the zone is a co-educational school that was established in 1973. Most of the structures are dilapidated with some structures taken over by grasses and trees. The school had 3 physics teachers on record even though it was difficult for the researcher to see any of them during the visits. Calls at the school informed by the school time-table where the researcher expected he would meet with the teachers, were not successful as the students were seen in class without the teachers during the physics periods. During the period of data collection, the researcher visited the school 6 times and was only able to meet one of the teachers on the 6th visit after several contacts on phone. Two of the teachers were reached separately outside the school in the State capital located about 60 miles away, where they responded to the QPT. One of the two who teaches the SSS3 class was interviewed in that meeting at the state capital. The number of physics students in the school was about 10 as the actual number on roll could not be ascertained by the teacher. The students expressed their frustration to the attitude of the teachers and how that has affected the attitude of some to be truant and unserious with their studies. Some of these expressions are captured in the interview.

The SSS 3 science classroom was shown to me by the vice-principal and students as their science laboratory for physics, chemistry and biology combined. The classroom had students desks for normal lessons with a broken down, very dusty open cupboard with some dirty beakers, funnels, rusted and out of use triple and analytical beam balances, weights, a few optical lenses, rusted venier callipers, spoilt and unused microscope, some parts of the human skeleton and a few others. In the words of one of the teachers in a response as to why students have not conducted practical or demonstrations, ‘few available materials are redundant’. This aptly describes the supposed ‘laboratory’ as claimed by some students and teachers in the school. The school had no electricity supply and during the visit to the school, the researcher observed that there were no computers used for instruction in the school.

School B1 is one of the co-educational schools that were used for the research in the zone. The school was established in the year 1978 and is located along a major high way that links the western and southern parts of the country. The school had some buildings that are dilapidated and as such, are no longer in use. The principal of the school occupies a table in the staff room as the roof of the administrative building housing his office was blown off by wind some years ago.

The school had only one physics teacher. The teacher was observed to show commitment as he was always present in school throughout my visits. The school was visited 4 times. The office of the physics teacher on the ground floor of the administrative building whose roof had been blown off by wind, doubles as the physics laboratory with a few resources for teaching physics placed on some wooden shelves as is common in most stores. There were no desks or stools seen in the office or 'laboratory' as the space looks too small for students' laboratory activities. The school had no electricity supply as observed during the researcher's visits. Other teaching resources like computers were also not seen in the school.

It is interesting to note that this school had a good population of students in SSS 1 and 2 classes – at least 40 physics students in each of the classes, but had only 15 in SSS 3. The entire number of students in the SSS3 class was less than 40. I was informed by the physics teacher during the interview that most of the students prefer registering for the SSCE examination in schools that are located in remote areas. Below is an excerpt from the interview:

> My observation in past… physics students in my school is that though, we… during… before examinations, we have a lot of students, come for classes but during examinations especially WAEC registration, most of the students would leave the school to other schools to register, reasons being that… before I came, they said they don't use to make results here… (B1T)

The reason can only be assumed to be in connection with the tendency for malpractice during the SSCE as this was not investigated. There is however good evidence in literature to support this assumption. See for instance, Onuka & Durowoju, 2013 and Tambawal, 2013.

School C1 is the only girls' school in this zone and has existed for over 30 years having been established in 1982. The school is located in one of the remotest communities in the zone. The school had only one physics teacher who teaches physics in all the 3 senior secondary classes where the subject is offered. The teacher was an inexperienced youth corps member, serving his mandatory one year national service after graduation from the university. Until his deployment, the researcher was informed that the school had no physics teacher as teachers frequently work their way to be posted out of the school due to the location of the school. Sometimes, other science teachers help with the subject.

There were no science laboratories in the school. When asked, the research was informed that the school had some physics apparatus and resources for learning and that the principal keeps them away for security as the school had no wall or secured fence to ensure the safety of the materials and resources in the school. The students reported, some of which are captured in the interview that they have no laboratory and have not conducted any practical in physics. During the researcher's visit, it was also observed that the school had no supply of electricity. Computers that are also used some times to show some simulations to aid learning were also not available in the school.

Like most of the schools in the zone, the student population was very low with less than 15 physics students offering physics at SSS 3 level. Most of the physics students that interacted with the researcher did not wear the school uniform. Investigations revealed that the principal in this school makes it mandatory for external students registered for the SSCE to attend classes prior to the exam. This may explain the relatively higher number in view of the remoteness of the school location.

School D1 is the only boys' school in the zone. It is located about 2 miles away from the girls' school in a neighbouring community. This school has existed since about 40 years ago with very old buildings most of which are dilapidated without windows and doors.

The school had only one physics teacher who had been teaching the subject in the school since 2013. According to the physics teacher, most of the students do not come to school regularly and have to be sought for in the community and requested to be in school for the research. As at the time of my data collection in the school, there were only about 10 physics students in the school as some external students registered for the SSCE joined the class.

The school had no physics laboratory. One of the dilapidated buildings was supposed to be housing the physics, chemistry and biology laboratories with some pieces of chemical reagent bottles, broken metal cupboard with some unused materials, rotted cartons of materials on the broken floor of the rooms. This building is probably what the teacher considered as having a physics laboratory. The school was not connected to the national grid for electricity supply. There were also no computers that were seen for instructional purposes in the school. The researcher however observed the use of a computer powered by a generating set and used for the registration of students for the senior school certificate examination during some visits to the school. On the availability of a physics laboratory in the school, the teacher was evasive to the question during the interview. The students however in their interview revealed that they do not have a physics laboratory and that they seek for help for practical work in physics individually outside the provisions of the school.

4.2.2 Schools in zone 2

The zone is among the high performing in SSCE physics for the 10 year record from 2004 – 2013 obtained from WAEC. Like in zone 1, there is one single-sex school each for boys and girls. The zone is located in a semi-urban or city area and as such, had a high population of students compared to the schools in zone one. 3 schools – the boys, girls and a mixed school were used for the study as explained earlier. Unlike the schools in zone 1, all schools in this zone have electricity supply. This is because of the location of the zone which incidentally house many oil companies that support the communities with the provision of electricity. The state and availability of laboratories in the various schools as observed is presented below. Like in all schools in zone 1 however, there were no observed computers for teaching and learning in all schools in the zone.

School A2 is the boys' school in the zone or local government area. The school established about 15 years ago inherited some structures of an old school which was established about 50 years ago. The school is located at the centre of this semi-urban community with a sizeable number of students. There were 50 students offering physics in the SSS 3 class that writes the SSCE. The school had 2 physics teachers with no physics qualification as gathered from the response on the Questionnaire for Physics Teachers. One of the teachers was not seen in school during the researcher's 5 visits to the school. His colleague informed the researcher that he sometimes absent himself from school for a period as much as one month without information or permission. His questionnaire was sent to him through the second teacher who also returned it to the researcher. The second teacher teaches the SSS 3 class and was at hand most of the times. He willingly participated for the interview, organized the students for the interview and PAT but was reluctant and evasive to have his physics teaching observed. All efforts to have the researcher observe his teaching were not successful as he repeatedly informed me that he was not a physics teacher and that he was only stepping in to assist the students as there was no one to teach the subject. This may be as a result of his self-perceived incompetence to teach physics being not a physics graduate as sincerely expressed in the interview. The school had no physics laboratory as corroborated by the 2 physics teachers and the students in the interview and as observed by the researcher.

School B2 is a co-educational school in the area. This school was established in 2008 as a senior secondary school and situated at the centre of the semi-urban community; the school is very highly populated. Most of the classes are congested with between 3-5 students sharing a desk that would normally sit 2. For instance, the SSS 3 students, divided into two classes of Arts and Science respectively share a hall that was not demarcated with any wall – wooden or block. They sit facing the opposite ends of the hall. The science class with 72 physics students with the over 150 Arts students at the other end, with an uncontrollable noise from both sides made it difficult for the researcher who initially sat at the back row to hear the teacher.

The school had two physics teachers who are both not qualified physics teachers as they do not have qualifications in physics. The school had a classroom designated as 'science laboratory' with some materials and resources for teaching physics, chemistry and biology. The students' interview was conducted in this laboratory. When the laboratory was opened, everywhere was heavily dusty as though the place had not been in use for a long time. The physics teachers confirmed that no practical had been conducted with the students as the time of the researcher's visit between weeks 6-8 into the term. It is therefore very likely that the 'laboratory' was not in frequent use either by the teachers or the students.

School C2 is the girls' secondary school in the community. The school is also situated in the centre of the community about 1 mile away in the North East and North West location of the boys' and mixed schools respectively. Established in the year 1981, the school is a little less populated than the boys' school. There were about 35 physics students in the SSS 3.

The school had only one physics teacher that teaches the three classes – SSS1, SSS2 and SSS3 where physics is chosen. The teacher, who had taught for 4 years, was a young, qualified physics teacher with an experience of about 2 years of teaching physics.

The school had separate 'laboratories' for biology, chemistry and physics with few equipment or resources and laboratory desks and stools. The science teachers and some other teachers were seen in the laboratories as they use it for their offices. This may have been the reason why the students in their interview claimed that they do not have a laboratory. However, both the teacher and students agreed that sometimes, the teacher brings in materials to 'show' to the students so as to facilitate their learning.

4.2.3 The science college

The science college was established in 1996 as a specialist science college, to meet the aspirations of the oil producing communities in the area for a quality education and man-power development, especially in the sciences at the senior secondary level that will lead students to study science based courses such as engineering, medicine and surgery, pharmacy, environmental sciences, geology and other physical sciences in university. As a science specialist school, all students mandatorily choose to study physics. The school is a co-educational school located in LGA16. The school is located within a tertiary institution in the state which exchanges some of its staff with the science school and provides a supervisory role over the college. Teachers are therefore closely monitored unlike the case of teachers in the state-owned schools especially those in the rural areas. The school had 3 physics teachers who the researcher had no difficulty to see in school during visits unlike the situation in other schools.

In terms of resources for learning, the school had separate laboratories for biology, chemistry and physics that are stuffed with functional facilities for the conduct of demonstrations and experiments. The school also had a computer laboratory that is used for teaching and learning. The school was however observed to be over populated with a class size of over 70 in each of the two SSS 3 classes. Some rowdiness and lack of class control and discipline was also observed among students in the school during the visits of the researcher.

Chapter 5: Records of students' enrolment and attainments in senior secondary school physics

5.1 Introduction

In this chapter, physics enrolment and attainment data of students in SSS 3 obtained from participating schools shall be presented. The enrolment data at the national level has been presented in chapter 1, Table 1(a) and briefly discussed. In this present chapter, the physics enrolment trend relative to biology and chemistry for 10 years is presented. Also, the enrolment data of the current SSS 3 class as at the time of the research is also presented. Thereafter, the 5-year SSCE results obtained from each of the schools was examined and compared with the current students' attainment in the Physics Attainment Test (PAT). The SSCE scores were first converted to percentages before comparing with the PAT scores. In the subsequent sections, the results of zone 1 are examined and compared, followed by those of zone 2 and then the science college. To conclude the chapter, a reflection on the outcomes of results of both the SSCE and PAT has been made in an attempt to explain the observed variation and differences especially between the SSCE and the PAT scores.

5.2 Physics enrolment data

The issue of decline in young pupils' interest to the study of sciences in general and particularly physics in many countries including the UK and the US has been well documented in literature (See for instance, Osborne, Simon & Collins, 2003; Semela, 2010). Before delving into school-based factors from the view point of students and teachers that may have encouraged this apathy for the choice of physics after the compulsory years of schooling, both secondary and primary data obtained from the schools are here presented. Table 5.1 shows the enrolment of students for the Senior School Certificate Examination (SSCE) in biology, chemistry and physics for 10 years in Rivers State. The table shows that for the period, physics was the least chosen subject among the 3 core science subjects with an average of 43.8% of the total number of students who enrolled for the SSCE examination, choosing physics. Chemistry was next with 44.7% while biology recorded nearly 100% enrolment.

Table 5.1: Summary of SSCE enrolment in Science subjects in Rivers State

Year	Total SSCE Enrolment	Biology		Chemistry		Physics	
		Enrolment	% Enrolment	Enrolment	% Enrolment	Enrolment	% Enrolment
2004	66,358	65460	98.6	27954	42.1	26964	40.6
2005	72,229	71497	99.0	31137	43.1	30000	41.5
2006	76,594	75749	98.9	33296	43.5	32587	42.5
2007	87,004	86136	99.0	38109	43.8	37338	42.9
2008	99,271	98519	99.2	42955	43.3	42145	42.5
2009	81,618	81038	99.3	36204	44.4	35518	43.5
2010	43,757	43160	98.6	20696	47.3	20456	46.7
2011	61,429	61091	99.4	28452	46.3	28203	45.9
2012	60,654	59808	98.6	27932	46.1	27712	45.7
2013	65688	65340	99.5	30689	46.7	30448	46.4
Average			**99.0**		**44.7**		**43.8**

The trend of enrolment is shown as a graph in Figure 5.1. The graph shows a distant gap in choice of students for biology relative to chemistry and physics. An almost consistent pattern of enrolment can be observed with the near flatness of the graphs.

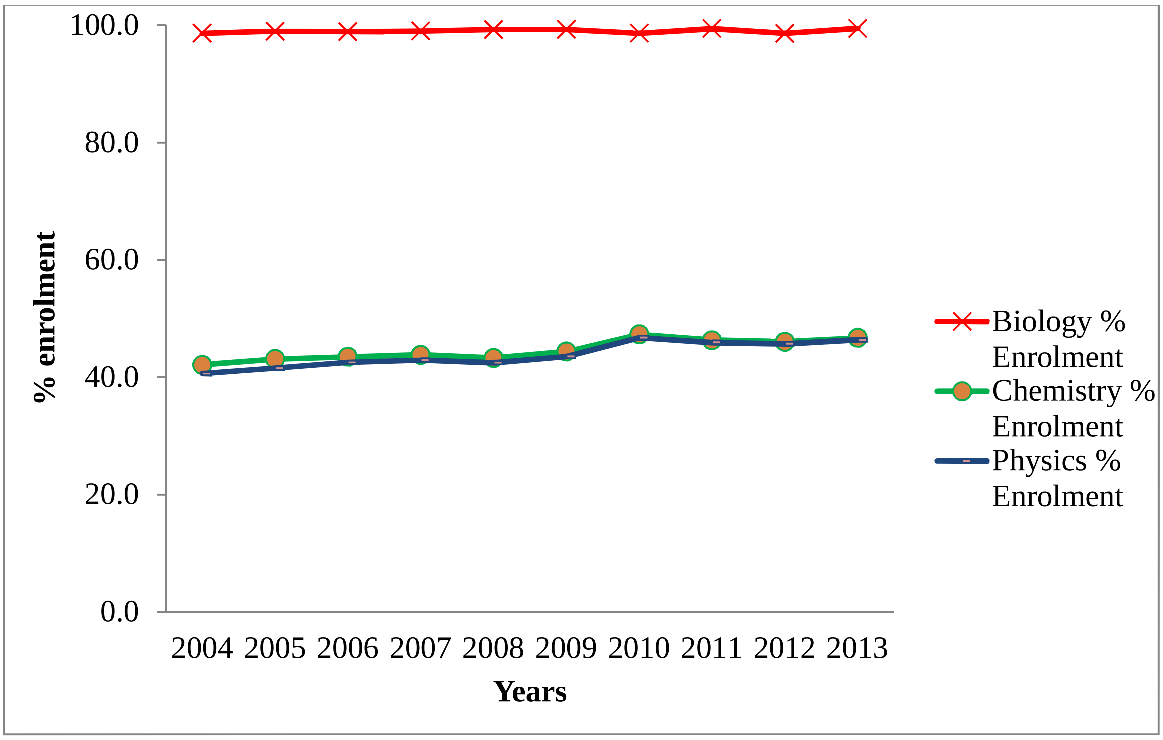

Figure 5.1: Enrolment trend of biology, chemistry and physics, Rivers State 2004-2013

The number of physics students relative to the total number of students in SSS 3 in the schools that participated in the study was also obtained. The data is presented in Table 5.2.

Table 5.2: Total SSS 3 and physics enrolment in sampled schools

Zones	Schools	Total Enrolment	No of physics students	Percentage
Zone 1	A	26	9	34.6
	B	36	15	41.7
	C	72	12	16.7
	D	31	10	32.3
Zone 2	A	116	50	43.1
	B	249	72	28.9
	C	98	35	35.7
SC	SC	172	172	100

The data as shown in Table 5.2 reveals that physics enrolment in all schools involved in the study except in school C ((16.7%), B2 (28.9%) and SC (100%) were around the national and state enrolment figures as shown in Tables 1(a) and 5.1. As explained earlier, all students in SC compulsorily choose physics as the school only admits science biased students. Figure 5.2 is a chart showing the number of physics students relative to the total number of students in the final class of secondary education in the participating schools.

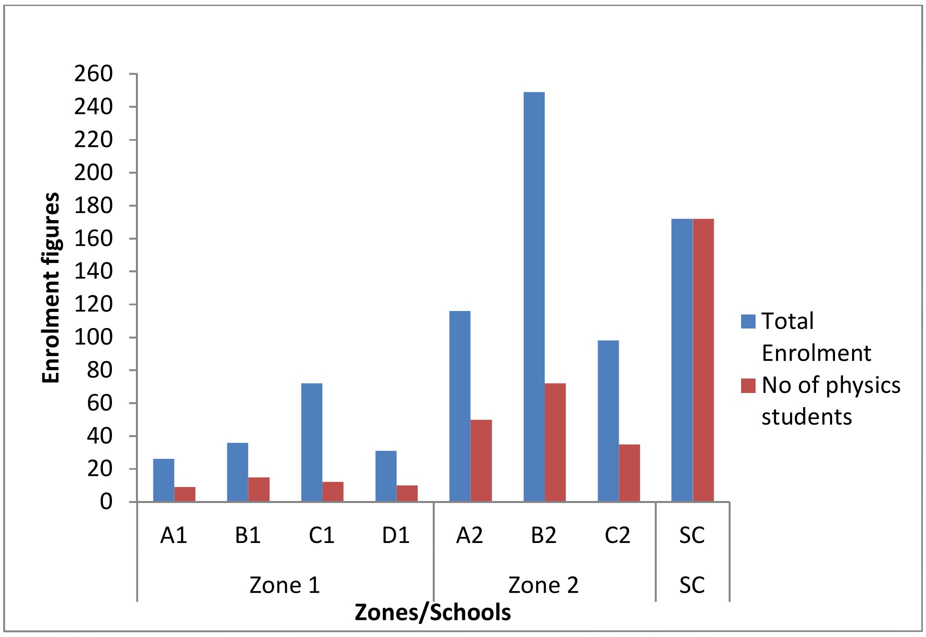

Figure 5.2: Enrolment trend of biology, chemistry and physics (participating schools) 2004-2013

5.3 Attainment pattern of physics students in selected schools

The SSCE attainment record for the period 2004 to 2013 for the entire Rivers State is presented in Table 5.3. The graph showing the trend of secondary school students' attainment in the SSCE for 10 years in Rivers State is shown below as Figure 5.3.

Table 5.3: Summary of SSCE Attainment in Science subjects in Rivers State (2004-2013)

Year	**Biology**		**Chemistry**		**Physics**	
	Enrolment	% A-C Grades	Enrolment	% A-C Grades	Enrolment	% A-C Grades
2004	65460	39.1	27954	42.8	26964	47.5
2005	71497	55.7	31137	67.8	30000	55.1
2006	75749	72.2	33296	68.6	32587	70.0
2007	86136	57.0	38109	71.3	37338	58.5
2008	98519	54.7	42955	56.6	42145	65.9
2009	81038	38.8	36204	45.4	35518	48.9
2010	43160	56.2	20696	50.4	20456	47.3
2011	61091	55.2	28452	58.8	28203	72.1
2012	59808	53.8	27932	54.4	27712	81.5
2013	65340	76.8	30689	84.8	30448	58.6
	Mean	**56.0**		**60.1**		**60.5**

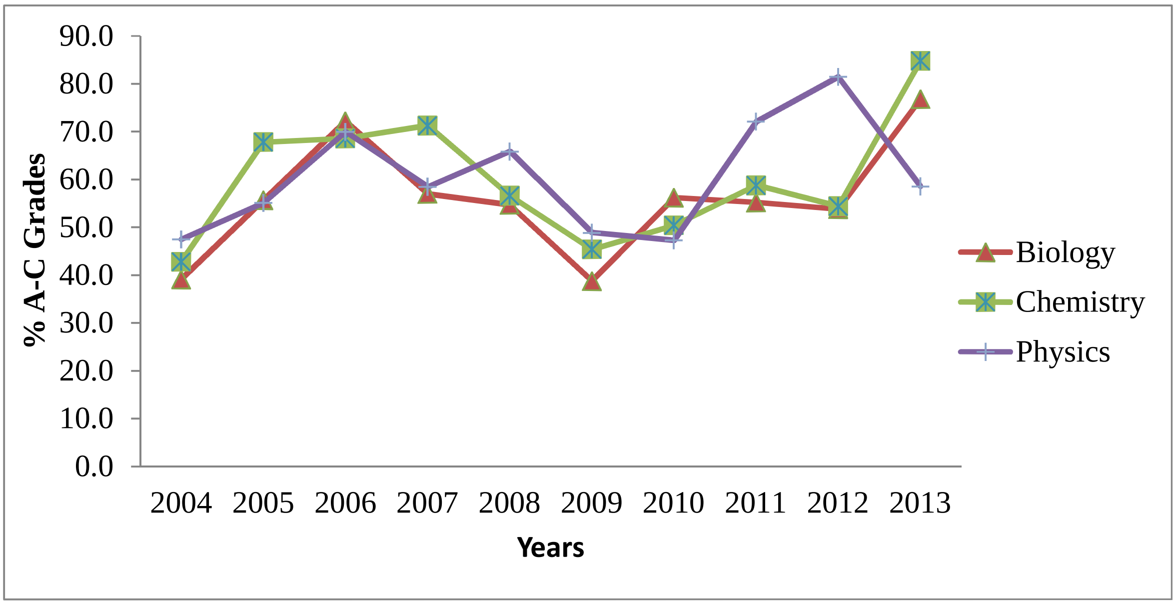

Figure 5.3: Attainment trend of biology, chemistry and physics, Rivers 2004-2013

The graph in Fig.5.3 clearly shows no trend in the attainment of students in all three core science subjects for the period of 10 years in Rivers State as is the case with the National results. As may be observed, there are periods of increase and decrease in performance for all the 3 subjects. For instance, the performance in physics appreciated between 2004 and 2006 and started undulating from 2007to 2010 when it rose significantly up to 2012 before dipping low in 2013. However, when compared for the period of the 10 years, students on the average achieved more A-C grades in physics with a percentage of 60.5, closely followed by chemistry (60.1%) and lastly biology with 56.0%. Students' attainment in Rivers State in all 3 core science subjects is also observed to be higher than the national averages within the same time.

The SSCE physics results for five years, from 2010-2014, of the schools involved in the main study were requested for and collected for the purpose of attempting to establish a baseline for students' attainment in physics in those schools. However, in some schools, the principals were unable to find past results in one or two years due to, according to them, the problem of effective handover from one administration to another. Also in some, the entire physics result for the school in certain years was cancelled. To validate the SSCE results of the schools in physics, the researcher introduced the Physics Attainment Test (PAT) as described in chapter 3. Since it is the interest of this research to examine school-based factors that might affect students' performance in physics, students from schools in two local government areas of Rivers State were involved in the study. The two local government areas were selected using the performance of physics students in the West African Examination Council (WAEC) conducted SSCE for 10 years. For the purpose of anonymity, the two local government areas that were used for the main study shall be referred as 'Zone 1' and Zone 2'. The science school shall simply be referred as 'Science College'. Zone 1 with 42.9% is selected from the local government areas with schools were students performed poorest in Physics from data collated from the West African Examination Council (WAEC) for the period 2004 -2013. While Zone 2 with 65.4% is the local government area with schools were students performed among the best in SSCE physics as collated from WAEC for the same period (see Table 3.7). The SSCE and PAT results are examined in the sections that follow.

5.3.1 SSCE and PAT results of schools from Zone 1

The SSCE results in physics as obtained from the WAEC master sheet for the years 2010-2014 of schools in Zone 1 is presented in Table 5.4 below. A general look at the table shows a difficulty in establishing trend of performance as observed in the national results. For instance, school A1 got 87.4% A-C grade pass rate in 2011, got the entire physics result cancelled in 2012 for examination malpractice, 53.8% in 2013 and a leap to 96.8% in 2014. To enable comparison with the PAT attainment scores in percentage, the SSCE scores in grades were converted to mean percentages and presented in Table5.6. The WAEC grading system of grades and equivalent raw scores in percentages was used for the conversion. The mean percentages adopted for each of the letter grades is shown in Table 5.5. The converted SSCE scores are then compared with the attainment scores in the PAT shown in Table 5.7. The Table shows a clear difference in the attainment of students in the SSCE compared to the PAT. In all schools, students obtained higher grades in the SSCE than in the PAT. This observed difference is discussed in the last section of this chapter.

5.3.1.1 School A1

Table 5.4 shows that SSCE results for 3 years – 2011, 2013 and 2014 were obtained from this school. The school principal could not locate the result for 2010 while the entire students result for physics was cancelled by WAEC in 2012. The commonest reason given by WAEC for the cancellation of results is massive examination malpractice (See for instance, WAEC cancels 2014 results of candidates, 2015).

In 2011, 83 of the 95 (87.4%) students that enrolled for physics obtained grades A-C and in the year following, the entire results were cancelled. After the cancellation in 2013, only 35 of the 65 (53.8%) obtained grades A-C. The pass rate increased to 96.8% in 2014. It can be also observed that the number of entry after the year the result was cancelled also decreased. For the years with SSCE results, the mean SSCE performance was 54.2%. The mean score on the PAT for students in this school was 15.5%. 6 students sat for the PAT the highest score was 25.6% while 7.0% was the least score. This is quite low compared to the average SSCE performance of 54.2% for the school (Table 5.7).

The cancellation of the entire SSCE physics result in 2012 may explain for the lower enrolment and performance in the subsequent year. This is because WAEC focuses attention on examination centres with stern warnings following result cancellation or cessation. Also, it is a common knowledge that candidates avoid centres with record of result cancellation or poor performance. This was also expressed by a teacher during the interview. According to him,

> "… before examinations, we have a lot of students, come for classes but during examinations especially WAEC registration, most of the students would leave the school to other schools to register, reasons being that… before I came, they said they don't use to make results here and for that it has given the school a bad name that is the reason the students leave the school to other schools" (B1T, 7-11).

One wonders why students believe that writing an examination at certain centres will 'guarantee' success and not necessarily the candidates' adequate preparation and reliability of the examination process. This explains the issue of the relatively higher number of enrolment for the SSCE examination compared to the regular students, generally, in rural schools.

This school was visited by the researcher in March, 2015 just about one month to the commencement of the SSCE examinations. The number of physics students in SSS3 – the class of registration for the SSCE examination was less than 10 and the entire students in SSS3 less than 30. The least SSCE enrolment in the school for the 5-year period from 2010-2014 was 62 (seeTable 5.4).It is therefore obvious that most of the students the school enrols for the SSCE examination are external candidates who just come in to write the examination. It is also common knowledge that such students do not attend classes in the school and are selective of the centres or schools where they go to enrol. They most often choose schools in rural areas where WAEC invigilators and other government regulatory bodies find it difficult to visit. This explains the much higher figures enrolled for the SSCE examinations compared to the current figure of students in SSS3.

5.3.1.2 School B1

The SSCE results for School B are shown on Table 5.4. Result for 4 years was obtained. The result for 2012 was not made available. The principal did not indicate whether or not it was cancelled. A look at the table shows that apart from 2011 when the percentage of candidates that made grades A-C was 25.3%, the school recorded 0% in 2010, 2013 and 2014. It is interesting to note that in 2010, the school enrolled 31 candidates for the SSCE examination and recorded 0% for grades A-C, enrolled 87 with 25.3% in 2011 and had no result available in 2012. The number of enrolment went down drastically the year following to 19 again with 0% pass rate for grades A-C. For the years with available results, the average SSCE performance was 31.6%. The mean PAT score for this school was 20.3%. Though, like the other schools, the mean PAT score here was lower than the SSCE mean performance, a close look at Table 5.7 shows that the difference between the scores of the SSCE (31.6%) and PAT (20.3%) is closest in this school. This may be interpreted to mean that the PAT is truly a good approximation of the physics attainment of students in this school. Also, although the school had the lowest SSCE mean performance in the zone, it had the highest mean PAT score.

It may be necessary to mention that this school is located along a major high way linking some states in the region with possibility of regular visits by examination regulatory bodies. It is possible therefore that teachers and students in such schools would be more serious with studies, teachers more regular at school with adequate preparation for their lesson delivery. It may be worth mentioning that during all the visit of the researcher, the physics teacher was always in school whereas in some schools, physics teachers could not be seen in school. Several appointments were made over the phone to be able to get them down to school for the interviews. In fact in one particular school in the zone, school A, the two physics teachers could not be seen in school for about a period of one month. The researcher was able to contact and meet with them in the state capital were they responded to the questionnaire and the interview. It is therefore not surprising that this school performed better in the zone in the PAT score.

The relative better performance of the students in this school B1 may be the result of the quality of the teacher, his commitment and utilization of available resources as expressed by both the students and the teacher in their interviews. For instance, on the use of resources and his style of teaching, the teacher explained that:

> "I go with… most times the apparatus that are available, to demonstrate to students on the use of these apparatus while teaching, like when I was teaching SS I just this morning (18/2/2015) I went with the conductor, I went with the ammeter, the volt meter, the cell, I went with the key and the… all necessary materials to demonstrate to them the need to understand what we mean by a circuit or what we mean by close circuit, open circuit and short circuit. So most

> times I do use the demonstration method to teach for easy understanding of the students" (B1T, 103-109).

All physics students interviewed were full of praise for the teacher and that he was a main factor for their choice of physics. This is captured in the expression of this student:

> "I choose to be a physics student because of the teachers we have in this school and due to the facilities. At times too in the class when you walk in to the class you understand physics clearly because he makes the formula, the definitions and every other thing very simple and so for us the students at times too it becomes somehow complicated because according to him he always uses laws, laws and laws and at times too we cannot just start cramming all the laws in our heads but still he made everything easy and for we the students though our brain is not as wide as his but he made everything simple so…by that…he makes it interesting" (B1P/1, 20-26).

Although the physics teacher would not say that the school had a physics laboratory, the students see the teacher's office that accommodates some facilities for demonstration and remains of resources used for past SSCE practical examinations as a 'physics laboratory'. According to the students, the teacher encourages them the use of his office for practical. This student puts it this way:

> "we the science students, we just took the lab as everyday activity to us; because having a place like that even if it is not well equipped, it gives us joy… the joy to witness or to carry out our practical. Like us here, he (*the physics teacher*) gives us freewill to come and perform any type of practical you want even if he himself has not taught us that, he like new ideas, he likes students being creative, he opens his door for anybody who wants to learn at any time he doesn't see us as people bothering him; so, it's also, will I say his office, because he is in charge of it. Any time you go for practical, he is… his hands are open for you to come" (B1P/2, 216-222).

Explaining further, on how students are organized for practical sessions, the student said,

> "He made it like typing a manual for us and listing so many practical that are compulsory, comprising of SS I, SS II & SS III, he made it compulsory and every, each and every one of us had that manual, so he made it like Thursdays or thrice a week or twice a week we go to that laboratory, as in not necessarily that it is one person, maybe group by group, he will bring this group A, look at the group leader, everybody will do this and bring the result, at the end he would analyse it and tell us where we are wrong" (B1P/2, 239-244).

The views expressed by the students were consistent with those of the teacher as presented in this excerpt:

> "Most times I use my office and when my office is not so convenient I use the other staff room when the teachers are not there. I arrange the tools and I ask the students to go in there for their practical to ensure that they will be able to do that themselves" (B1T, 90-93).

So, there seem to be some form of teaching in this school, where students not only get theoretical exposure to the study of physics, but also, some practical demonstration. These may explain the relative better performance in the PAT of students in this school. In terms of the enrolment figures, the number of physics students enrolled in SSS3 at the time of my visitation was 15. Like in school A, it was a common practice for most principals to register external candidates for the SSCE examination who do not attend normal classes but only come in to write the examination. The location of the school along the high way linking most states in the region may explain for the fewer number of students enrolled for the examination compared to school A, a similar mixed school which is located in the interior part of the area.

5.3.1.3 School C1

The SSCE results of school C are shown in Table 5.4. Like explained earlier, this is a single sex girls' school located in one of the remotest locations in the zone. The school had no laboratory and physics resources for the teaching and learning of physics. The only physics teacher in the school is an in-experienced youth corps in his mandatory one year national service. As shown in the table, in 2010, only 4 students entered for physics in the SSCE examination with one of them (25%) making a grade A-C. In 2011, 10 enrolled for physics with 2 (20%) making grades A-C. The school had no record of SSCE results from 2012 to 2014. Although the school could not give reasons for the non-availability of the results, it was however confirmed that the entire result for the school in 2013 was not released by WAEC. Again, WAEC normally relies on proven evidence of sharp examination malpractices to cease school results. The mean SSCE score for the school was 45.2% while that of the PAT was 13.5% (Table 5.7). 11 students wrote the PAT with 30.2% and 4.7% as the highest and lowest scores respectively. This shows a poor performance especially in the PAT. It could be observed that the PAT mean score for this school was second from the rear. This may not be unconnected to the lack of qualified physics teacher in the school, lack of resources and low motivation of students under these circumstances to study physics as expressed by the teacher and some students. According to the teacher,

> "the challenge we are having here is actually the... some apparatus to perform practical, but students actually have an interest but due to some lack of instruments, that is why some of them are not more interested in it, so they look as if physics is more abstract than other science courses" (C1T, 7-10).

Explaining further, the physics teacher maintained that,

> "Well, in my school we lack so many things, like we don't have anything like online resources, computer, using computer to demonstrate physics em... apparatus or some of other practical equipment, like all these electricity, we don't have light here so you cannot do something on electricity much…" (C1T, 53-56).

This was also asserted by the students "Well, in this school we don't have all these apparatus that assist in physics, just that the teacher would come in, he will try to teach…" (C1P/1, 154-155). Until, the physics teacher was posted to the school for his mandatory national youth corps service, the school did not have a physics teacher. The youth corps member, as at the time of the visit of the researcher, was the only physics teacher - teaching the SSS1, 2 and 3 classes. One of the non-physics students said she would have been a science student but for the lack of teachers in the subjects:

> "When I was in SS 1, I wanted to be a science student, but then, our teachers were not many, we did not have physics and chemistry teachers so I decided to leave it and go for the arts class that is why I'm not offering physics" (C1N/1, 63-65).

Students were asked the question: “what do you think can be done to make the learning of physics interesting so as to improve students’ performance?” Students opined that the provision of well-equipped laboratories and qualified teachers would encourage better participation and performance in the subject. Another contribution of a physics student to the above question may have provided an insight into how physics is taught in the school.

> “For student enrolment I would like the teachers to interact more with students to know if they are like, comprehending, understanding what they are saying, not that the teacher will just go, solve on the board, he will not even ask the students if they understand or not, they should try to give them exercise to do and em... get feedback” (C1P/3, 212-215,217).

It is therefore not surprising that students in this school scored among the least in the Physics Attainment Test (PAT). The issue of teaching methods adopted by teachers will be discussed later in chapter 6. However, the forgoing would suggest that there may not have been adequate teacher-students interactions and feedback that are necessary for better attainment.

5.3.1.4 School D1

The SSCE results for this school are shown on Tables 5.4 and 5.6. Results for 4 years (2010, 2011, 2013 and 2014) were obtained as the school could not account for the 2012 result. The percentage of students achieving grades A-C in the SSCE was 0, 23.1, 60 and 100 for 2010, 2011, 2013 and 2014 respectively. The mean SSCE attainment for the school as a result of outliers of 0 and 100 was 47.9% (Table 5.6). It can be observed that this school had 100% of all its students obtaining grades A-C in 2014. A look at Table 5.7 comparing the SSCE and PAT scores in the zone shows that the school made the least mean score (11.6%) in the PAT, not only in this zone, but for all schools involved in the study; even though it had the second best attainment in the SSCE (47.9%) in the zone. Some insight in the discrepancies between the SSCE and PAT are discussed in section 5.4.

The students’ interview gave some insight as to the possible causes of poor performance of physics students in this school. The students were blunt in their assertion that all is not well in the teaching and learning of physics in the school. A student who dropped physics after initially opting to study physics had this to say:

> “Em… as for me, enh… as for me, I never love the subject and I see the subject as a boring subject, doing the calculating and those things… I never like the physics and since for my dream… em, it is not in my future. So I don’t like doing physics… I don’t even like how they are teaching it… when the teacher teaches in the class the class will be so cool... no action… I mean the teacher will do straightforward and just discuss as in… … in our school here, we don’t normally use to do enh… practical and enh…” (D1N/1, 37-40, 44-45, 49, 56-57).

Another student, this time a physics student while responding to the question on what to be done to make the teaching and learning of physics more interesting requested that:

> “…they have to provide a nice teacher which can settle down and teacher us more better that we can ask questions – a teacher that is so friendly…that will… as in because some teachers if you look at their face you can’t ask them any question. They have to bring a nice teacher who can cool down and teach students about physics” (D1P/1,216-219).

On laboratory activities in the teaching and learning of physics, the students revealed that they do not have such sessions in school except they individually source for help outside the school.

> “Sir, we don’t… we don’t, as in we don’t use to do it unless, unless individually, you can as in go out to search for some help or some practical, but if it is in this school, we don’t have anything like that” (D1P/3, 175-177).

The teacher in his interview also alluded to the fact that the school lacked basic resources for the reaching and learning of physics. According to him,

> “where there is no standard facility like here, they are not accessible to computer, you cannot use… this… enh… television in teaching like all this DVD as in teaching this… so what we always do is the chalk-board method, the highest computer that they would use is calculator… so if you cannot bring in teaching materials then some other facilities like the laboratory facilities, the things we are using, that is why I say it’s below average” (D1T, 229-234).

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Table 5.4: SSCE performance in physics for 2010-2014 of participating schools in Zone 1

Years / Zone1	2010			2011			2012			2013			2014		
	No of Entry	Scored Grades A-C	%	No of Entry	Scored Grades A-C	%	No of Entry	Scored Grades A-C	%	No of Entry	Scored Grades A-C	%	No of Entry	Scored Grades A-C	%
SchAZ1	NA	NA	NA	95	83	87.4	NR	NR	NR	65	35	53.8	62	60	96.8
SchBZ1	31	0	0.0	87	22	25.3	NA	NA	NA	19	0	0.0	26	0	0.0
SchCZ1	4	1	25.0	10	2	20.0	NA	NA	NA	NR	NR	NR	NA	NA	NA
SchDZ1	18	0	0.0	26	6	23.1	NA	NA	NA	20	12	60.0	41	41	100

(NA – Result was Not available, NR – No Result (Result for Physics was cancelled)

Table 5.5: WAEC grading system and mean percentages adopted

Letter Grades	Scores in percentages	Mean %
A1	75 – 100	87.5
B2	70 -74	72
B3	65 – 69	67
C4	60 – 64	62
C5	55 – 59	57
C6	50 – 54	52
D7	45 – 49	47
D8	40 – 44	42
F9	0 -39	19.5

Table 5.6: Mean Zone 1 SSCE attainment scores in percentages

Years / Zone1	2010	2011	2012	2013	2014	Mean %
SchAZ1	NA	55.5	NR	51.1	55..9	54.2
SchBZ1	28.6	44.1	NA	23.4	30.1	31.6
SchCZ1	47.0	43.4	NA	NR	NA	45.2
SchDZ1	40.3	45.8	NA	48.4	57.1	47.9

Table 5.7: Comparison of Zone 1 SSCE and PAT scores in percentages

Exam Type / Zone1	Mean SSCE	PAT Scores	Difference
SchAZ1	54.2	15.5	38.7
SchBZ1	31.6	20.3	11.3
SchCZ1	45.2	13.5	31.7
SchDZ1	47.9	11.6	36.3
Mean	**44.7**	**15.2**	**29.5**

5.3.2 SSCE and PAT results of schools from Zone 2

The SSCE physics results from 2010-2014 of schools in Zone 2 is presented in Table 5.8. The Table shows again the difficulty in predicting performance of students in the zone. For instance school A with 76.2% in 2010, dropped to 52.2% the following year and a great leap to 94.4% in 2012.

Three schools were used as part of the study in this Zone – a boy, girl and mixed schools. As explained earlier, the SSCE grades were converted to percentage scores to enable comparison with the PAT scores. The converted SSCE scores in each school of the zone are presented in Table5.9. Again, the converted SSCE scores are compared with the PAT attainment scores and shown in Table 5.10.

As was the case of schools in zone 1, there are marked differences in scores of students between the SSCE and PAT. The performance of students in the PAT test is seen to be lower in all schools in the zone relative to the SSCE. Despite the fact that the SSCE results were not too impressive, the strict examinations conditions enforced during the PAT would suggest that students' attainment may even be lower considering the credibility issues in the conduct of the SSCE as discussed in section 5.4. The implication of all these is that the two sets of scores could not be reasonably describing the attainment of students from the schools used for the study in that zone. A possible explanation for the differences in scores is offered in subsequent sections.

5.3.2.1 School A2

The SSCE results for the school are shown on Table 5.8. All the 5 years results for the school from 2010 – 2014 were obtained. The percentage of physics students that obtained A-C grades in physics for the school was 76.2, 52.2, 94.4, 95.9 and 92.7 for 2010, 2011, 2012, 2013 and 2014 respectively. The converted SSCE scores in percentages and school mean (52.9) are presented on Table 5.9. The mean PAT score for the school was 25.3% and is presented on Table 5.10. A comparison of the SSCE and PAT attainment scores for the school shows a contrast with students obtaining lower scores in the PAT than the SSCE. 22 students wrote the PAT out of which only 1 student scored 53%. All others scored less than 50 which is the lower boundary of the C grade in the WAEC, SSCE grading system (Table 5.3).

The students and teachers in this school threw some light on the teaching and learning of physics in the school which may have some negative effects on physics enrolment and attainment of students. The senior physics teacher during the interview lamented the poor state of teaching resources in the school. According to him:

> "As in my school here, you talk about the resources for teaching physics. I don't think if there is, because for two years I've been here and they have not mentioned laboratory, there is nothing to show that there are resources for teaching physics, so that one too is contributing to… to… non-compliance to physics" (A2T, 43-46).

When asked on how he handles the practical aspect and content of the physics curriculum, he said:

> "We don't… I have not seen... we don't even have a laboratory to start with. It's only when you have a laboratory then you can talk of, you can talk of enh... the resources. We don't have a laboratory… Yeah! Maybe during WAEC they sought for… when there is examination they sort for these materials… for the resources then carry out any practical, depending on the specimen, so but for a lab that the school is supposed to own, there is no one in this school… there are topics you would want to teach, the students will echo sir, lets practicalize, show us, lets experiment, which ordinarily that is what is supposed to be; at least you take them in the theoretical part, you go to the practical part of it to experiment one or two things to buttress the (*theory or*) throw more light, yes! or confirming the theory, but this one, there is nothing like that, you only teach the theory and leaving the practical behind because of lack of resources" (A2T, 51-55, 67-72).

The teacher said he teaches only the ‘theory’ aspect of physics as there were no resources for demonstration and laboratory work. This was also corroborated by the students and that that has affected both the enrolment and understanding of the subject.

> “Actually right from the onset, we have never done anything like physics practical” (A2N/1, 291).
>
> “… this is what we are saying, this is the problem we physics students are facing today, em… when we look into the learning environment, we find out that there are no good things to back up em… the study of physics that is why most students run away; in fact there is no laboratory in which we conduct most practical, all things are theoretical which are not helping matters and this is one of the things that make students run away because they don’t understand this, because practical makes you understand more, that is just the thing” (A2P/4,300-305).

It is therefore not surprising that under strict examination conditions as was the case of the PAT, students’ performance was relatively poor compared to the schools’ record of SSCE performance. It is also interesting that the teacher honestly recognizes himself as an ‘unqualified teacher’ when he was asked if there were any factor that may have hindered or incapacitated his effective teaching. He said:

> “The factor that has really hindered is … I will mention lack of qualified physics teacher because in my own case I am not… in as much as I am teaching physics I am not a qualified physics teacher based on the fact that I’m supposed to be trained as a physics teacher, major physics, you know, attend some seminars that will be very helpful and you know, but there is nothing like that. I’m only teaching based on the background that I am (*was*) a science student, so these are the factors, lack of qualified teachers, and lack of resources for teaching physics” (A2T, 92-97).

The students unfortunately also recognize the incompetence of the physics teacher as they were unanimous in their request for a qualified physics teacher.

> “One, what I will say about is that just laboratory, to give us a good laboratory and a good physics teacher because the one we have now is not even … he did not study physics, he did not study physics in the school so because of no job in the

> country so, he just have to manage to teach us, so we need a good teacher" (A2P/1,327-330).
>
> "We need a laboratory and a well-grounded teacher, a teacher that knows what he is doing" (A2P/2, 332-333).
>
> "One other thing why most students are running away from the study of physics… Not as if they don't love the physics but we find out that the teachers we have now teaching physics many of them, they are not grounded in physics they don't explain things which one should understand when you see them solving most calculations in physics you don't see them following it step by step to the understanding of the students so these thing are also things that make students run away from physics" (A2P/4, 130-135)

On the quality of teachers and how that may have affected enrolment, a student who dropped off the physics class in SSS 1 explained that:

> "Actually I wanted to read marine engineering but when I was in SS I, I met chemistry, I met physics, met biology and some other science subjects. It made me scared because the teachers then were scaring… our physics teacher then in SS I, when he comes to the class, there is only one thing he does, is to laugh, tell us stories, make us laugh and then the next thing you hear is, I'm leaving the class… the way the teacher is behaving… is not taking things serious, you don't expect me to catch up in that manner, so instead I just dropped" (A2N/1,269-271, 273-275, 279-280).

It is evident that these conditions of lack of adequate teaching resources and quality teachers have resultant effect on the interest, enrolment and attainment of students especially in a science subject like physics.

Interestingly, the students in this school performed relatively better in the PAT with an average of 25.3%, coming up 2nd in the zone and 3rd of the 8 schools involved in the study. The physics students in this school, by their expressions appear to be well self-motivated to study physics. Some of them explained their continuous stay on physics despite the situations they have considered not encouraging to study physics.

"We did not have a physics teacher then we had a Corper[1], a Corper that was to take us on physics, but you know the situation of Nigeria, the Corper was as in … he didn't know what he was doing, he only comes to the class just to chat with students… But it's just the few students which have the passion in that physics course that usually, come together to talk about the things which they have found in the physics text book or in their readings, so they will now discuss about it" (A2P/2, 241-243, 246-249).

"The reason why I am going into physics is that I love nuclear weapon a lot and I want to learn how to produce all these nuclear weapons because whenever I see, I watch war, like the Gaza and Israel war, I feel how can something - this small thing, destroy a whole nation[1]? So that - the love for nuclear weapon has made me to study physics and I love it a lot. I love studying physics; I love it because of the love of nuclear weapon" (A2P/3, 44-48).

"The reason why I decided to offer physics is that sometimes I do watch the Television and I do see what the Americans do produce like Technologist, phones and aeroplane, aircraft… my friend brought out a book and showed me some guys - a group of guys, just like my age mate producing all sorts of things, like motor, aeroplane with container, I was now asking myself, how were they able to produce this, that if the people can do this, I was now thinking, thinking, before I knew it, I now said that I have to study physics in order to know how these things move, how this rocket is being produced, what makes this rocket to fly and how does a pointer, when somebody hold a gun, how does somebody get its target when he is afar, citing somebody close to you. All these kind of thoughts gave me idea; I now decided to pick up physics as a course" (A2P/2, 14-23).

"I am such a one that have the mind of creating things, so with the help of physics that scope of understanding can be broadened whereby I can be able to create things and there about, but the problem is that the secondary school we have now-

[1] A 'Corper' is one in the mandatory post-university graduation National Youth Service Corps in Nigeria.

a-days they are not helping matters because there is no standard laboratory, nothing to back up the study of physics that is why students have low performance in physics so these things are factors that are pushing students away, but because of the love I have and that the course I want to study is related to physics, I cannot do without it, this is one other thing that push me and make me zealous towards studying physics" (A2P/4, 58-65).

It is likely that the collaboration among the students in the study of the subject and 'passion' for physics may have reflected in the relative better attainment in physics in this school as evident in the PAT.

5.3.2.2 School B2

This is a co-educational school. Results of the SSCE obtained from the school are shown in Table 5.8. Only results for 3 years – 2011, 2012 and 2013 were obtained from the school. The school did not register for SSCE in 2010 having been established in 2008. This implied that it is only the 2014 result that was not available. No reason was given for the non-release of the result. For the three years, the percentage of students that obtained grades A-C in physics was 93.3, 95.0 and 83.3 respectively. The converted SSCE scores in percentages are shown in Table 5.9. The percentage scores were 55.2, 61.0 and 52.3 respectively for 2011, 2012 and 2013. The mean percentage SSCE score for the school was 56.2. The mean PAT score of students for the school was 18.7% and is shown on Table 5.10. Fifty students participated in the PAT out of which only one student scored 53.5%. The rest of the students scored less than 50% which is the lower mark of the C grade in the WAEC grading system for the SSCE. Again, comparing the SSCE and PAT scores, one clearly observes the disparity between both scores of students from the school. Although the school's 56.2% mean in the SSCE was the 2nd best in the zone and 3rd of all 8 schools used for the study, its PAT score (18.7%) shown in Table 5.10 was the least in the zone and 5th of all 8 schools involved in the study.

To have a glimpse of how students learn physics in the school in relation to use of resources,, students were asked the question as to whether they carry out some activities 'to find out things for themselves'. A student responded:

> "No, we have not done student activities. No! No! No! We have not experienced most of those things" (B2P/1, 312-313).

The assertion of the students was confirmed by the teacher who also opined that lack of resources was contributory to students' low interest in the study of physics. According to him,

> "The availability of those resources is poor… very poor because from the onset I said that physics is all about practical experience. When you teach somebody about electricity, you need to perform what you have told them in the class practically - not coming with a text book or instructional materials like chalk and other handout or whatever. You talk to them theoretically… but practically they are not seeing. So the resources available are very poor so that makes the interest of the student towards the subject… reducing in percentage" (B2T, 80-86).

Although this school had a 'comprehensive' laboratory for chemistry and physics, it does appear that students and teachers do not use it and the few facilities in the teaching and learning of physics. All students – both physics and non-physics students during the interview affirmed that the school does not have a physics laboratory. On how they carry out physics laboratory activities, the students revealed that they engage in such activities during the holidays.

> "Specifically, mainly during holidays that we can set… em… holiday lessons with other schools that we normally go to the laboratory and carry out such activities" (B2P/1,352-353).

This agrees with what the teacher explained during his interview on the conduct of laboratory activities:

> "Yes, we do organize practicals for them. Like during the holidays I pass the information to the interested ones because I know everybody would not be so interested because its holiday period..." (B2T, 103-104).

The interview with the teacher was conducted about the 7th week of the 2nd term, barely 3 months to the SSCE exams and students have not been so much exposed to practical work in physics, "So for this term we have not done any (*practical*)" (B2T, 109). Although the teacher attributed the non-conduct of practical classes to the political crises in the community, it is difficult to rationalize his idea as the crises never affected the smooth day-to-day activities of schools in the area during the period.

> “And, the school resumed… the school resumed with crisis in our environment, so everybody is always afraid but as at yesterday (11/2/15) the students met and came to me and said that we can now start up the practicals. So for this term, we have not done any because of the crisis in the environment, but we hope to start these practicals by next week Monday” (B2T, 107-110).

The state of teaching and learning of physics as presented by both physics students and teachers it is thought, would not encourage a sustaining interest and performance in the subject and may have resulted in the poor performance of students especially in the PAT.

5.3.2.3 School C2

School C in zone 2 is the only single-sex girls’ school in the zone and one of the 2 girls’ schools used in the study. SSCE results for 2010, 2011, 2012 and 2014 were obtained from the school. The result for 2013 was not available as the researcher was informed that the master sheets were requested for and returned to WAEC. The mean percentage of students with A-C grade pass in physics for the school was 100, 92.3, 80.5 and 76.5 respectively for 2010, 2011, 2012 and 2014 (Table 5.8). The converted SSCE scores in percentages of 64.0, 67.0, 51.9, and 50.7 with a mean of 58.4% for the 4 years are shown on Table 5.8. The mean PAT score for the school was 27.6%. It can be observed that this school recorded the highest mean SSCE attainment in all 8 schools used in the study. Its mean was 0.2 higher than the science school although the science school scored much higher in the PAT with a difference of 19.8%. The PAT score of students in this school (27.6%) was the 2nd best after the science college.

As observed in all schools, the PAT attainment score (27.6%) was much lower than that of the SSCE (58.4%) as shown in Table 5.9. Fourteen girls wrote the PAT with only 1 student scoring 58.1%. The others scored below 50% to obtain at least a ’C’ grade using the WAEC grading system.

The issue of late exposure of students to laboratory activities was highlighted when the teacher said that:

> “… but I think as of last year during their WAEC (West African Examination Council) we had somebody that came to highlight them on how the WAEC

practicals, the experiment would be like, just to prepare their minds" (C2T, 30-32).

Although the students said the school does not have a physics laboratory, the teacher maintained that the school had a physics lab. When asked on how frequently students utilize the laboratory and its resources, the teacher explained that:

"Any student that *wishes* to, the laboratory is there for him or for her. If you wish to go anytime all you need to do is to seek the attention of the physics master, then the physics master will now link you to the laboratory attendant who will give you whatever you want" (C2T, 75-77).

When asked if he does not use the laboratory for experiments and demonstrations to complement theoretical concepts instead of just allowing 'any student that wishes', the teacher further explained how he utilizes lab resources in physics lessons. According to him,

"Well, what I normally do... there are some topics that they need to see some of these things, so in such topics what I do, I pick some of those things from the laboratory and take it to the class, as I am teaching, I also show them for them to see and know it" (C2T, 88-90).

The students also gave an insight into how they engage in practical activities. According to them,

"Nevertheless the fact that we don't have a physics laboratory, we still have some equipment for physics practical in the laboratory, so we still bring some of them from there and hold the practical in our class, so that's how we perform our practical" (C2P/1,308-310).

The students also revealed that they sometimes make contribution for the acquisition of materials for the conduct of laboratory activities.

"…like, eh.... a practical we had when we were in SS II, we had to pay money so that our teacher could get the instrument so that we would be able to do the practical since we didn't have the equipment" (C2P/2, 325-327).

"Like we said, its ... sometimes we see practical…the equipment and students as we all know will not like bringing money, bringing money, bringing money and the teacher will not like to pester the students on bringing money. So, the thing is,

> most of the times we don't see them, we just understand what the teacher is saying and accept it the way it is, and other ones that we have in the laboratory we can also use them and the ones that require less amount of money, the students can contribute and carry out the practical, but most a times we don't see them" (C2P/1, 336-341).

The students also expressed some confidence in the teacher as a positive influence.

> "I study physics and I'm a physics student. Physics, I find it very interesting and the way my teacher teaches physics and he analyses it…if it is a topic, he brings out the things to show us and we understand it…the class flows when he teaches, so I just like it" (C2P/2, 6-8).

Another student added: "…the teacher is so good, he teaches very well" (C2P/3, 15).

The foregoing shows that although all is not well in the teaching and learning of physics in the school, there seem to be a fair utilization of available resources and some personal efforts to facilitate effective teaching and learning as revealed by both the teacher and physics students in the school. This may have contributed to the relatively better attainment of students in physics in this school compared to students in other schools in both zones 1 and 2.

Table 5.8: SSCE performance in physics for 2010-2014 of participating schools in Zone 2

Years / Zone2	2010			2011			2012			2013			2014		
	No of Entry	Scored Grades A-C	%	No of Entry	Scored Grades A-C	%	No of Entry	Scored Grades A-C	%	No of Entry	Scored Grades A-C	%	No of Entry	Scored Grades A-C	%
SchAZ2	105	80	76.2	90	47	52.2	90	85	94.4	97	93	95.9	55	51	92.7
SchBZ2	NA	NA	NA	119	111	93.3	121	115	95.0	168	140	83.3	NA	NA	NA
SchCZ2	23	23	100	26	24	92.3	41	33	80.5	NA	NA	NA	34	26	76.5

(NA – Result was Not Available)

Table 5.9: Mean Zone 2 SSCE attainment scores in percentages

Years / Zone 2	2010	2011	2012	2013	2014	Mean %
SchAZ2	51.5	43.9	56.1	59.4	53.7	52.9
SchBZ2	NA	55.2	61.0	52.3	NA	56.2
SchCZ2	64.0	67.0	51.9	NA	50.7	58.4

Table 5.10: Comparison of Zone 2 SSCE and PAT scores in percentages

Exam Type / Zone 2	Mean SSCE	PAT Scores	Difference
SchAZ2	52.9	25.3	27.6
SchBZ2	56.2	18.7	37.5
SchCZ2	58.4	27.6	30.8
Mean	**55.8**	**23.9**	**32.0**

5.3.3 SSCE and PAT results of the science college

SSCE result for all five years was obtained from the school and presented in Table 5.11.

Table 5.11: SSCE performance in physics for 2010-2014 of the Science College

Years	No of Entries	Scored Grades A-C	Percentage
2010	117	102	87.2
2011	144	143	99.3
2012	128	102	79.7
2013	127	60	47.2
2014	150	138	92.0

Like as been expressed earlier, close look at the table shows the difficulty in predicting a trend in physics attainment for the school. In 2010, the school made 87.2% which rose to 99.3% in 2011 and fell back to 79.7% in 2012. In 2013 it fell to 47.2% and dramatically climbed to 92% the next year. As explained earlier, the SSCE grades were converted to percentage scores to enable comparison with the PAT scores. The converted SSCE scores of the school are presented in Table 5.12 while the school means for the SSCE and PAT are shown in Table 5.13.

Table 5.12: Mean Science College SSCE attainment scores in percentages

Years	Percentages
2010	65.7
2011	67.6
2012	54.0
2013	46.3
2014	57.6
Mean	**58.2**

Table 5.13: Mean Science College SSCE and PAT scores

Exam Type	School Mean (%)
SSCE	58.2
PAT	47.4
Difference	10.8

It is interesting to note that this school performed best in the PAT with a mean of 47.4% and that the difference in both the SSCE and PAT means is also the closest in this school than all other schools in the study. Although the attainment of students in this school is somewhat better, it is nonetheless not impressive as the 47.4% in the PAT score is less than a C grade in the WAEC grading system.

The senior physics teacher attributed the perceived better performance of students in the school to “the kind of exposure that we give to them (students) in this school *and* the facilities on ground” (SCT, 10).

> “As far as SC is concerned, we have enough material resources… we have the textbooks, we have an available library stocked with books where the students… even if you… if there is any particular text you don’t have, it’s there in the library. In addition to that, we also have an e-library with all the facilities that the students can access for whatever materials they need… so in terms of material resources we have it here” (SCT, 126-130,135).

Although the school had a well-equipped physics laboratory, observations during the visit of the researcher and responses of both the students and teachers in the interviews and questionnaires revealed that the facilities were not adequately accessed and used for physics teaching and learning in the school. When asked on the frequency of utilization of the laboratory and its resources for teaching and learning, student SCP/1 responded “Yeah, once in a while” (SCP/1, 150). Contributing, another student said:

> “the only time we are given a chance to enter into the laboratory is when the teacher goes with us, but as for individually we want to go and learn or study something inside the laboratory, you can’t go because they are always afraid that if we go there, we might spoil something” (SCP/5, 152-155).

One may ordinarily have no problem with this response as the laboratory is truly not a place to allow young children to access without adequate supervision. However, further probe as to how frequently the teacher takes students to the laboratory, the students respond was: “Sir, once in a while, it’s not every time” (SCP/1&5, 159). Student SCP/1 explained further when he said: “any particular topic that need practical. When a particular topic that need practical is taught he would take us there” (SCP/1, 163-164). While this may be considered a fair response since one would not expect the teacher to belabour unnecessarily the students with practical work or demonstration for a topic that does not require one, the students’ response on the questionnaire to the question “My school has enough facilities for conducting experiments or investigations in physics” was sort of contradictory with 57.6% of respondents either disagreeing or strongly disagreeing with the statement while only 28.3% agreed (or strongly agreed) with the statement as shown in the table below.

Table 5.14: Students’ response to the question: my school has enough facilities for conducting experiments or investigations in physics

Responses	No of responses	Percentage
Strongly Agree	3	3.0
Agree	25	25.3
Disagree	29	29.3
Strongly Agree	28	28.3
Can't say	14	14.1

In another follow-up interview on the phone, the teacher was asked to comment as to why most of the students were disagreeing with that statement, with the evidence of an existing laboratory with adequate resources. He explained that the increasing class size without adequate expansion of facilities may have informed the response of the students.

> “The only thing the students can say about the lab is that as I speak to you now, the lab is not as big as it should; because as the number of students is increasing, there is supposed to be a commensurate expansion. But in terms of setting up… having the materials to set up the practical, we have all that it takes” (SCT, 198-201).

In a further probe as to whether the students’ response was indicative to the fact they are not exposed to laboratory work early, the teacher said:

> “Probably yes… probably that could be what they may be thinking. But there is no way we could expose the students to laboratory work from SS1… you don’t expect… because most of the topics in SS1 would not take them to the lab. It is in 2nd term in SS2 that we actually begin the laboratory work for SS2 and then SS3” (SCT, 209-212).

One who is conversant with the physics curriculum will however find it difficult to accept the view of the teacher that physics topics in SS1 do not require laboratory work as all topics of the physics curriculum from SS1 have activities for both teachers and students, most of which could be carried out in the laboratory. For instance, using metre rule, tapes, spring balance, chemical balance, venier callipers etc. to “demonstrate the measurement of the fundamental quantities” (FME, 2009: 1) is an activity for the 1st topic in week 1 of the SS1 physics. How interesting and inspiring it will be to engage young minds in a laboratory to find out things for themselves just in the first week in a physics class.

This school had the highest mean score in the PAT as has been mentioned earlier. The level of availability of resources and fair utilization coupled with the quality and commitment of physics teachers in the school relative to others in the study may explain the better attainment of students in this school. Also, both scores of the SSCE and PAT are relatively higher in this school compared to the other schools. Since both tests are designed to assess students’ attainment in physics, there can be said to be an agreement in both tests for assessing the physics attainment level of students in this school.

5.4 Reflections on the variation and commonalities of the SSCE and PAT results

As it can be clearly observed, the attainment levels are generally low in the PAT than the SSCE. This may be attributed to 3 factors.

(1) Level of preparation for the examination. Students for the SSCE are more likely to have prepared adequately than those for the PAT. The SSCE being the final examination and a requirement for students’ progression into university education and other career prospects. It is possible that students may have had a low stake for the PAT and so did not prepare seriously for the exams and hence the low performance.

(2) Level of difficulty. Although the PAT items were validated by physics teachers in Nigeria as adequate for use, that all schools had lower averages in the PAT than the SSCE may also imply that the PAT with items adapted from GCSE may have a higher difficulty level than the SSCE conducted by the West African Examinations Council, WAEC.

(3) The conduct of the examinations. The PAT was conduct under strict examination conditions unlike the SSCE which is usually characterized by various sorts of

examination malpractice (See for instance WAEC report, 2009, p2). This may have resulted in the relative lower attainments of students in the PAT.

Although the SSCE scores were not generally impressive with a mean SSCE percentage of 50.6 (Table 5.15) for all schools selected for the study for the 5 year period, it is likely that the physics attainment levels in these schools could be worse. Several authors have decried the high rate of examination malpractice in Nigeria (Adeyemi & Ige, 2002; Tambawal, 2013; Onuka & Durowoju, 2013; Anzene, 2014). According to Tambawal (2013), the high stake on certificate possession and not skills in Nigeria, use of examination grades of students as basis for teacher and school reputations, inadequate school facilities are some of the causes of high level examination malpractice in Nigeria. In the view of Anzene (2014)

> 'Nigeria has a deplorable value system, therefore immoral acts such as cheating, dishonesty including embezzlement and stealing of public funds and properties do not attract the condemnation and punishment they deserve' (p4).

The rate and level of examination malpractice in Nigeria where some teachers, parents and school heads collude to deceptively gain better grades in examinations so as to promote their reputation has casted doubts on results and the integrity of examinations conducted in Nigeria over time. In the 2009 annual report of WAEC, the Registrar reported that:

> 'in spite of our concerted efforts at fighting examination malpractice to a standstill, there was in the reporting year, an alarming increase in the incidence of collusion among candidates, in some cases with assistance from teachers, invigilators and other agents that we used in the conduct of the examinations' (p2).

Furthermore, the insistence of Universities to conduct their separate selection tests other than the Joint Admissions Matriculation Board Examination results is further evidence against the integrity of examination conducts and results in the country. It is also important to note the closeness between the mean (58.2%) SSCE score for the science college and the PAT score (47.4%) relatively on the high side and that of school B1 with 31.6% SSCE score and 20.3% PAT score. In other schools, a wide margin is observed between the SSCE and PAT mean performances. Table 5.15 and Fig. 5.4 compare the SSCE and PAT scores of all schools used in the study. Although school C2 had the highest SSCE mean score (58.4%), its PAT score was 27.6%.

Table 5.15: SSCE and PAT Performance by school

Zones	**Schools**	Mean SSCE %	Mean PAT %	Difference (%)
	A1	54.2	15.5	38.7
Zone 1	B1	31.6	20.3	11.3
	C1	45.2	13.5	31.7
	D1	47.9	11.6	36.3
	A2	52.9	25.3	27.6
Zone 2	B2	56.2	18.7	37.5
	C2	58.4	27.6	30.8
SC	SC	58.1	47.3	10.8
Mean		50.6	22.5	

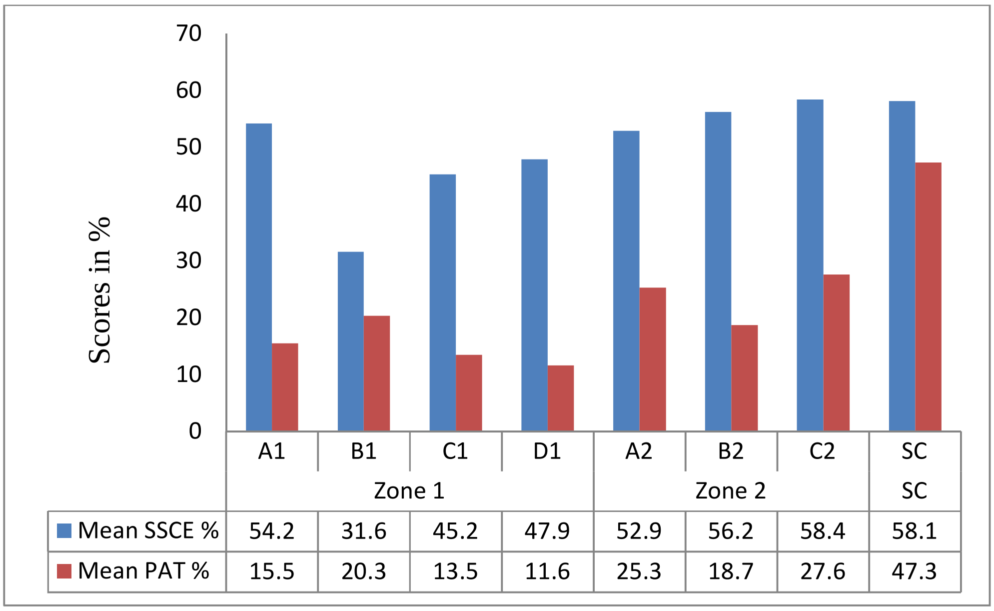


Fig. 5.4: Comparison of SSCE and PAT

Since both the SSCE and PAT tests measure the attainment level in physics of students, one would normally expect a correlation in the attainment of students from the schools. The Pearson correlation was calculated in SPSS and shown in Table 5.16.

Table 5.16: Pearson correlation of SSCE and PAT Performance of schools

		SSCE	PAT
SSCE	Pearson Correlation	1	.428
	Sig. (2-tailed)		.291
	N	8	8
PAT	Pearson Correlation	.428	1
	Sig. (2-tailed)	.291	
	N	8	8

The result shows a weak positive correlation, r = 0.428 that is also not statistically significant with p = 0.29, > 0.05. A scatter plot of SSCE versus PAT was also done for all 8 schools and shown in Figure 5.5. The 'add reference line from equation' option of lines in SPSS was selected as it assumes a linear correlation between the variables. As was explained earlier, since both the SSCE and PAT are designed to assess physics attainment, a linear correlation was expected.

The graph shows the SC with 58.1% SSCE and 47.3% PAT scores on the line. The next point closer to the line is the B1 School with 31.6% and 20.3% for the SSCE and PAT respectively. The scores of the other 6 schools are seen to deviate strongly from the line which implies that that the SSCE and PAT scores from those schools do not correlate positively. The schools have high grades in the SSCE exams but low in the PAT. Students' SSCE scores are observed to be higher in these schools with comparatively lower PAT scores. The SSCE and PAT scores for the science college correlate fairly better with 58.1% and 47.3 % in the SSCE and PAT respectively followed by those of B1with all low scores of 31.6% and 20.3% for the SSCE and PAT respectively.

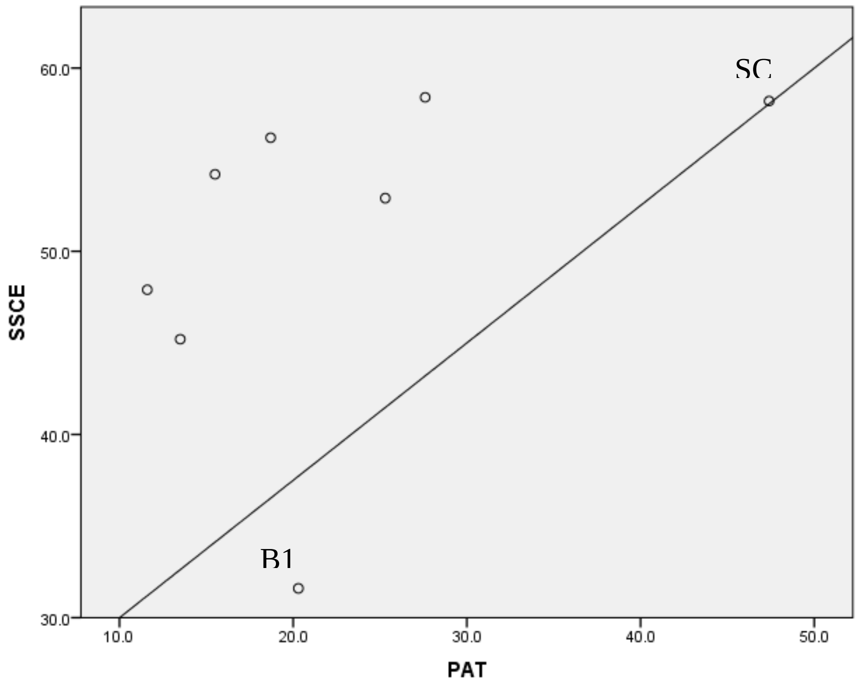


Fig. 5.5: Scatter plot of SSCE and PAT scores

The implication of the foregoing is that there is an agreement in the assessment of physics attainment of students in schools SC and B1 by both the SSCE and PAT instruments. School B1 scored low while the SC scored relatively higher in both exams. The other 6 schools generally scored high in the SSCE but obtained lower scores in the PAT. Earlier in this chapter - Section 5.3.1.2, the situation in school B1 with a higher number of students in the SS1 and 2 classes who fail to enrol and write the SSCE examination in the school had been reported. The regular visit of examination regulatory bodies to this school, especially during examinations may have resulted in a strict compliance to examination conduct with the result of a ‘true’ measure of the physics attainment of students. The PAT exam was also conducted under strict examination conditions. The SC situated in the heart of the city is also known as a school where examination malpractice is not tolerated. The school is relatively well equipped with qualified teachers whose activities are closely monitored by the tertiary institution within whose campus the school is located. It may therefore be concluded that although the conduct of SSCE is generally marred with report of malpractices in Nigeria, the results of both the SC and school B1 in the SSCE and PAT shows that the level of malpractice if any may not have been as high in these 2 schools as it may have been in the other 6 schools. Also, as have been reported earlier (see 5.3.1.2 and 5.3.3), the quality of the teachers, their commitment and utilization of available resources for physics teaching and learning in these 2 schools may have contributed to their relatively better performance in the PAT. Generally, despite the issue of credibility in the conduct of the SSCE examination in Nigeria, the attainment of students in physics can be said to be very poor in Nigeria with between 40.8 and 67.2% A* - C grade pass levels in SSCE physics between 2004 and 2013 (See Table 1(b)). In the UK for instance, students have consistently obtained between 90 and 93% A* - C grades in GCSE physics since 2005 to date (Joint Council for General Qualifications, 2015).

From the foregoing and in view of the credibility of the WAEC conducted SSCE, and also considering the fact that the SSCE scores do not correlate with the PAT scores as discussed above, the PAT scores with much lower means as shown in Fig. 5.4, where the tests were conducted under strict examination conditions could therefore be considered a better reflection of the physics attainments level of students in the schools. Subsequently, therefore, the attainment of students in the PAT will be used as a measure of physics performance of students in the schools for my study.

Chapter 6: Findings on physics resource availability and utilization for teaching and learning

6.1 Introduction

In this chapter, the findings on the availability and utilization of resources for the teaching and learning of physics in schools used for the study are presented, in line with the research questions guiding the study. Data obtained from questionnaires, o physics students as perceived by both physics teachers and students are presented in Section 6.6. This is followed in Section 6.7 with a presentation and analysis on the teaching strategies and classroom interactions adopted by teachers and the effect on students' enrolment and attainment. Findings on the effect of school climate on teaching and learning in schools used for the study are presented in Section 6.8. To conclude the chapter, findings on teachers' professional development and effectiveness are presented in section 6.9.

6.2 Relationship between teacher's qualification and experience with students' enrolment and attainment in physics

The teacher is unarguably a key resource in the school system. Even with the shift from the teacher-centred classrooms to the more vibrant, innovative, student-focused classroom settings, the role of the teacher as a facilitator of learning cannot be overemphasized. Some of the characteristics of teachers that have been considered necessary to investigate and that might have some effect on the teachers' effectiveness are his/her qualification and experience (Zuzovsky, 2005; Owolabi & Adedayo, 2012; Aliyu, Yashe & Adeyeye, 2013).

A lot of educational policy makers are increasingly using students' attainment and development as a tool for assessing the effectiveness of teachers (McCaffrey, Lockwood, Koretz, Louis & Hamilton, 2004; Zuzovsky, 2005; Buddin & Zamarro, 2009). In this section, students' attainment in the Physics Attainment Test (PAT) is correlated with some teacher characteristics such as qualification and experience.

In scoring the teachers for their qualification, teachers gain the following points for any of the qualifications obtained: Nigeria Certificate in Education, NCE (Physics) – 1, Higher National Diploma, HND – 1, Non Physics degree – 2, Physics degree – 3, Post Graduate Diploma in Education (+1), Non-Physics Master's degree (+1), Physics Master's degree (+2) and

PhD (+2). The teaching experience of physics teachers was divided into 2 segments – years of teaching and years of teaching physics. For each of the segments, a teacher is scored 1 point for 0-2 years of teaching, 2 for 3 – 5 years, 3 for 6-8 years, 4 for 9-11 years, 5 for 12-14 years and 6 points for teachers with 15 years or more of teaching experience. The total score from both segments is then divided by 2 to obtain the teachers' 'teaching experience'. A range of 2 years has been considered for the computation of teacher's years of experience as teachers are normally considered for promotion in Nigeria in their third year having considered to have gained some experience. Also, the actual years of teaching was not simply adopted as the years of teaching since both the 'years of teaching' and the 'years of teaching physics' which vary for some teachers were combined in the computation. Similarly, the resource availability and utilization indices were computed for each school from the questionnaire responses of the teachers.

The Resource Availability index was computed from teachers responses to questions on availability of a physics laboratory, level of equipment of the laboratory, whether or not the school has a laboratory assistant, availability of required teaching and learning resources for the various core topic areas of the senior secondary physics curriculum in Nigeria. Particularly, teachers' response to questions 8, 10, 13 and 21 of the QPT were computed to obtain the Resource Availability index. Similarly, the Resource Utilization index was computed from the teachers' response on the QPT to questions on the usage of physics teaching and learning resources, frequency of usage and such related items. Particularly, teachers' response on the QPT to questions 9, 15a and 15b were computed to obtain the Resource Utilization index. The Teacher's qualification, Experience, Resource Availability index and the Resource Utilization Index were then correlated with the PAT attainments and physics enrolment of students in the various schools. Interval data were elicited from the PAT and questionnaire responses for the teacher and resource factors.

The Spearman rank order correlation has been considered more appropriate and utilized to investigate the association between students' attainment with teacher qualification, teacher experience, resource availability and resource utilization. The statistic is most appropriate with non-parametric data that are not normally distributed with ordinal or scale data (Cohen, Manion & Morrison, 2011; Bryman, 2012; Field, 2013). The normality test as shown in Table 6.0 indicates that for both Kolmogorov-Smirnov and Shapiro-Wilk test statistics, $p < 0.05$ which indicates that the data for all variables are not normally distributed. The correlations are shown in Table 6.1.

Table 6.0: Test for Normality

Variables	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PAT scores	.137	171	.000	.924	171	.000
Teacher Qualification	.287	171	.000	.715	171	.000
Teaching Experience	.374	171	.000	.682	171	.000
Resource Availability index	.237	171	.000	.835	171	.000
Resource Utilisation index	.200	171	.000	.903	171	.000

Table 6.1: Spearman Rank Correlation of Students' Attainment with Teacher and Resource Factors

		Teacher Qualification	Teaching Experience	Resource Availability index	Resource Utilization index
PAT scores	Spearman rho's Correlation	.552**	.131	.534**	.423**
	Sig. (2-tailed)	.000	.088	.000	.000
	N	171	171	171	171

The result shows a significant positive correlation, $r = 0.552$, $p<0.05$ between PAT attainment and teacher qualification. A very weak positive correlation, $r = 0.131$ that is however not significant, $p = 0.088(>0.05)$, is reported between the PAT attainment and teaching experience of physics teachers. The Table also shows that PAT attainment scores have significant positive correlation with resource availability, $r = 0.534$, $p < 0.05$ and resource utilization with $r = 0.423$, $p < 0.05$. The r-value for resource utilization however indicates a weak positive correlation (Rumsey, 2011). The plots of the correlations from SPSS between PAT scores and each of Teacher Qualification, Teaching Experience, Resource Availability index and Resource Utilization index are presented in Figures 6.1(a) – (d).

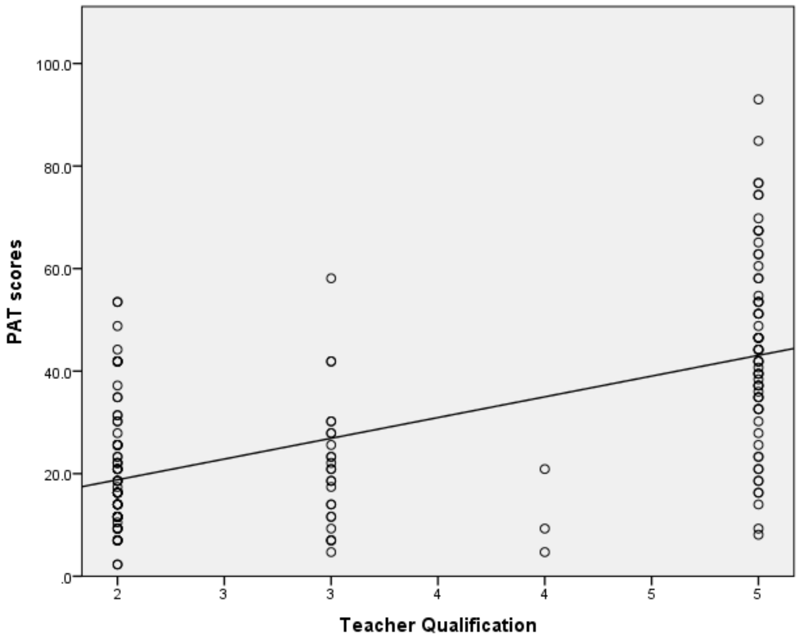


Fig. 6.1(a): Graph of PAT score Vs Teacher Qualification

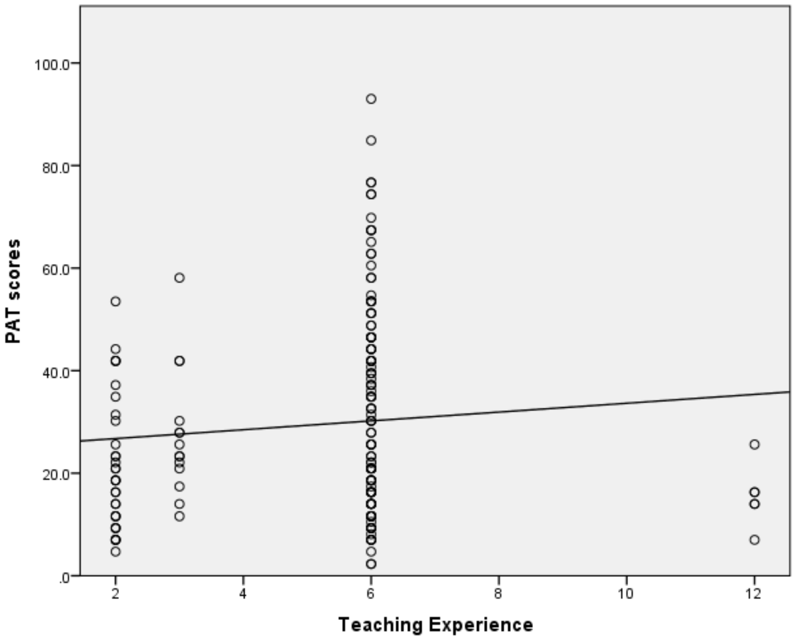


Fig. 6.1(b): Graph of PAT score Vs Teaching Experience

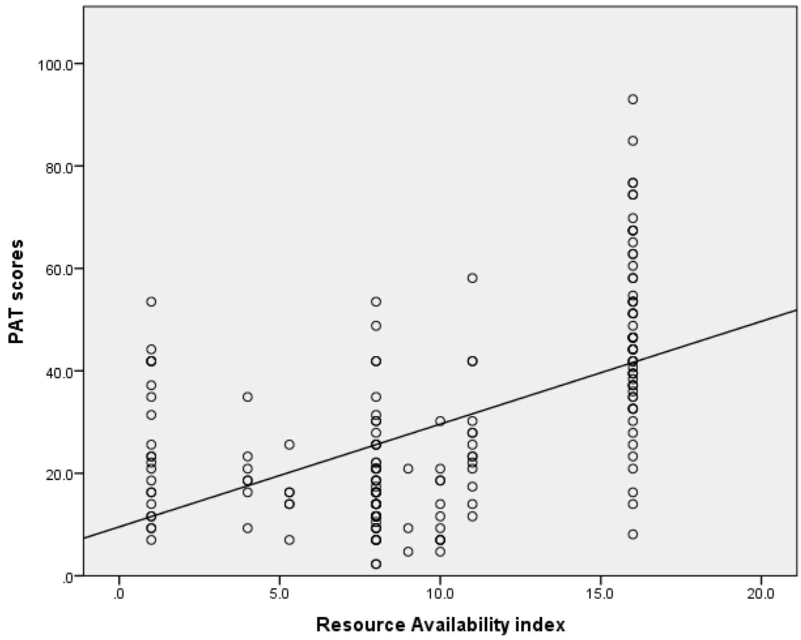


Fig. 6.1(c): Graph of PAT score Vs Resource Availability index

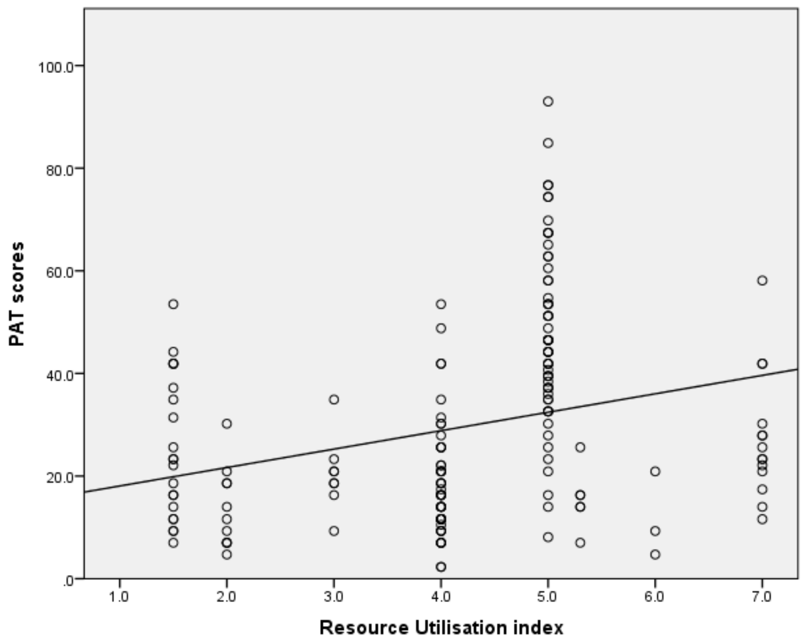


Fig. 6.1(d): Graph of PAT score Vs Resource Utilization index

The correlation of PAT scores with teacher and resource factors were also computed separately for boys and girls to investigate the association between each of the factors and attainment in terms of gender. The results are presented in Tables 6.2(a) and 6.2(b).

Table 6.2(a): Spearman Rank Correlation of boys' physics Attainment with Teacher and Resource Factors

		Teacher Qualification	Teaching Experience	Resource Availability index	Resource Utilization index
PAT scores	Spearman rho's Correlation	.527**	.107	.466**	.352**
	Sig. (2-tailed)	.000	.299	.000	.000
	N	96	96	96	96

The results as shown in Table 6.2(a) reveal positive and highly significant correlations between boys' attainment scores in the PAT and Teacher Qualification, $r = 0.527$, $p < 0.05$; Resource Availability index, $r = 0.466$, $p < 0.05$ and Resource Utilization index, $r = 0.352$, $p < 0.05$. For Attainment and Teaching Experience, the result shows a very weak positive correlation that is not statistically significant, $r = 0.107$, $p > 0.05$. These results of correlations for the boys are similar to those obtained for all students irrespective of their gender as shown in Table 6.1.

Table 6.2(b): Spearman Rank Correlation of girls' physics Attainment with Teacher and Resource Factors

		Teacher Qualification	Teaching Experience	Resource Availability index	Resource Utilization index
PAT scores	Spearman rho's Correlation	.675**	.151	.757**	.564**
	Sig. (2-tailed)	.000	.195	.000	.000
	N	75	75	75	75

Table 6.2(b) shows the correlation of girls' physics attainment with teacher and resource factors. The result reveals a positive significant correlation between girls' physics attainment with teacher qualification, $r = 0.675$, $p < 0.05$. Similarly, positive significant correlations were obtained for both Resource Availability index, $r = 0.757$, $p < 0.05$ and Resource Utilization index, $r = 0.564$, $p < 0.05$. The correlation between girls' attainment and teachers' teaching experience was weak positive. These results obtained for the girls are similar to those obtained for the boys and the overall student attainment irrespective of gender. However, a careful look at

the correlations for the boys and girls on physics attainment with resource availability index shows a stronger correlation for the girls than for the boys (Figure 6.2c). The SPSS group plots of physics attainment with Teacher Qualification, Teaching Experience, Resource Availability index and Resource Utilization index respectively, split by gender are shown in Figures 6.2 (a) – (d).

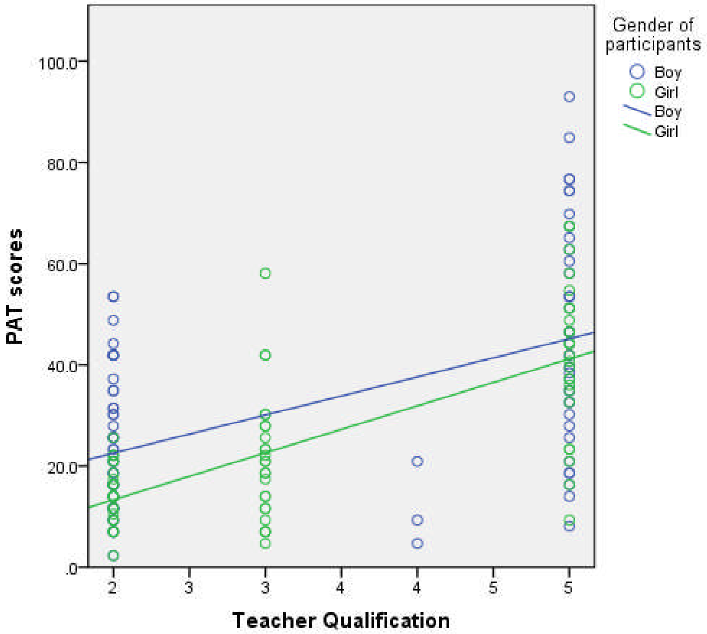


Fig. 6.2(a): Graph of PAT score Vs Teacher Qualification by gender

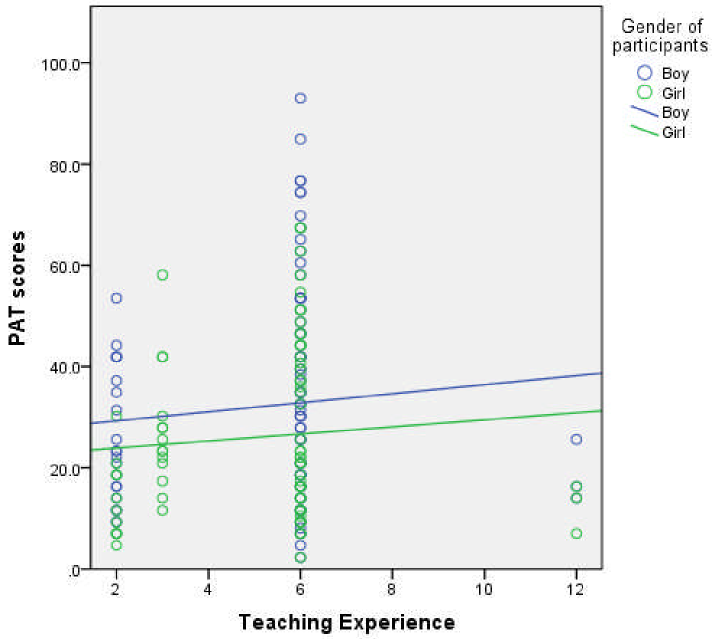


Fig. 6.2(b): Graph of PAT score Vs Teachers' Teaching Experience by gender

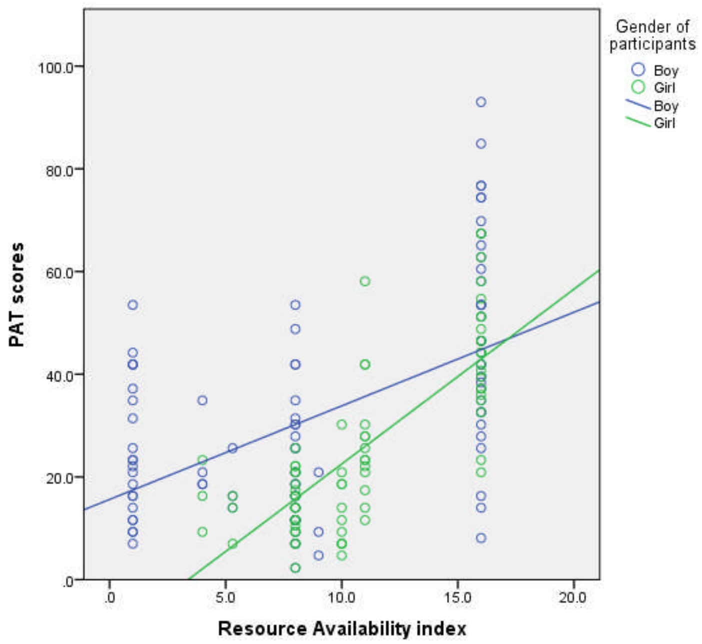


Fig. 6.2(c): Graph of PAT score Vs Resource Availability index by gender

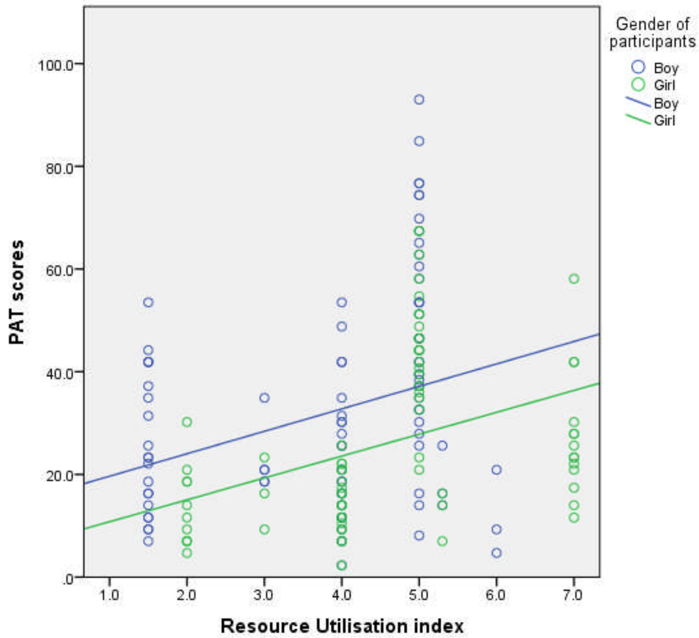


Fig. 6.2(d): Graph of PAT score Vs Resource Utilization index by gender

To further probe the association between resourcing and attainment, students' performance in the PAT in each of the 3 core content areas covered by the test was examined with the level of resourcing available in the schools as reported by the teachers in response to the questionnaire. The PAT scores for each student in each of the 3 content areas were computed in percentage and the average for each of the areas computed for all 171 students that sat for the PAT. Teachers' response on a 3 point scale of 'Don't Have', 'Don't Have Enough' or "Have Enough' for the level of resourcing of apparatus needed for the effective teaching of the topic areas was converted to percentage and compared with the Average percentage score of all students in each of the topic areas. The overall picture of all 171 students in the 8 schools that were used for the study is presented in Table 6.2(c) and Figure 6.2(e)

Table 6.2(c): Teachers' response on resource availability on specific topic areas and students' PAT scores

	Response	**Topic Areas** Interaction of matter, space and time	Conservation principles	Fields at rest and in motion
Resource level (%)	Don't Have	21.4	42.9	35.7
	Don't Have Enough	64.3	50	50
	Have Enough	14.3	7.1	14.3
PAT Av. Scores (%)		17.4	50.2	25.1

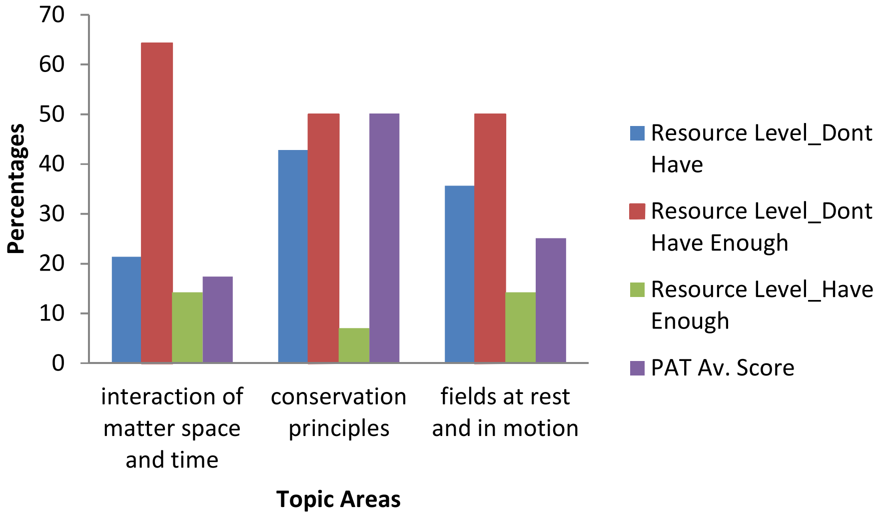


Fig. 6.2(e): Chart showing Resourcing levels and PAT Achievement

The result as shown in Table 6.2(c) indicates that resourcing for topics under 'conservation principles' was least with about 42.9% of teachers stating that their schools do not have resources for teaching topics under that area. 50% of the teachers claim that their schools do not have enough facilities while only 7.1% were of the opinion that their schools have enough facilities for the teaching and learning of topics under 'conservation principles'. In terms of the students' attainment, the table indicates that students obtained higher scores in content areas under 'conservation principles' with about 50.2%. Students performed least in 'Interaction of Matter, space and time' with 17.4% while the average score for 'Fields at rest and in motion' was 25.1%.

To further investigate the state of resourcing and students' performance in the various topic areas covered in the PAT, separate computations for the 2 zones and the science college were made and the results are presented in Tables 6.2(d) – (f) and Figures 6.2(f) – (h). The computation could not be done for each school to compare the resource levels with students' attainment as some schools have only 1 physics teacher. However, the science college was computed separately due to its peculiarity in resourcing as explained earlier and also, there were 3 physics teachers in the school that makes for a better moderation of the teachers' responses.

Table 6.2(d): Teachers' response on resource availability on specific topic areas and students' PAT scores in Zone 1

		Topic Areas		
	Response	Interaction of matte, space and time	Conservation principles	Fields at rest and in motion
Resource level (%)	Don't Have	16.7	66.7	33.3
	Don't Have Enough	66.7	33.3	66.7
	Have Enough	16.7	0	0
PAT Av. Scores (%)		2.4	42.6	7.8

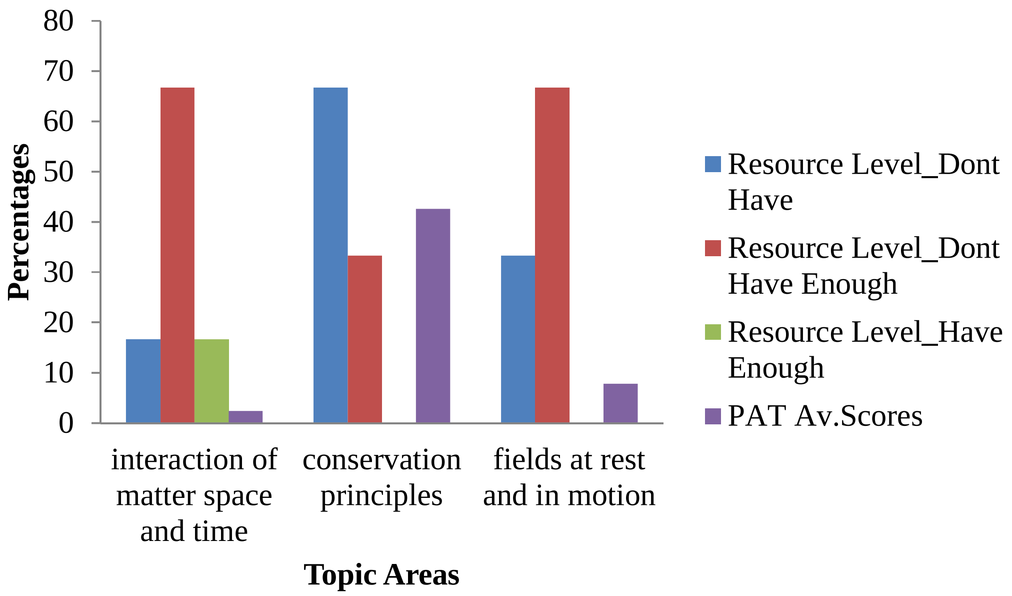


Fig. 6.2(f): Chart showing Resourcing levels and PAT Achievement in Zone 1

The data for the resource availability level and PAT attainment for schools in zone 1 is presented in Table 6.2(d). All 6 physics teachers from the 4 schools involved in the study responded to the questionnaire. 27 students sat for the PAT in the zone. The opinion of teachers on levels of resourcing shows that 'conservation principles' with 66.7% of teachers claiming that they 'don't have' resources for teaching and learning appears to be the topic area with the least resources in the zone. Topics under 'Fields at rest and in motion' also appear to have few resources with 33.3% of teachers indicating that they do not have resources for teaching and learning. Interestingly, Students scored higher in the PAT on 'conservation principles' that is least resourced with an average of 42.6%.

Table 6.2(e): Teachers' response on resource availability on specific topic areas and students' PAT scores in Zone 2

		Topic Areas		
	Response	Interaction of matter space and time	Conservation principles	Fields at rest and in motion
Resource level (%)	Don't Have	40	40	60
	Don't Have Enough	60	60	40
	Have Enough	0	0	0
PAT Av. Scores (%)		8.7	46.2	15.4

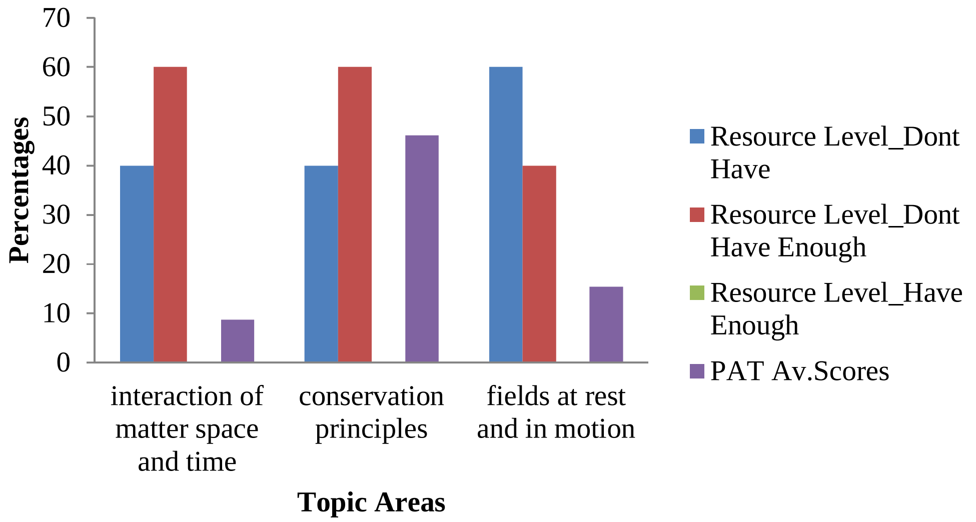


Fig. 6.2(g): Chart showing Resourcing levels and PAT Achievement in Zone 2

The result for the level of resourcing claimed by teachers and the students' PAT average scores in the 3 topic areas is presented in Table 6.2(e) and Figure 6.2(g). All 5 physics teachers in the 3 schools that participated in the study gave their opinions on the level of resourcing in their schools. 86 students sat for the PAT in all 3 schools in the zone. The result as shown in the table above indicates that none of the teachers claimed that their schools 'have enough' resources for teaching all 3 topic areas. 40% of the teachers claimed that their schools do not have resources for the teaching and learning of all the 3 topic areas, while 60% were of the opinion that they do not have enough resources. For the students' performance in the PAT, the pattern is not different with those of zone 1 and the overall for all students in all schools, with students obtaining higher grades in the content area 'conservation principles' (46.2%) followed by 'fields at rest and in motion' (15.4%) and worst in 'Interaction of matter, space and time' with 8.7%.

Table 6.2(f): Teachers' response on resource availability on specific topic areas and students' PAT scores - Science College

		Topic Areas		
	Response	Interaction of matter, space and time	Conservation principles	Fields at rest and in motion
Resource level (%)	Don't Have	0	0	0
	Don't Have Enough	66.7	66.7	66.7
	Have Enough	33.3	33.3	33.3
PAT Av. Scores (%)		37.3	59.6	47.7

The result of teachers' responses and the PAT attainment scores for the science college is presented in Table 6.2(f). All 3 physics teachers in the school participated in the study together with 58 students who sat for the PAT. On the level of resourcing, all 3 physics teachers agreed that they have resources for the teaching of all 3 core areas of 'interaction of matter, space and time', 'Conservation principles' and 'Fields at rest and in motion'. 66.7% of the physics teachers in the school were of the opinion their school does not have enough resources for the topic areas under investigation while 33.3% claimed that the school had enough resources for the teaching of topics in all 3 areas. The results in the table also show that the average scores obtained by students in this school were higher for all the 3 topic areas than those obtained by students in zones 1 and 2. The pattern of attainment however, appears to be similar to those of the zones.
The average score was highest for 'conservation principles' (59.6%), followed by 'Fields at rest and in motion' (47.7%) and lastly, 'Interaction of matter, space and time' 37.3%.

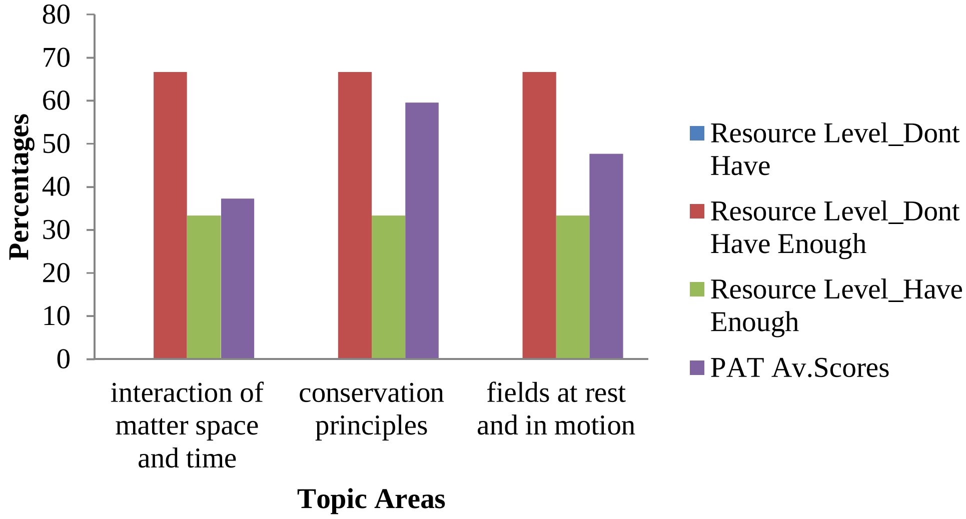


Fig. 6.2(h): Chart showing Resourcing levels and PAT Achievement in Science College

The students' enrolment for physics was correlated with teacher characteristics such as teaching qualification and experience and school resource factors as shown in Table 6.3. The percentage of the total number of students in the SSS 3 classes that enrolled for physics as shown in Table 5.2 was used for this computation. Considering the non-normality of the data distribution, smallness of the sample size of schools (8) used in the study, and the 'outlier' in the physics enrolment of 100% in one of the schools, the Spearman rank order correlation has been utilized to investigate the measure of association between students' enrolment and factors such as teacher qualification, teaching experience, resource availability and resource utilization. Field (2013) posited that for data having outliers or is not normal with small sample size; ranked correlations such as the Spearman rank order should be used.

Table 6.3: Spearman rho's Correlation of Students' Enrolment with Teacher and Resource Factors

		Teacher Qualification	Teaching experience	Resource availability index	Resource utilization index
% of total students in SS3 enrolled for physics	Spearman rho's correlation	.346	.038	-.024	.157
	Sig. (2-tailed)	.401	.928	.955	.711
	N	8	8	8	8

The result shows low positive correlations (Rumsey, 2011), between students enrolment in physics and teacher qualification, teaching experience and resource utilization with r-values of 0.346, 0.038 and 0.157 respectively. The correlations were however not statistically significant with all p-values > 0.05 as shown in the Table. The result also shows very weak negative correlation between physics enrolment and resources utilization with r –value of -0.024. Again, this correlation was also found to be statistically insignificant with p = 0.711. Plots of the correlations are shown in the Figures 6.3(a) – (d).

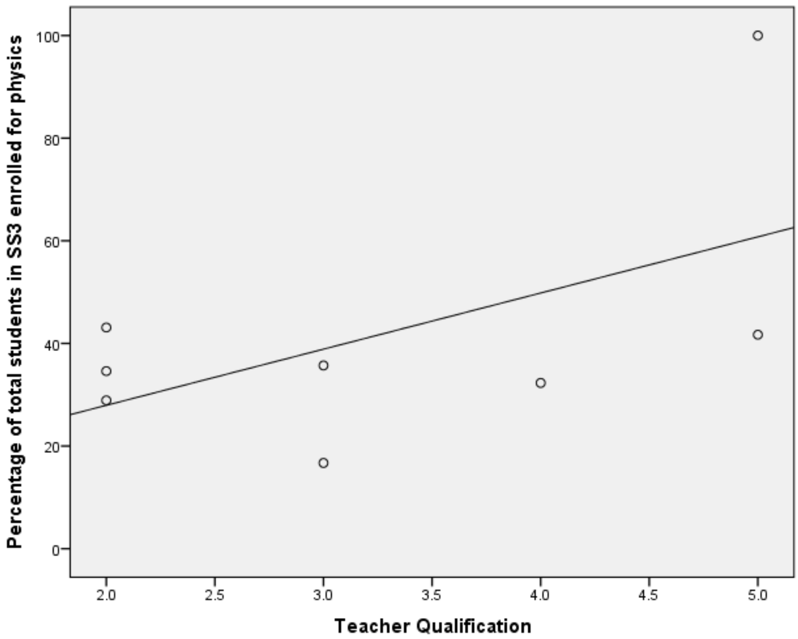


Fig. 6.3(a): Graph of Enrolment Vs Teacher Qualification

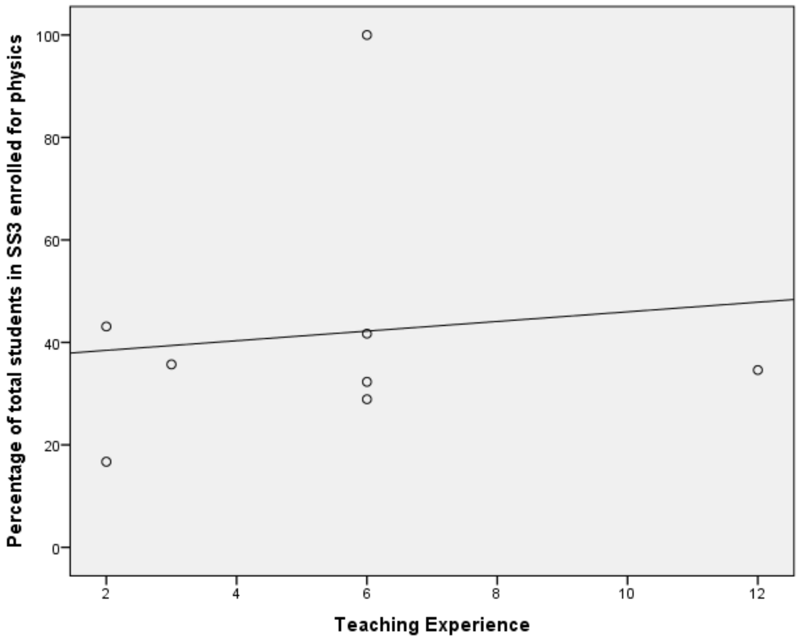


Fig. 6.3(b): Graph of Enrolment Vs Teacher Experience

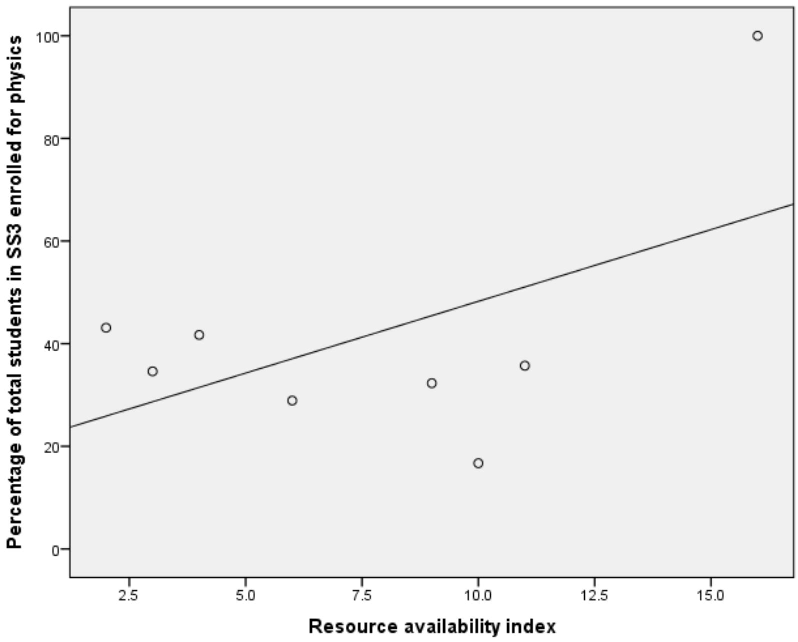


Fig. 6.3(c): Graph of Enrolment Vs Resource Availability index

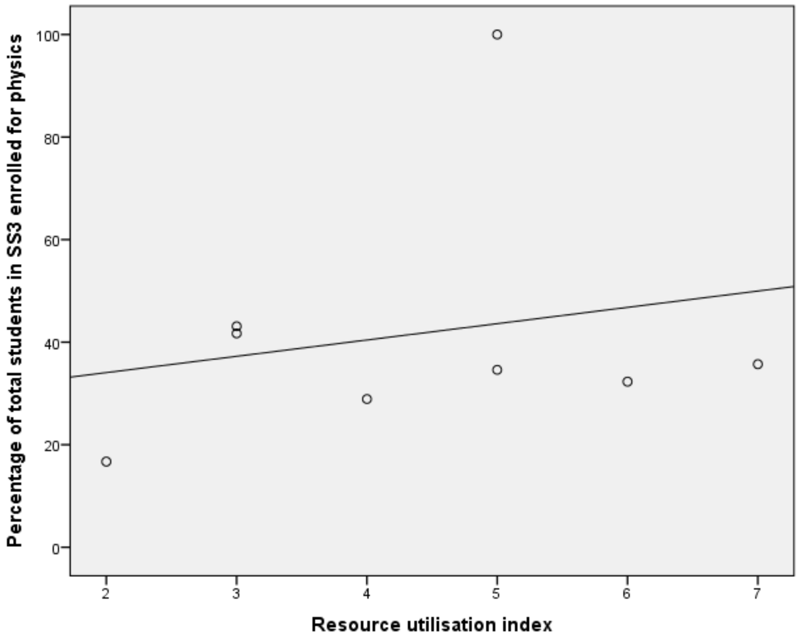


Fig. 6.3(d): Graph of Enrolment Vs Resource Utilisation index

The percentage of enrolled physics students by gender was computed for the 8 schools and correlated with teacher and resource factors. Like the overall trend without the split by gender, no significant correlations was found between male or female physics students' enrolment with teacher qualification, teaching experience, resource availability index and resource utilization index as shown in Tables 6.3(a) and 6.3(b). The graphs of the correlations are presented in Figures 6.3(e) – 6.3(l).

Table 6.3(a): Spearman rho's Correlation of Male Students' Enrolment with Teacher and Resource Factors

		Teacher Qualification	Teaching experience	Resource availability index	Resource utilization index
% of male physics students in SS3	Spearman rho's correlation	.031	-.735	-.145	-.224
	Sig. (2-tailed)	.953	.096	.784	.670
	N	6	6	6	6

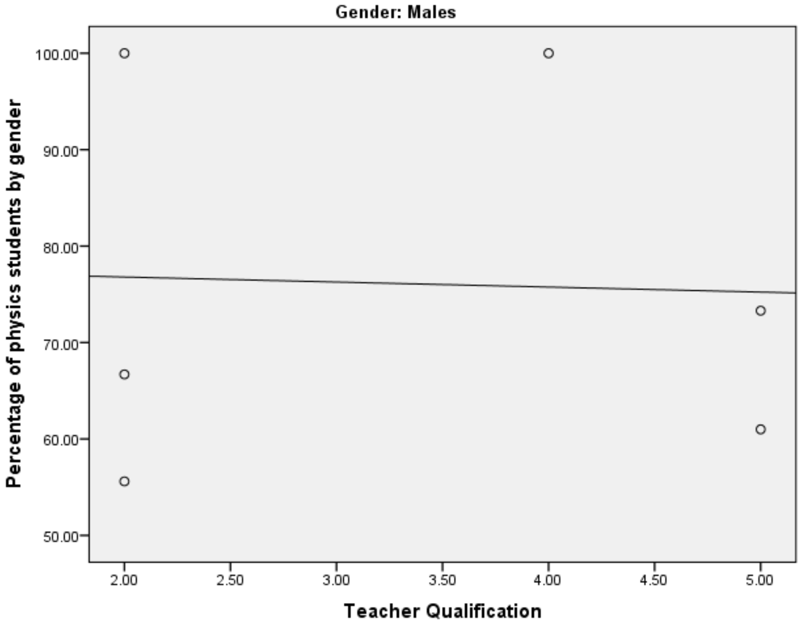


Fig. 6.3(e): Graph of Male Enrolment Vs Teacher qualification

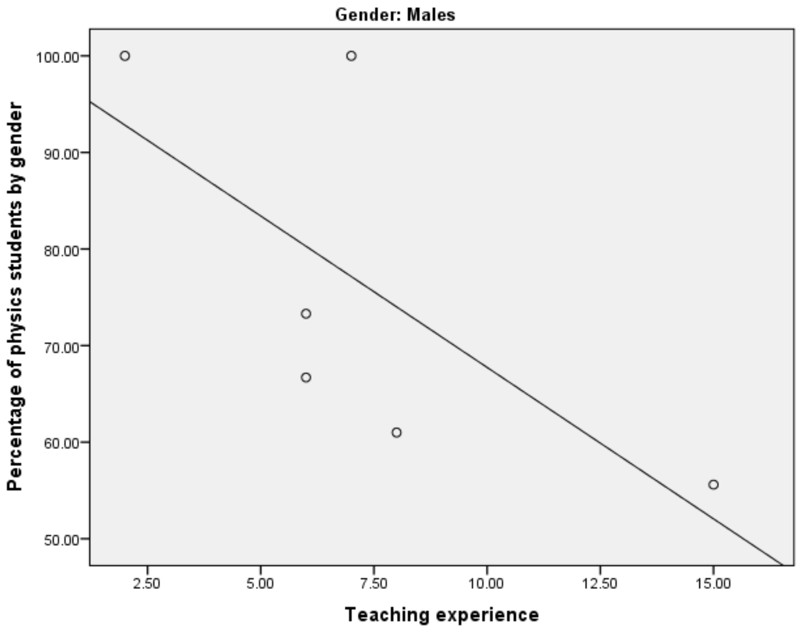


Fig. 6.3(f): Graph of Male Enrolment Vs Teaching experience

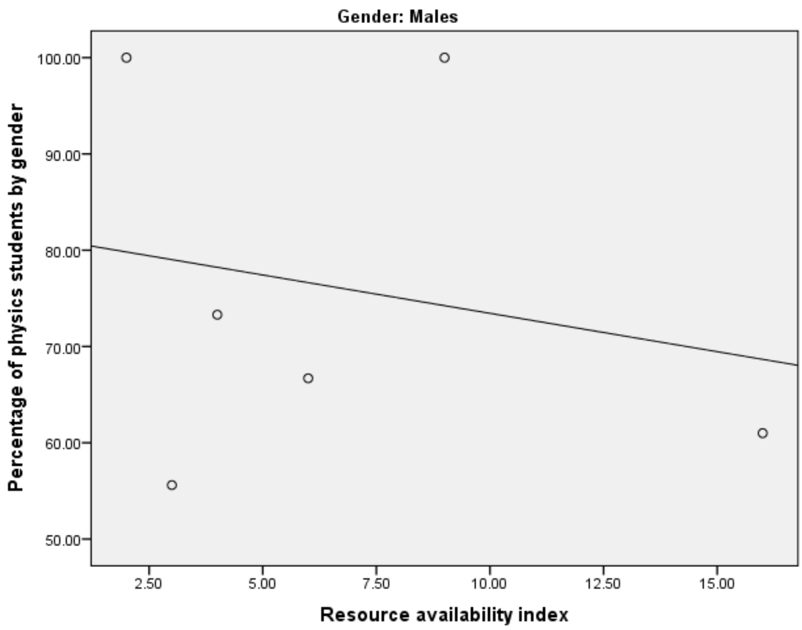


Fig. 6.3(g): Graph of Male Enrolment Vs Resource availability index

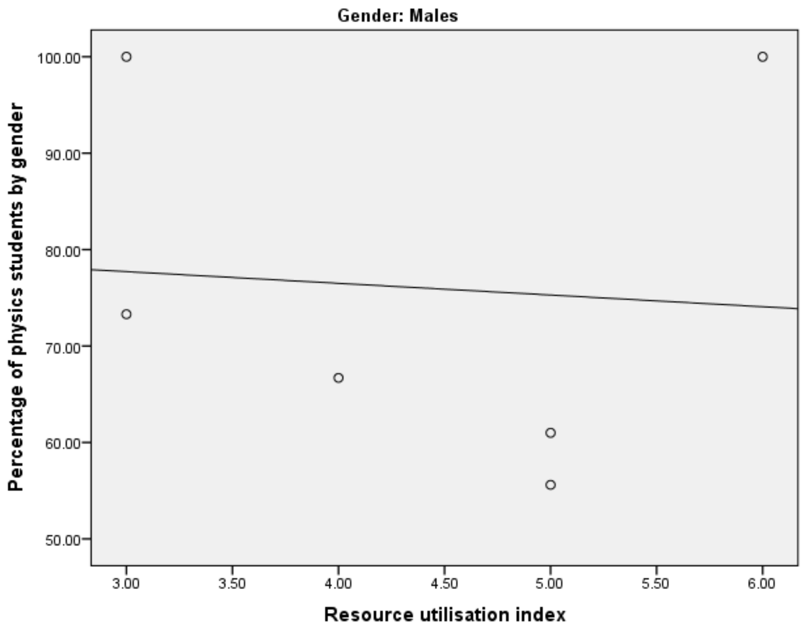


Fig. 6.3(h): Graph of Male Enrolment Vs Resource utilisation index

Table 6.3(b): Spearman rho's Correlation of Female Students' Enrolment with Teacher and Resource Factors

		Teacher Qualification	Teaching experience	Resource availability index	Resource utilization index
% of Female physics students in SS3	Spearman rho's correlation	-.243	-.441	.348	.265
	Sig. (2-tailed)	.643	.381	.499	.612
	N	6	6	6	6

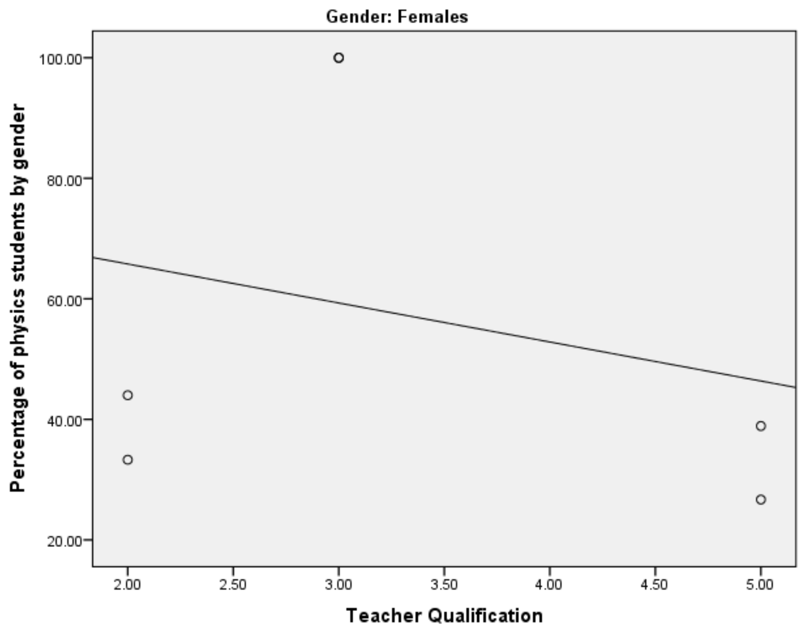


Fig. 6.3(i): Graph of Female Enrolment Vs Teacher qualification

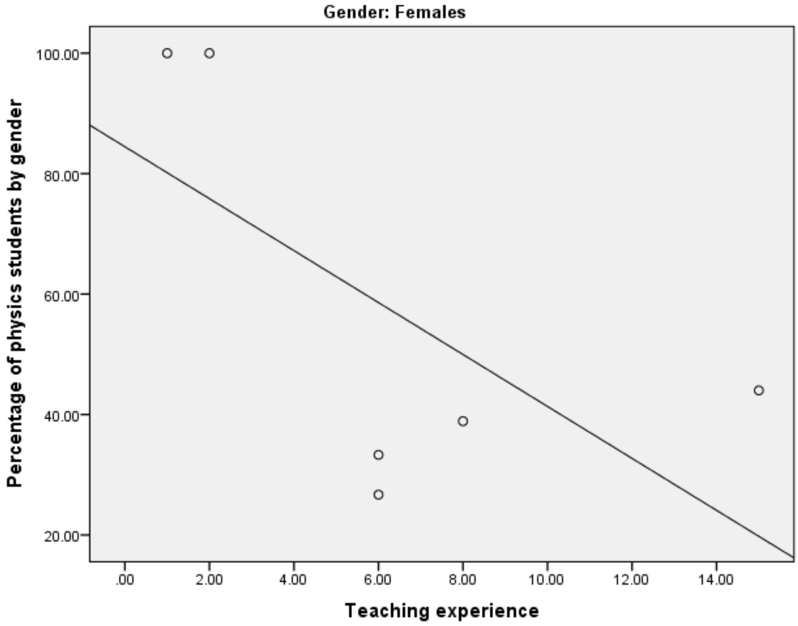


Fig. 6.3(j): Graph of Female Enrolment Vs Teaching experience

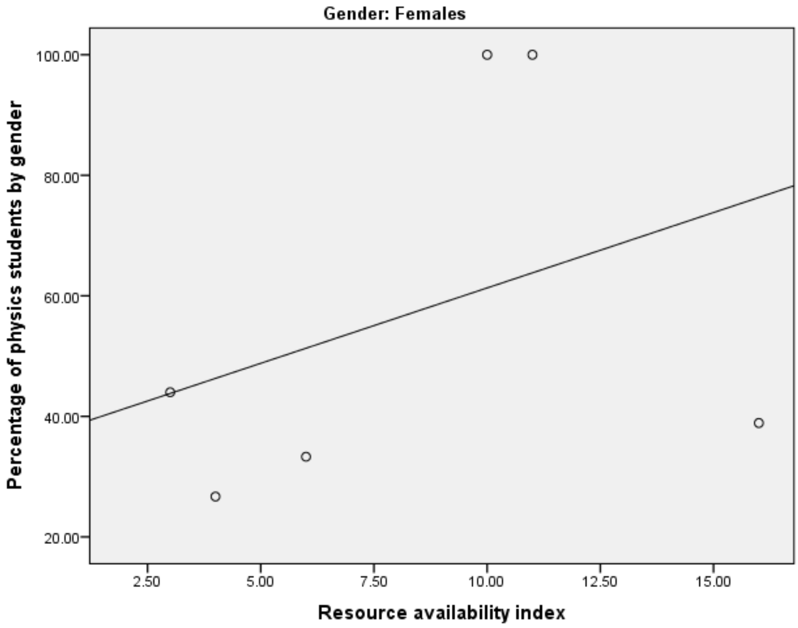


Fig. 6.3(k): Graph of Female Enrolment Vs Resource availability index

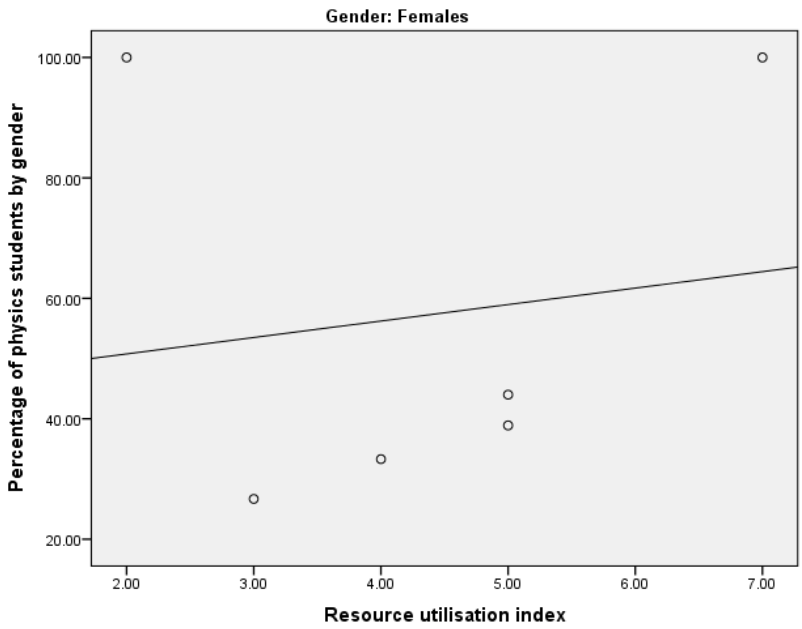


Fig. 6.3(l): Graph of Female Enrolment Vs Resource utilisation index

Students also bared their mind in their interviews on the effect of teacher qualification, experience and resource factors on both attainment and enrolment. For instance, student A2P/2 explained that many students dropped physics in their SSS 1 class as a result of the lack of a competent teacher.

> "Well, starting from our SS I classes, we did not have a physics teacher then we had a Corper, a Corper that was to take us on physics, but you know the situation of Nigeria, the Corper was as in … he didn't know what he was doing, he only comes to the class just to chat with students, that is the Corper, when we were in SS I, so that made so many students in SS I to enrol away from physics" (A2P/2, 241-245).

On the other hand, some students in some schools associated their continued enrolment in physics to the teaching competencies of their teachers. This is what a student said:

> "I choose to be a physics student because of the teachers we have in this school and due to the facilities. At times too in the class when you walk in to the class you understand physics clearly because he makes the formula, the definitions and every other thing very simple" (B1P/2, 20-22).

For this student, the teacher's competency, teaching strategy and use of available resources are main reasons for her continuity in the physics class. She also explained how the teacher makes the understanding of the subject easy which no doubt would enable better performance in the subject. According to this student, the teacher facilitates students understanding of physics by making 'very simple', the formulas and definitions.

Most students who do not offer physics or who had dropped off from the physics class expressed that the lack of practical activities in the teaching and learning of physics was a major factor in their not enrolling in the subject. For instance, this position is captured in the words of this student:

> "When I was in JSS (*Junior Secondary School*) our physics teacher was the basic science teacher, he always talked about... also the basic technology teacher… they talked of light, he talked of plus and minus, maximizing things and they don't do practicals, they don't do it, they just say it, they just say it theory and we don't even understand what they are saying and they don't even care, they just say it… And that is why I didn't find physics interesting because I like things that are clear to me (B2N/1, 328-331, 342).

Some of the physics teachers also attributed the low enrolment in physics to lack of laboratory facilities in the schools for the teaching and learning of physics. For instance, this is what a physics teacher had to say:

> "…you talk about the resources for teaching physics. I don't think if there is, because for two years I've been here and they have not mentioned laboratory, there is nothing to show that there are resources for teaching physics, so that one too is contributing to… to… non-compliance to physics" (A2T, 43-46).

The impression from the above quote is that the lack of resources for the teaching and learning of physics has contributed to the unpopularity of the subject among students in the post-compulsory classes of secondary education.

Some students explained how the utilization of resources in teaching enhanced their understanding of physics. This student in a single-sex girls' school gave a vivid description of how the teacher's use of demonstration enabled her understanding of 'electric field' which was not understood when taught theoretically.

> "…we were learning electric field; he came with some materials which he wanted to use as examples to show us, because the last time he came, we told him we wanted to practicalize it because we were like finding it difficult to flow… So when he came, the class was like noisy, so when he entered, we saw him and we saw the materials he was holding so we decided to keep quiet and know what he was about to do. So, when he started teaching, he told us, he referred us back to what he told us the other time, we said yes, then he brought out the instrument and showed us and said well, this is what I was talking about. This is how it works, this is what to do, everybody was like surprised, oh, I've seen that before, oh, that's what you were teaching about though I do not know it, now I know… So when the teacher comes into the class with materials to teach, it makes the students to understand more" (C2P/2, 260-262, 263-270).

Another student lamented the poor state of learning physics without adequate facilities and attributed that to students' low performance in the subject.

> "the problem is that the secondary school we have now-a-days they are not helping matters because there is no standard laboratory, nothing to back up the study of physics that is why students have low performance in physics so these thing are factors that are pushing students away" (A2P/4, 60-63).

Some teachers argued that physics cannot be taught effectively just by theory without practical activities and that the use of resources in teaching physics would improve the performance of students in the subject.

> "Physics is a practical subject, you don't teach only theoretical aspect of it. It makes the students not to understand more" (B2T, 160-161).
>
> "Available resources being utilized, yes, if the available resources are being utilized, I think the attainment would be better" (C2T, 102-103).
>
> "Yeah, the resources are what really hinder the subject in some other way too, em… good laboratory apparatus and all the rest they are good resources for learning the subject… I think it's of the other side bringing these things together,

and this will help students to have good performance in the subject (A1T, 51, 52-53, 54-55).

These positions as portrayed by some students and teachers support the finding as presented earlier that there is a correlation between students' attainment and teachers' qualification, attainment and resource availability and attainment and resource utilization. In term of physics enrolment, although a statistical significance in the correlations was not achieved, it is possible to infer from the responses of the students that more students would enrol for physics and have improved performance if qualified teachers are recruited and adequate teaching resources are made available for the teaching and learning of physics.

Apart from teacher and resource related reasons for which students prefer not to choose physics after the compulsory years of schooling, students also gave some insight on the reasons for the least popularity of physics compared to biology. According to some students, the nature of physics, lack of relevance of most physics concepts to everyday life and the perceived difficulty level of physics as opposed to the practical nature of biology are reasons for the more popularity of biology among secondary school students. For instance, the position of most non-physics students when asked on the reasons for students' preference for biology to physics in the interviews is captured in the expression of this student:

> "Like I said before, I like to, I love studying what I can apply … whatever you learn, you have to put it into practice, it should be practical. I don't find physics something that can become practical, like a topic we learnt in physics, in SS II; I was a science student, a physics student rather, before I switched over to arts. Em ... we learnt about equilibrium of forces, we had a practical, but as in…I was not really flowing along, because it's all drawing, I can't apply it, even when I got home I tried to apply, I can't apply, but in other subjects like biology you know about your body, you would know about your body, you know how things happen… so I believe that it's because students can't apply what we have been taught in physics. They find it very hard to apply what they've been taught that's why they don't…as in physics is one of the least, in fact it's the least subject to students" (C2N/2, 138-148).

The response of this student would suggest that she finds it difficult to relate the lessons in physics class to practical occurrences around her. The student could not unfortunately match the force diagrams drawn on paper with materials and objects that demonstrate the equilibrium of forces in nature. For this student and some others who think like her, biology is more about the human body unlike physics and so biology lessons find easy reference and application to their daily experiences and so when an option to choose any one science subject comes at the post compulsory classes, most students prefer biology to physics.

Some students maintain that physics is boring, uninteresting and only for the ‘well able’.

> “Physics is all about ability so it’s like something that has been segregated because it has to take ability, one’s ability to do it, while the other subjects they are easier, like me I want to really go for Biology, it’s easier it won’t take much stress the way physics will do” (C1P/2, 90-93).

In the opinion of this student, physics is difficult to understand and is meant to be chosen by students that are intellectually ‘able’. Her opinion also suggests that biology on the other hand is less difficult to understand, easier and does not require ‘much stress’ to understand which drives most students to opt for it.

From the foregoing, it can be concluded that evidence from students and teachers involved in the study show that physics has a low popularity among secondary school students and that teacher factors, lack of resources, the perceived high difficulty level of physics and the nature of the subject are some reasons for the low popularity of the subject among secondary school students in Nigeria. The implication of this stance is that students would be happier to choose subjects that they have interest in and that is perceived as understandable and relevant both to their everyday living and also in their desired life careers. According to Williams et al, (2003), when students perceive a subject as being difficult, they also tend to develop a negative attitude towards the subject and would like to choose subjects which they find interesting. It therefore follows that students would be motivated to develop interest in physics when teachers make conscientious efforts to make their teaching real by exploring all resources to make their lessons relevant with applications to students’ daily experiences in the environment. Students who develop the desired interest in the subject and are well supported by the school are most likely to present a positive attitude towards physics which may result in increased enrolment and attainment in the subject.

6.3 Findings on availability of learning resources for physics teaching and learning

In this section, data on the findings on resources for the teaching and learning of physics in schools are presented. Information elicited from the teachers' and students' questionnaires, interviews and classroom observations are presented in the sections that follow.

6.3.1 Analysis of the questionnaire for physics teachers on learning resources

In a bid to obtain information from physics teachers on school-based factors that affect the teaching and learning of physics in schools, the 22-item Questionnaire for Physics Teachers (QPT) was adapted from existing instruments as explained in chapter 3. Among other factors, the QPT was intended to capture opinions of physics teachers on the availability and utilization of resources for the teaching and learning of physics. Table 6.4 and Figure 6.4 show the responses of teachers on the question 'Does your school have a physics laboratory?' The table shows that 10 out of the 14 teachers representing 71.4% indicated that their school has a physics laboratory while 28.6% said there was no physics laboratory in their school. It may be interesting to note the conflicting opinions of teachers in the same school on the availability of a physics laboratory. For instance 1 of the 3 teachers in school A1 said the school has no laboratory while 2 of the teachers indicated that the school has a laboratory. All students in this school at the focused interview answered 'No' to the question 'Does your school have a physics laboratory? There is also the conflict of teachers' and students' response on the availability of physics laboratory. These conflicts together with the observation report of the researcher shall be discussed in the section on critical evaluation of data from respondents.

Table 6.4 Teachers' response on availability of physics laboratory

Response	Frequency	Percent	Valid %	Cumulative %
Yes	10	71.4	71.4	71.4
No	4	28.6	28.6	100.0
Total	14	100.0	100.0	

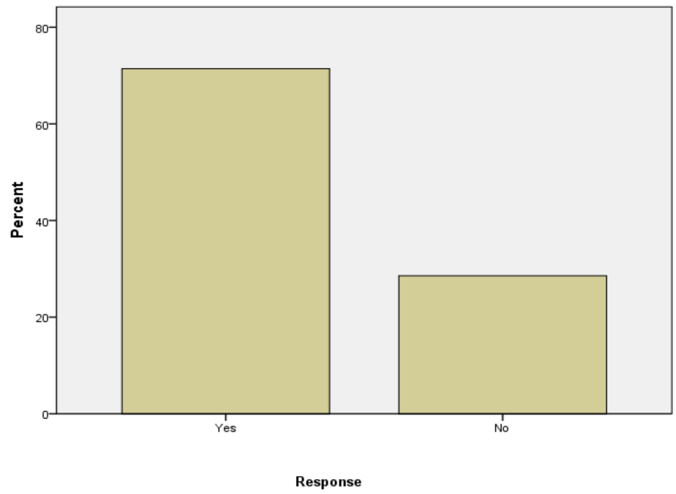


Figure 6.4: Teachers' response on availability of physics laboratory

The response of teachers to the question on the extent of availability of laboratory materials and resources for teaching and learning of physics is presented in Table 6.5 and Figure 6.5. Three (3) of the 14 teachers did not respond to the question on the level of equipment of physics laboratory in their schools as they had responded 'no' to the question 'does your school have physics laboratory?' The table shows that 36.1% which represents 3 of the 11 teachers who indicated the presence of physics laboratory in their schools stated that the laboratories are either highly or very highly equipped. While a total of 4 teachers representing 36.4% revealed that the level of equipment was low or very low.

Table 6:5 Teachers' response on the level of equipment of physics laboratory

Response	Frequency	Percent	Valid %	Cumulative %
Very high	1	7.1	9.1	9.1
High	2	14.3	18.2	27.3
Moderate	4	28.6	36.4	63.6
Low	3	21.4	27.3	90.9
Very low	1	7.1	9.1	100.0
Total	11	78.6	100.0	
Missing System	3	21.4		
Total	14	100.0		

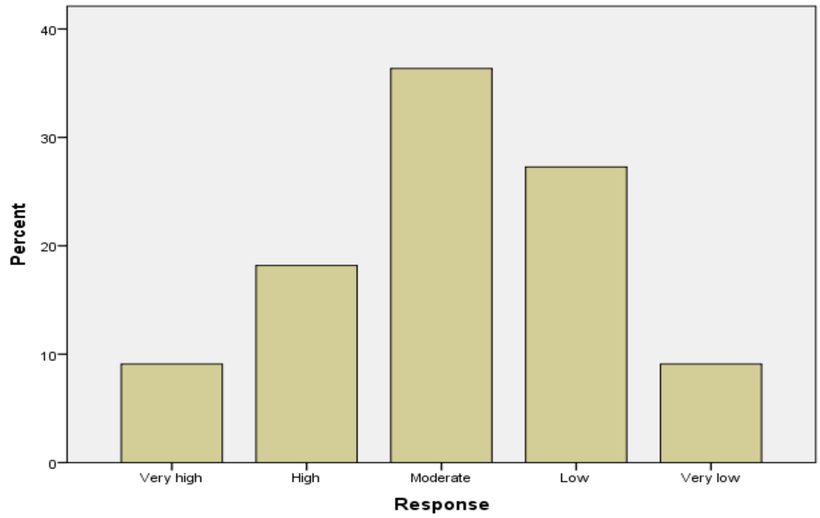


Figure 6.5: Teachers' response on the level of equipment of physics laboratory

To assess the equipment of laboratories with teaching resources, some apparatus required for the teaching of key concepts in the physics curriculum (as stated in the curriculum) were listed and teachers were required to indicate the extent of availability of the apparatus in their schools. The responses of teachers in the 5 key topic areas are presented in Table 6.6 below. Chart showing their responses is also shown in Figure 6.6.

Table 6.6: Teachers' response on the availability of resources for teaching and learning of core topic areas in physics

	Core topic areas (% respondents)				
Response	Interaction of matter, space and time	Conservation principles	Fields at rest and in motion	Energy quantization and duality of matter	Wave motion without material transfer
Don't Have	21.4	42.9	35.7	71.4	35.7
Don't Have Enough	64.3	50	50	28.6	57.1
Have Enough	14.3	7.1	14.3	0	7.1

The data as shown in Table 6.6 shows that schools do not have enough resources for the effective teaching and learning of most topic areas of physics. Particularly for the teaching and learning of related concepts on 'energy quantization and duality of matter' none of the participating schools in the study have enough materials that were prescribed by the National curriculum for teaching and learning. The detailed analysis of the data in the table is presented in the following sub-sections under the various core physics topic areas and particular reference to the participating schools.

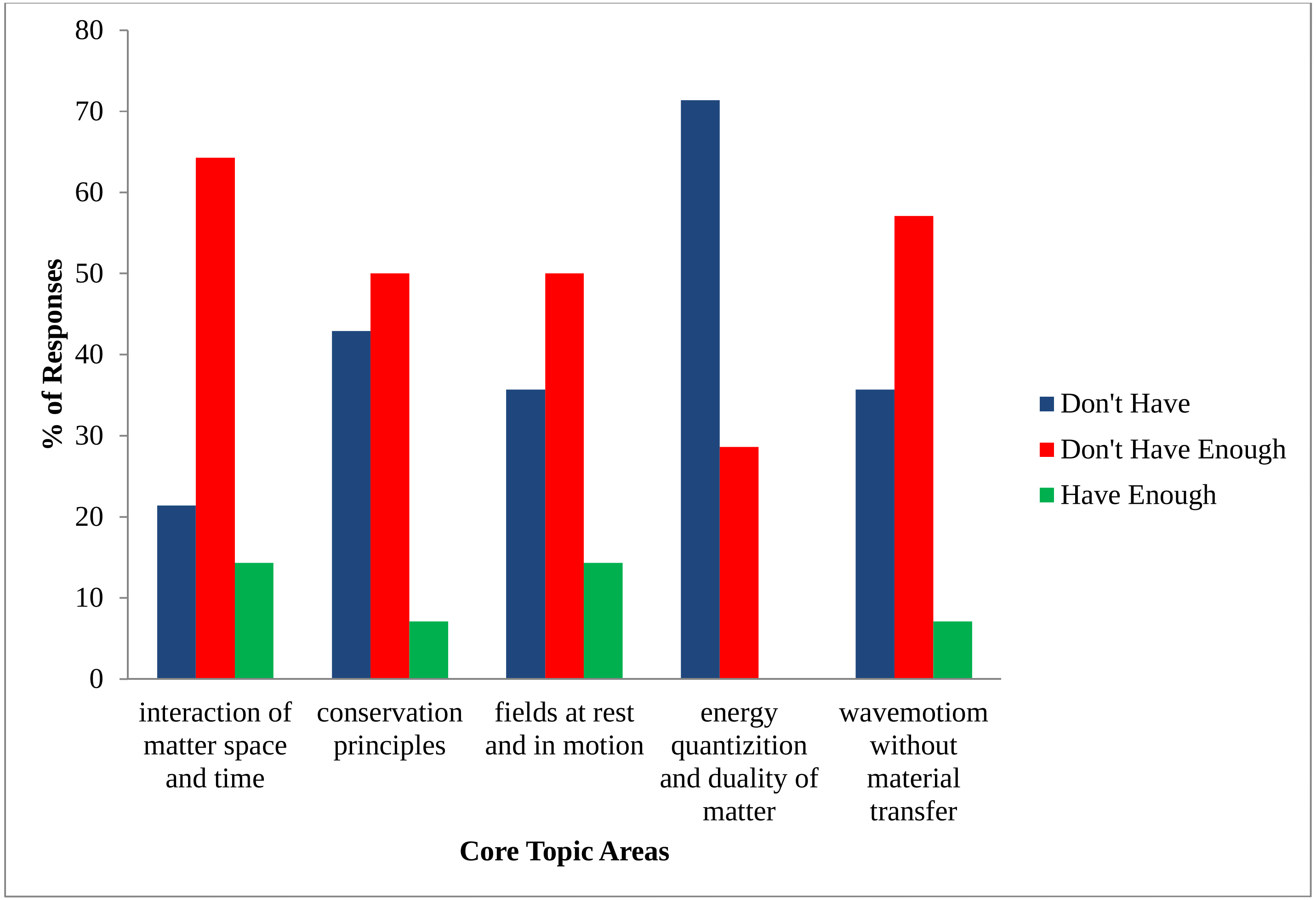


Figure 6.6: Teachers' response on the availability of teaching resources in core topic areas in physics

6.3.1.1 Interaction of matter, space and time

On the topic area 'interaction of matter, space and time, the data as shown in Table 6.6 reveals that only 14.3% of teachers indicated that their schools 'have enough' apparatus for the effective teaching of concepts in that topic area. 64.3% of teachers reveal that their schools 'do not have enough' while 21.4% of the teachers disclosed that there schools 'do not have' apparatus for teaching and demonstrations of concepts in that topic area. 2 of the 3 teachers in school A1said they 'do not have' the apparatus for the teaching and demonstration of concepts in this area while 1 indicated that the school 'does not have enough'. The teacher in school B1 responded 'don't have enough' even though he had said the school does not have a laboratory. It is possible that the school had some equipment/resources for teaching preserved in places and used when needed either by the teacher or students. In schools C1 and D1, the teachers responded 'have enough' and 'don't have enough' respectively. For schools in zone 2, the teachers in school A2 said the school does not have resources to teach the topics even as they indicated that there school does not have a physics laboratory. All 2 teachers in schools B2 and the C2 responded 'don't have enough' to the question on the availability of apparatus for the demonstration and teaching of concepts on 'interaction of matter, space and time'. 1 of the 3 teachers from the science college said the school has enough apparatus and resources while 2 indicated that the school does not have enough apparatus for the teaching of related topics in 'interaction of matter, space and time. Figure 6.6 is a chart showing the summary of the teachers' responses.

6.3.1.2 Conservation principles

Teachers' responses on the availability of apparatus for the teaching and demonstration of related concepts in the topic area 'conservation principles' as prescribed by the curriculum are presented in Table 6.6 and Figure 6.6 above. The table shows that 6 out of the 14 teachers representing 42.9% indicated that there schools do not have apparatus for the teaching and demonstration of concepts under 'conservation principles'. 7 teachers (50%) responded 'don't have enough' while only 1 teacher (7.1%) from the Science College responded 'have enough'. 2 of the 3 teachers from the science college indicated that the school does not have enough apparatus for the teaching of related topics under 'conservation principles'. 4 out of the 6 teachers in zone 1 indicated that their schools 'don't have' the required apparatus while 1 from school A1 and the teacher in school D1 indicated that there schools 'don't have enough' apparatus for the teaching and demonstration of concepts under ‘conservation principles’. For schools in zone 2, only the teachers in school A2 responded that their school does not have apparatus while all teachers from the other schools in the area indicated that their schools do not have enough apparatus for the teaching of the topic area.

6.3.1.3 Fields at rest and in motion

Table 6.6 and Figure 6.6 show the responses of all 14 teachers on the availability of apparatus for the teaching and demonstration of concepts under ‘fields at rest and in motion’ as suggested by the physics curriculum. Only 2 of the 14 teachers which represent 14.4% indicated that their schools have enough apparatus as required by the curriculum for teaching and demonstration of related concepts in ‘fields’. The 2 teachers are of the science college. The other teacher responded ‘don’t have enough’. 5 teachers representing 35.7% indicated that their schools do not have recommended apparatus for teaching and demonstration of concepts under the topic area. From schools in zone1, 2 out of the 3 teachers in school A1 responded that their school does not have the required apparatus for the section, while 1 said the school does not have enough. All 3 teachers from schools B1, C1 and D1 said there schools do not have enough apparatus for demonstration of concepts under the topic area of ‘fields’. For schools in zone 2, all 2 teachers in school A2 together with 1 teacher in school B2 indicated that their schools do not have apparatus while the other teacher in school B2 and the teacher in school C2 said their schools do not have enough apparatus for the teaching and demonstration of concepts under ‘fields’.

6.3.1.4 Energy quantization and duality of matter

The response of physics teachers on the availability of laboratory apparatus and facilities for the teaching and demonstration of concepts under ‘energy quantization and duality of matter’ is shown in Table 6.6 and as a chart in Figure 6.6. All 14 teachers responded to the question and the table shows that none of the 8 schools involved in the study have enough resources for the teaching of this section of the curriculum. 10 of the 14 teachers representing 71.4% indicated that there schools ‘do not have’ the required apparatus while 4 teachers which represents 28.6% said their schools ‘do not have enough’ facilities for the teaching of concepts in the topic area. From zone 1, 2 of the 3 physics teachers in school A together with the teachers in schools B and C responded ‘don’t have’ while 1 teacher in school A and the teacher in school D responded ‘don’t have enough’ to the question on the extent of availability of apparatus for demonstration on energy quantization and duality of matter. 4 of the 5 teachers in the 3 schools in zone 2 indicated that there schools do not have the required apparatus while 1 teacher in school B said the school does not have enough. In the science college, 2 of the teachers said the school does not have the apparatus while 1 indicated that the apparatus were not enough.

6.3.1.5 Wave motion without material transfer

The responses of teachers on the extent to which their schools have apparatus both for demonstration and teaching of concepts covered under 'wave motion without material transfer' are presented in Table 6.6 and Figure 6.6 above. 5 teachers representing 35.7% indicated that there schools do not have the prescribed apparatus, 8 teachers (57.1%) said their schools do not have enough apparatus while only 1 teacher from the science college, who represents 7.1% indicated that his school has enough apparatus for teaching and demonstration under 'wave motion without material transfer'. A breakdown of the analysis shows that 2 teachers from school A in zone 1 indicated that their school does not have the required apparatus for teaching and demonstration in the topic area while the other teacher together with all 3 teachers from schools B, C and D said their schools do not have apparatus. In zone 2, the 2 teachers in school A and 1 from school B said their schools do not have the prescribed apparatus while the other teacher in school B and the teacher in school C indicated that their schools do not have enough apparatus. From the science college, 2 of the 3 teachers held that their school does not have enough apparatus for the demonstration and teaching of wave motion.

To capture the experience of teachers on availability of materials for the conduct of physics experiments or investigations, teachers were asked the question: 'in your current school, how severe is each problem? …materials are not available to conduct physics experiments or investigations'. Teachers responded on a 3-point scale of 'Not a problem', 'Minor problem' or 'Serious problem'. Their responses are presented in Table 6.7 and Figure 6.7 below.

Table 6.7 Teachers' response on the problem of availability of materials for physics investigations

Responses	Frequency	Percent	Valid %	Cumulative %
Not a problem	2	14.3	14.3	14.3
Minor problem	4	28.6	28.6	42.9
Serious problem	8	57.1	57.1	100.0
Total	14	100.0	100.0	

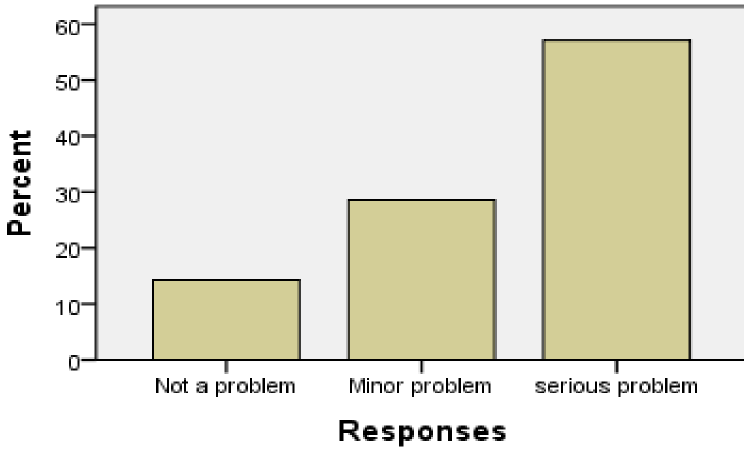


Figure 6.7 Teachers' response on the problem of availability of materials for physics investigations

The data in Table 6.7 shows that 2 teachers (14.3%) reported that they do not have a problem with materials for the conduct of physics experiments in their schools. 4 (28.6%) reported a minor problem while 8 teachers representing 57.1% reported that materials not available for the conduct of physics experiments is a serious problem in their schools. Apart from the teacher in school D1 who reported a 'minor problem', all teachers in schools in zone 1 reported that 'materials not available for physics investigations' were a serious problem in their schools. For schools in zone 2, all 2 teachers in school A and 1 teacher in school B reported a 'serious problem' whiles the other teacher in school B and the teacher in school C indicated that the non-availability of materials for physics experiments was a minor problem. 2 of the 3 teachers in the science college reported that it was not a problem while 1 indicated that non-availability of materials to conduct investigations was a minor problem. What this shows is that apart from the science college, all the teachers in the other schools reported that the lack of materials for the conduct of experiments or investigations in physics lessons was a problem. Some teachers gave reasons why their students have not conducted any experiment or demonstration as at the time of filling in the teachers' questionnaire. Below are some excerpts:

> "No availability of science equipment" (A2T1).
>
> "because of lack of lab equipment" (A1T2).
>
> "few available materials are redundant" (A1T3)
>
> "no laboratory" (A2T2).

> "the topics are appropriately handled in class" (B2T1).
> "due to the crisis in the area" (B2T2).

These revelations from the physics teachers themselves may suggest that the teaching and learning of physics in schools in the country does not comply with the prescribed mode of delivery of the subject and generally science at least, as contained in the national senior secondary school curriculum in Nigeria that states that: "In order to stimulate creativity and develop process skills and correct attitudes in students, the course (*physics)* is student-activity oriented with emphasis on experimentation, questioning, discussion and problem-solving" (FME, 2009:iii).

Another resource for teaching and learning that was investigated in terms of its availability and usage in schools the computer. The relevance of computer usage in science teaching and learning cannot be over emphasized. Its usage in instruction facilitates the development and application of students' scientific knowledge while enhancing their learning of science (de Jong & Joolingen, 1998; NSTA, 1999; Tekbiyik, Konur & Pirasa, 2008). The response of physics teachers was sought on 'how often' they use computer as a teaching aid or instructional material on a 4-point scale of 'Every or almost every lesson', 'About half the lessons', 'Some lessons' or 'Never'. Table 6.8 shows the teachers' response. All 14 teachers responded to the question out of which 13 representing 92.9% indicated that they 'never' use a computer in their physics instructions. The table reveals that only 1 teacher (who happens to be in the science college) said he uses computer in 'some lessons' in teaching physics. The bar chart of the teachers' response is shown as Figure 6.8. During the school visits, the researcher can confirm that only the science college had a computer laboratory that the students access following a Rota. In all other 7 schools, there were no computers for use either by the teacher or the students.

Table 6.8 Teachers' response on how often they use a computer as a teaching or Instructional material

Responses	Frequency	Percent	Valid %	Cumulative %
About half the lessons	0	0.0	0.0	0.0
Some lessons	1	7.1	7.1	7.1
Never	13	92.9	92.9	100.0
Total	14	100.0	100.0	

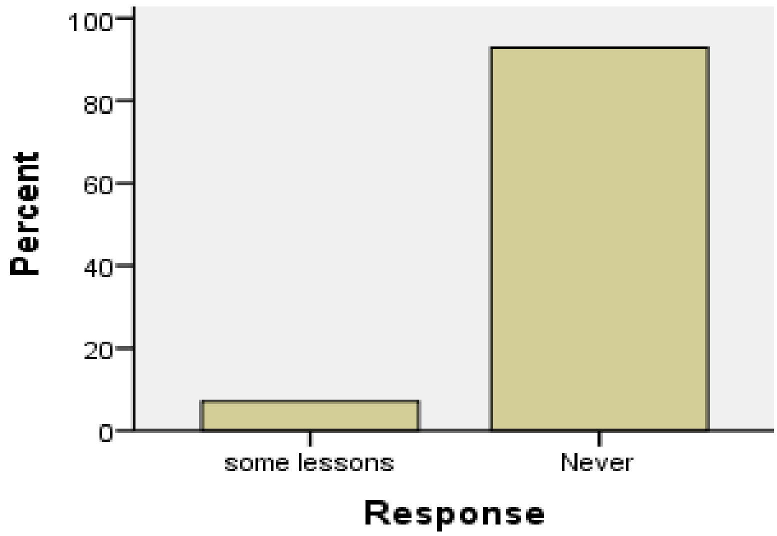


Figure 6.8: Teachers' response on how often they use computer in teaching

6.3.2 Analysis of the questionnaire for physics students on learning resources

The questionnaire for physics students, QPS featured some items that elicited responses from students on the availability of resources for the teaching and learning of physics in their schools. In this section, some of the views of students as expressed in their questionnaires on the state of learning resources are presented. Students were asked to respond to the item "my school has enough facilities for conducting experiments or investigations in physics" on a 5-point Likert scale of 'strongly agree', 'Agree', 'Disagree', 'Strongly disagree' and 'Can't say'. 242 out of the 248 participants representing 97.6% in all 8 schools responded to the item. The frequencies and percentages of their response is shown in Table 6.9 and illustrated in Figure 6.9 below.

Table 6.9: Students' response on 'my school has enough facilities for conducting experiments or investigations in physics'

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	10	4.0	4.1	4.1
	Agree	50	20.2	20.7	24.8
	Disagree	71	28.6	29.3	54.1
	Strongly Disagree	90	36.3	37.2	91.3
	Can't say	21	8.5	8.7	100.0
	Total	242	97.6	100.0	
Missing	System	6	2.4		
Total		248	100.0		

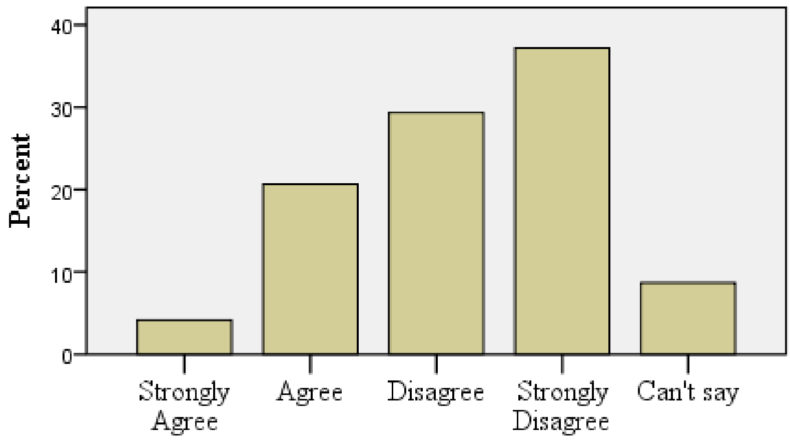


Fig. 6.9: Students' response on 'my school has enough facilities for conducting experiments or investigations in physics'

Table 6.9 shows that most students are of the view that their schools do not have enough facilities for conducting investigations in physics which undoubtedly facilitates learning. 161 students representing 66.5% 'disagreed' or 'strongly disagreed' with the statement while only 60 students (24.8%) 'Agreed' or 'Strongly agreed' with the statement. Comparing the students' response with that of the teachers as shown in Table 6.6, one may observe the lack of resources for effective teaching of physics in most of the schools under investigation. For instance, the percentage of teachers who agreed that their schools have enough resources for the teaching of the 5 core areas of physics as stated in the national curriculum, ranged from a paltry 0 – 14.3%. This is obviously very low. Very sadly, for the topic area 'energy quantization and duality of matter', 71.4% of teachers agreed that their schools do not have resources for the teaching of concepts in that area (Table 6.6).

6.4 Analysis of qualitative data on availability of resources for physics teaching and learning in schools

The use of more than one method to investigate a research problem to verify and ascertain the validity of findings is much in use in social science research (Guion, 2002; Bryman, 2012). Particularly, methodological triangulation has been used in this research. What follows is the presentation of some qualitative data relating to the availability of resources for the teaching and learning of physics as expressed by both teachers and students in their respective interviews.

Teacher A1T answering the question on the extent of availability of physics resources for teaching and learning said: “Yeah, the resources are what really hinder the subject in some other way too” (51). On factors that have hindered the effective teaching and learning of physics in his school, the teacher replied: “Yeah, then em… basically then I will say apparatus, apparatus and other resources” (A1T, 115). In school A1, the poor state of resource availability was given by students as a major reason why most students develop less interest in the study of physics. All students in school A1 said there school does not have a physics laboratory (A1P, 278,282) and that as at the 7th week of the second term, just about 2 months to their SSCE exams, they have not conducted any practical in physics (A1P, 201). In school D1 students also revealed that their school does not have a physics laboratory (D1P, 167, 171).

> “I think that why some students are not serious of learning physics is because… in some few aspects there are some equipment, the equipment that the school need to provide for the physics practical and when you come to the laboratory you see that some of them are not there and the ones that are there are not good… the equipment for us to praticalize are not there…” (A1P/3, 147-150, 151-152).
>
> “Sir, some students don’t like learning without practical, they like when they learn, when the teacher teach, then they do the practical so that they will understand it more better” (A1N/3, 157-158).

Some students also bared their minds on the truancy of teachers who absent themselves from school leaving students unattended to during physics periods and attributed that to the low popularity of physics among students.

> “…due to the teacher that is teaching that particular subject physics, some are not serious… like a term, he will just come twice or thrice… serious as in whereby you know you have a class to teach, you will be absent” (A1P/4, 130-131. 133, 141).
>
> “Sir, we do have practical but not all the time in the sense that the teacher does not normally come to school all the time” (A1P/4, 177-178).

There seem to be a consistency among both teachers and students in zones 1 and 2 that their schools are in dearth of adequate resources for teaching and learning of physics. According to one of the teachers,

> “Government is not doing well in that area. Why do I say so? They only come out with tools for experiment or carrying out practical whenever WAEC is coming, they bring out those materials that the students will use for the experiment and after that nothing is being done again” (B1T, 77-80).

Explaining further, he disclosed that his school does not have a physics laboratory: “As for now, we don’t have one” (B1T, 86).

The situation of resource availability is however different in the SC. According to the teacher,

> “As far as SC is concerned, we have enough material resources - in terms of text books, we have the textbooks, we have an available library stocked with books where the students… even if you… if there is any particular text you don’t have, it’s there in the library. In addition to that, we also have an e-library with all the facilities that the students can access for whatever materials they need. Also we have our laboratories, though built over the years and all that but the fact still remains that we have the apparatus, enough apparatus to demonstrate at this level whatever they are supposed to know” (SCT, 126-132).

The claim of the teacher on the extent of availability and use of resources for the teaching and learning of physics in the SC may have contributed to the better attainment of students in both the SSCE and PAT for this school.

6.5 Utilization of available resources for physics teaching and learning

The importance of students’ participation and involvement in hands-on activities for effective learning is very aptly illustrated by a popular Chinese proverb, mostly attributed to Confucius or Xunzi, that what “I hear I forget; I see and I remember; I do and I understand”. If students must learn effectively and not simply rely on rote memorization especially in the sciences, it is important that there is adequate interaction between students and resources in science classrooms. Students build up skills in critical thinking, analysis and scientific discoveries when they get engaged in ‘doing’ and ‘experiencing’ science. In terms of utilization of resources for teaching and learning, there are possibilities of having two extremes – one in which the teacher has vast knowledge and training in the use of resources, but where the resources are either not available or insufficient for use and two, where the resources are available but teachers are inadequately trained for the use of available resources and so do not utilize those that are available. The state of availability of resources has been presented in sections 6.3 and 6.4. In this section, both quantitative and qualitative data from teachers and students on resource utilization for physics teaching and learning in schools are presented.

Table 6.10 below shows teachers' response on how often they utilize the laboratory and its facilities in teaching physics. 13 out of the 14 teachers that participated in the study, representing 92.9% responded to the question. The teacher who did not respond to the question together with the 2 teachers who responded 'Never' had also indicated that their schools do not have a physics laboratory. The Table further reveals that 38.5% of respondents use the lab and its facilities 'about once in a term' or 'rarely' with only 1 teacher (7.7%) utilizing the lab 'one of every two lessons'. The response is illustrated in Figure 6.10 with a bar chart.

Table 6.10: Teachers' response on use of the laboratory and its facilities in teaching physics

	Response	Frequency	%	Valid %	Cumulative %
Valid	One of every two lessons	1	7.1	7.7	7.7
	About once in a term	5	35.7	38.5	46.2
	Rarely	5	35.7	38.5	84.6
	Never	2	14.3	15.4	100.0
	Total	13	92.9	100.0	
Missing	System	1	7.1		
Total		14	100.0		

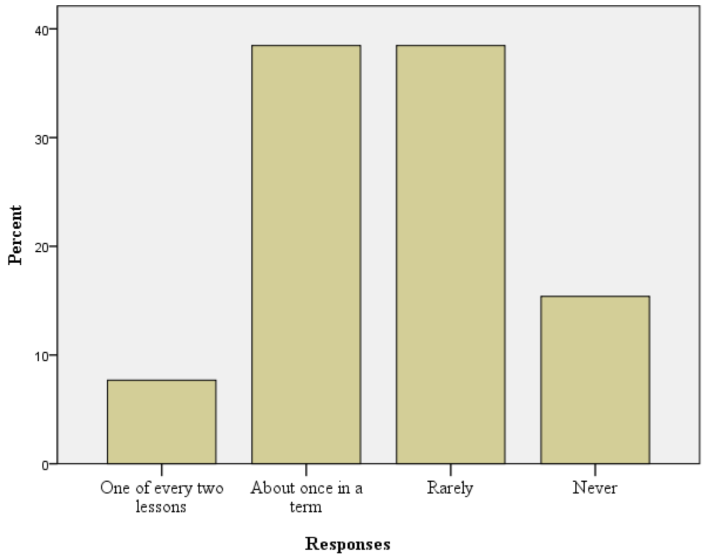


Figure 6.10: Teachers' response on use of the laboratory and its facilities in teaching physics

Data obtained from the teachers' interview also threw some light on the use of laboratory and its facilities in the teaching and learning of physics. For instance, the teacher in school C2 was observed teaching 'factors affecting resistivity' before the interview session. He was observed teaching the topic theoretically without any form of illustration or demonstration. When asked on how he utilizes the laboratory and its facilities in teaching, he responded:

> "Well, what I normally do... there are some topics that they need to see some of these things, so in such topics what I do, I pick some of those things from the laboratory and take it to the class, as I am teaching, I also show them for them to see and know it" (C2T, 88-90).

For him, "there are some topics they need to 'see' some of these things". So for those topics, he thinks they need to 'see', he brings the apparatus for the students to 'see' and not necessarily for them to 'do'. He probably did not consider that students need to 'see' anything in teaching 'factors affecting resistivity'. The teacher in school B2 was asked if he organizes laboratory practical for his students and if so, how frequently he does so. His response reveals that his students were not involved in practical work as part of their physics learning in the school.

> "Yes, we do organise practical for them. Like during the holidays, I pass the information to the interested ones because I know everybody would not be so

> interested because its holiday period, that if you are interested we'll be coming around so-so date for practical" (B2T, 103-105).

For this school, practical for the subject are organized during the holidays and for 'the interested ones'. Another teacher talked about the lack of time and the over-loaded physics syllabus that make teachers to give little attention to use of lab resources.

> "Available resources being utilised, yes, if the available resources are being utilised, I think the attainment would be better, but like I said, time - time factor is the only problem we have … other subjects, looking into their syllabus; I don't think it's as elaborate like that of physics" (A2T, 102-103, 116-117).

This unstructured approach to the teaching and learning of physics will no doubt not only de-motivate young people from studying the subject, but may also not facilitate effecting grasping of concepts and understanding of the subject. The frustration in the way physics and science in general is taught in this school (B2) was expressed by this student during the interview:

> "When I was in JSS our physics teacher is the basic science teacher, he always talk about... also the basic technology teacher… they talk of light, he talk of plus and minus, maximizing things and they don't do practicals, they just do it, they just say it, they just say it theory and we don't even understand what they are saying and they don't even care, they just say it…." (B2N/1, 328-331).

This seems to be the sorry state of facilities for the teaching and learning of physics in schools in the study area. A teacher in another school, A2 who had said the school does not have a physics laboratory was asked how then he manages with the practical aspect of the content of physics. He replied:

> "We don't… I have not seen... we don't even have a laboratory to start with. Its only when you have a laboratory then you can talk of, you can talk of enh... the resources. We don't have a laboratory… Yeah! Maybe during WAEC they sought for… when there is examination they sort for these materials… for the resources then carry out any practical, depending on the specimen, so but for a lab that the school is supposed to own, there is no one in this school" (A2T, 51-55).

His response indicates that he does not conduct practical classes with his students. It is very doubtful if meaningful learning can take place especially in science related fields without illustrations and or hands-on students' activities.

It is evident that genuine learning entails the active engagement of learners in the learning process and not just having them as passive listeners in the class. One way of actively engaging students would be the arrangement as part of the school curriculum of series of hands-on activities such that they do not only learn about scientific theories, but also have opportunities at their level to experience, proof, verify or determine some of those scientific facts or theories themselves. To assess students' involvement in active learning, students in their questionnaire were asked to respond to the statement 'students are allowed access to laboratory facilities for experiments and practical investigations'. Students were required to respond on a 5-point scale of 'strongly agree', 'agree', 'disagree', 'strongly disagree' or 'can't say'. A total of 242 of the 248 students (representing 97.6%) that participated in the study responded to the statement. Their response is similar to that of the teachers, and suggests that students are not adequately exposed to laboratory activities in their learning of physics in school. The students' response is shown in Table 6.11 and Figure 6.11. The Table shows that, 76 students representing 31.4% agreed (agree or strongly agree) with the statement while 134 students (55.4%) disagreed (disagree or strongly disagree) with the statement.

Table 6.11: Students' response on having access to laboratory facilities for Investigations

	Responses	Frequency	%	Valid %	Cumulative %
Valid	Strongly Agree	35	14.1	14.5	14.5
	Agree	41	16.5	16.9	31.4
	Disagree	45	18.1	18.6	50.0
	Strongly Disagree	89	35.9	36.8	86.8
	Can't say	32	12.9	13.2	100.0
	Total	242	97.6	100.0	
Missing	System	6	2.4		
Total		248	100.0		

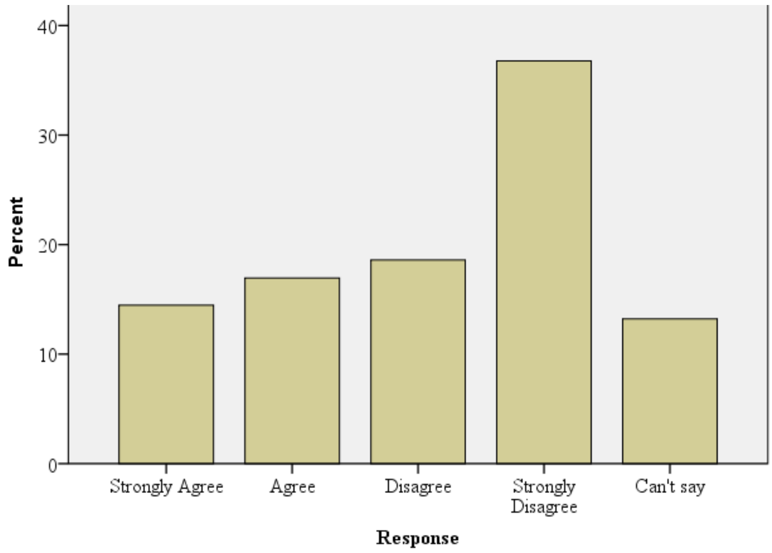


Figure 6.11: Students' response on having access to laboratory facilities for Investigations

There are many online resources to facilitate physics teaching and learning and where physics teachers could get help to effectively teach concepts in physics in a more innovative approach to the teaching and learning of physics. Computer simulations in the teaching and learning of physics have been found to effectively deal with students alternative conceptions or misconceptions (Jimoyiannis & Komis, 2001; Chang, Chen, Lin & Sung, 2008). According to Trundle & Bell (2010:1078), "these simulations are designed to facilitate science instruction and learning through improved visualization and interactivity with dynamic models of natural phenomena". To further investigate students' utilization of resources in learning, students were asked to respond to the use of technologies and computer simulations in their physics classrooms. Their response is presented in Table 6.12 and Figure 6.12.

Table 6.12: Students' % response on use of technologies in physics classrooms

	% response		
Response type	Use DVDs, Videos in physics lessons	Use computer simulations on physics	We watch our teacher demonstrate physics on a computer
Every or almost every lesson	0.4	1.2	1.7
About half the lesson	0.4	2.1	1.7
Some lessons	1.2	5.0	2.1
Never	98.0	91.7	94.5

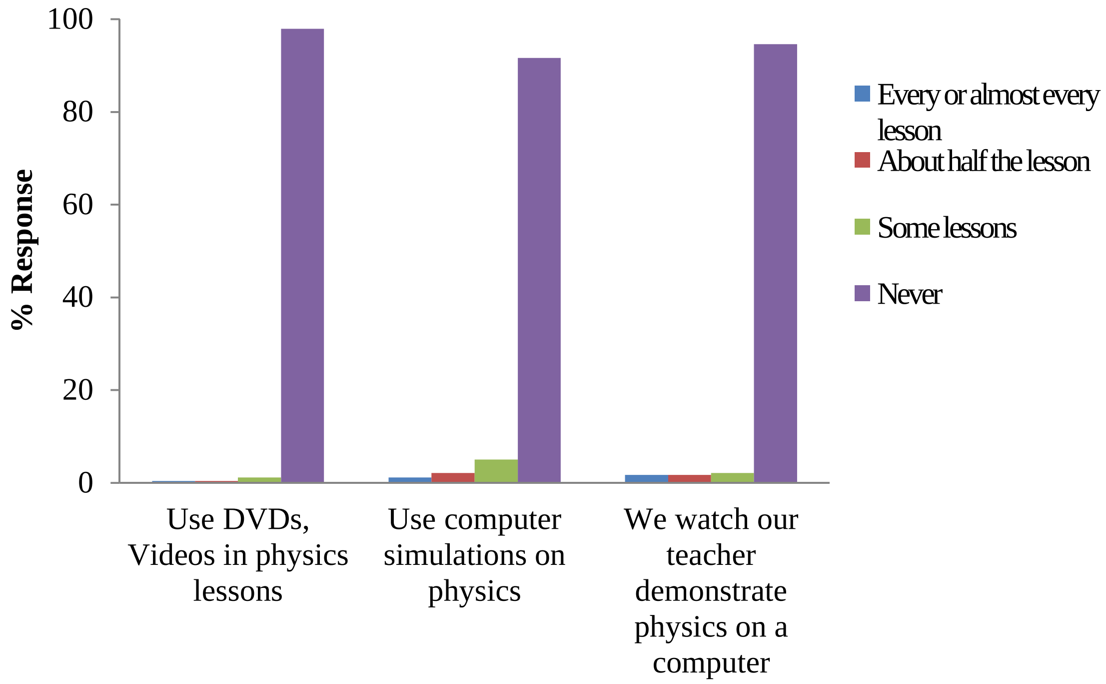


Fig. 6.12: Students' response on use of technologies in physics classrooms

The data as shown above clearly shows that students learn physics more theoretically with less aids and resources that have been known internationally to facilitate understanding of physics concepts. The result of the analysis shows that 98% of physics students responded that they have "Never' used DVD's and videos in their physics lessons. Also, 91.7% of the students revealed that computer simulations on physics have 'Never' been used in their physics lessons, while 94.5% of students said they have 'Never' watched their teacher demonstrate physics on the computer. The students' response also agrees with that of the teachers (see Table 6.8) on the use of computers in physics instructions. It is likely that the rare or non-use of such facilities and technologies in physics teaching and learning could hamper effective learning. The International comparison in physics attainment has shown that "students coming from theoretically more advanced countries perform worse than the average" (Esquembre, 2002:13). This again may explain the low performance of students in the Physics Attainment Test, PAT.

6.6 Data on school-related factors affecting enrolment and teaching of physics

The opinion of teachers was sought on what they think are the main school related factors affecting students' choice of physics on a 5-point scale of *strongly agree, agree, disagree, strongly disagree and can't say*. The result of the teachers' opinion is presented in Table 6.13 and Figure 6.13. In presenting the results, both 'strongly agree' and 'agree' will be simply grouped as 'agree' while 'strongly disagree' and 'disagree' responses would be similarly compressed as 'disagree'. This is simply for the sake of presentation. The degree or strength of the responses are however unaltered in the table and chart. The percentage responses are indicated in bracket in the table.

The result in Table 6.13 shows that on 'lack of qualified physics teachers', 8 teachers representing 57.1% either strongly agree or agree that it is a main school related factor why students opt not to choose physics while 5 teachers (35.7%) did not agree (strongly disagree or disagree) to the statement that lack of qualified physics teachers is a main school-related factor affecting students choice of physics. On 'teaching physics by theory without practical work' 9 of the 14 teachers which represent 64.3% agreed to the fact that it is a major factor that discourage students in choosing physics while 4 teachers (28.5%) disagreed. 9 teachers (64.3%) were of the opinion that lack of lab equipment for demonstration and conducting experiments was a main school related factor that affect students' choice of physics while 5 representing 35.7% did not agree that lack of lab equipment for demonstration/experimenmts is a main factor that negatively affect students' choice of physics. Result from the Table shows that all teachers involved in the study that responded to the question on lack of career guidance/counselling services agreed that that is a main school-related factor that affects students' choice of physics. 8 of the 13 teachers (61.5%) strongly agreed while 5 teachers (38.5%) agreed. 1 teacher did not respond to the question. Teacher's opinion was also sought as to whether or not the 'unsocial lifestyle of some physics teachers' is a factor that affects students' choice of physics. Their responses as shown in Table 6.10, reveals that 5 teachers, representing 35.7%, agreed that that is a factor while 7 teachers (50%) disagreed. 2 teachers did not express their opinion on that issue.

The opinion expressed by some physics teachers that the lack of laboratory facilities negatively affects their effective classroom interaction can be seen in the expressions below by teachers when asked to mention instances when their teaching had been hindered by the lack of resources.

> "Like enh… I know of ripple tank, I think I can remember that one ripple tank, when we are discussing waves. I needed to show them ripple tank and how it operates - how it produces the various types of waves but it was not there" (C2T, 156-158).

Another teacher said:

> "The availability of those resources is poor… very poor because from the onset I said that physics is all about practical experience. When you teach somebody about electricity you need to perform what you have told them in the class practically not coming with a text book or instructional materials like chalk and other handout or whatever. You talk to them theoretically…but practically they are not seeing so the resources available are very poor so that makes the interest of the student towards the subject… reducing in percentage" (B2T, 80-86).

These expressions of the physics teachers in schools clearly demonstrate the paucity of physics teaching resources in schools in Nigeria. In all, the response of the teachers as summarized in Table 6.13 suggests that lack of adequate number of qualified physics teachers, teaching physics by theory without practical work, lack of laboratory equipment for demonstration/experimentation and lack of career guidance/counselling services with 57.1%, 64.3%, 64.3% and 100% respectively are the main school-related factors that affect students' choice of physics.

Table 6.13: Teachers' opinion on main school-related factors affecting students' choice of physics

Factors/Responses	Strongly Agree	Agree	Disagree	Strongly disagree	Can't say	Total
Lack of adequate number qualified physics teachers	7 (50.0)	1(7.1)	2(14.3)	3(21.4)	1(7.1)	14
Teaching physics by theory without practical	4(28.6)	5(35.7)	3(21.4)	1(7.1)	1(7.1)	14
Lack of lab equipment for demo/experiments	7(50.0)	2(14.3)	1(7.1)	4(28.6)	0(0)	14
Lack of career guidance/counselling services	8(61.5)	5(38.5)	0(0)	0(0)	0(0)	13
Unsocial lifestyle of some physics teachers	2(14.3)	3(21.4)	3(21.4)	4(28.6)	2(14.3)	14

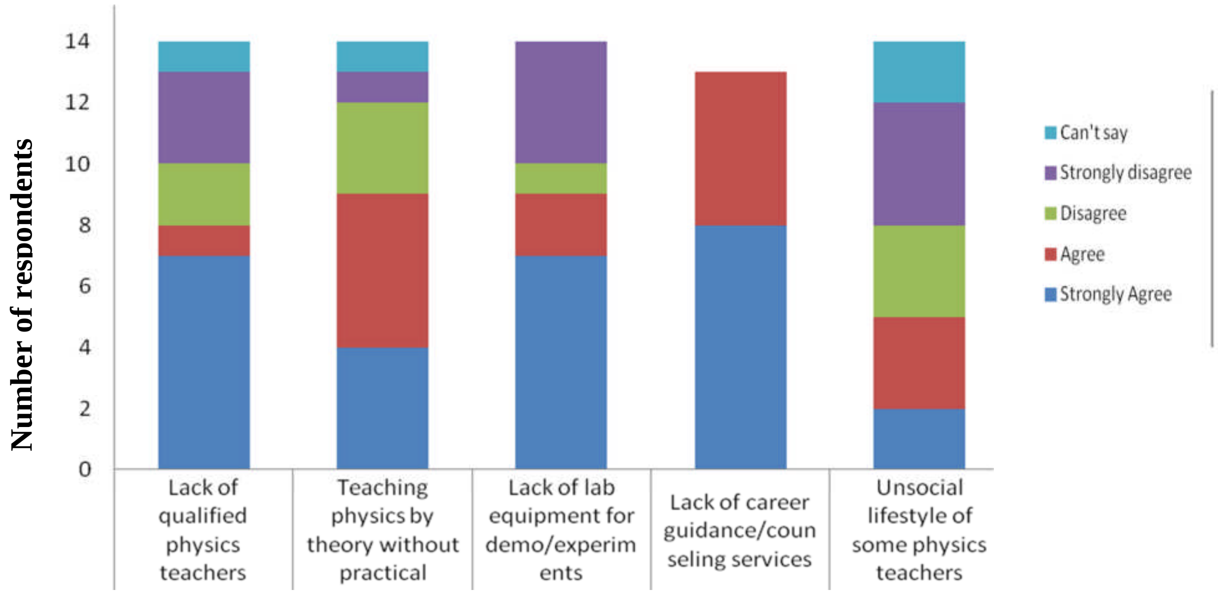


Fig. 6.13: Teachers' opinion on main school-related factors affecting students' choice of physics

To capture the experience of teachers as to the limiting circumstances to their effective teaching of physics, they were asked the question: ‘in your view, to what extent do the following limit your teaching of physics?’ on a 3-point scale of *‘Not at all’*, ‘*A little or some’* and *‘A lot’*. Items listed were shortage of computer hard ware, software, textbooks for students, equipment for both teacher and students’ use, physical facilities and high student/teacher ratio. 2 out of the 14 teachers did not answer any question from this section of the questionnaire. 1 of the 12 that answered questions on this section did not however answer the question on ‘inadequate physical facilities’. The ressponses of teachers are shown both in Table 6.14 and Figure 6.14. In the table, figures in bracket represent the percentage responses.

On the shortage of computer hardware, only 1 teacher (8.3%) responded it does not limit his teaching of physics. 7 teachers representing 58.3% agreed that it limits their teaching a little or to some extent while 4(33.3%) of the teachers said it limits their effective teaching a lot. On shortage of computer software, 2 (16.7%) indicated it does ‘not at all’ limit their teaching with 6 representing 50% saying it does a little or to some extent limit their teaching while 4 (33.3%) responded that it limits their teaching ‘a lot’.

Table 6.14 reveals that it is the view of most teachers that, shortage of text books, instructional equipment for students’ use, equipment for teacher’s use in demonstrations and other exercises, inadequate physical facilities and unavailability of computers with internet access with 66.7%, 83.3%, 58.3%, 54.5% and 66.7% respectively are main factors that limit their effective teaching of physics in schools.

Table 6.14: Teachers' opinion on factors limiting the effective teaching of physics in schools

Factors/Response	Not at all	A little or some	A lot	Total respondents
Shortage of computer hardware	1(8.3)	7(58.3)	4(33.3)	12
Shortage of computer software	2(16.7)	6(50.0)	4(33.3)	12
Shortage of textbooks for students' use	1(8.3)	3(25.0)	8(66.7)	12
Shortage of instructional equipment for students' use	0(0)	2(16.7)	10(83.3)	12
shortage of equipment for teacher's use in demo	3(25.0)	2(16.7)	7(58.3)	12
Inadequate physical facilities	0(0)	5(45.5)	6(54.5)	11
High student/teacher ratio	3(25.0)	5(41.7)	4(33.3)	12
Unavailability of computers with internet access	0(0)	4(33.3)	8(66.7)	12

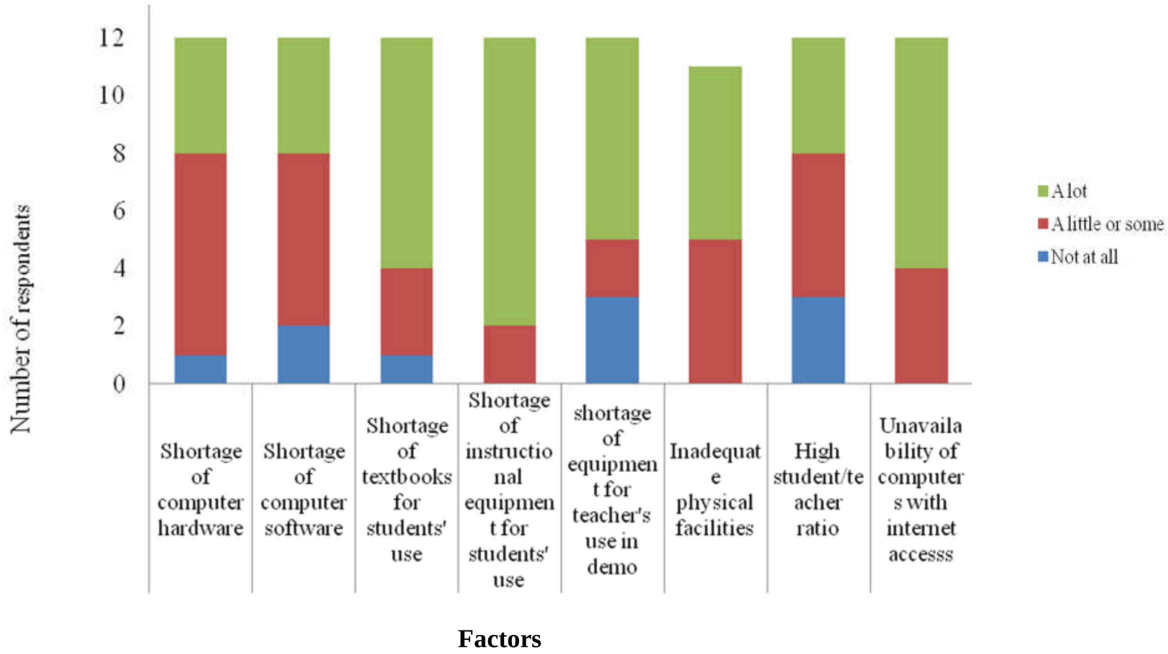


Fig.6.14: Teachers' opinion on limiting factors to effective physics teaching

6.7 Teaching strategies adopted by physics teachers and effect on students' enrolment and attainment

The primary goal of every teacher is to ensure that his students gain proper understanding of the materials and or concepts they are engaged with, in the classroom or school setting so as to produce a reasonable change in behaviour. This is what is referred in literature as 'teachers' educational goals' (Rich, 1993), or 'learner goals' as one of the categories of goals teachers may set (McGreal, 1980). According to Tebabal & Kahssay (2011), such desired changes in behaviour expected of students 'may be in the form of acquiring intellectual skills, solving problems and inculcation of desirable attitudes and values' (p. 374). Teachers employ different strategies and create enabling environment so as to support students acquire the desired skills and knowledge with various classroom and or laboratory experiences.

Teachers' self-reporting in response to the questionnaire item on the teaching strategies they usually adopt in teaching physics to the students is presented below. All 14 teachers responded to this section of the questionnaire although, one teacher did not make any response for 'demonstration'. In Table 6.15, the numbers in bracket represent the percentage response while the numbers preceding the brackets are the actual count of teachers that responded to the questionnaire item. The chart of the teachers' responses is presented in Figure 6.15.

Table 6.15: Teachers' self-reporting of teaching strategies adopted for physics lessons

Responses / Strategies	Every or almost every lesson	About half the lesson	Some lessons	Never	Total response
Demonstration	8 (61.5)	1 (7.7)	3 (23.1)	1 (7.7)	13
Lecture	1 (7.1)	3 (21.4)	3 (21.4)	7 (50)	14
Guided discovery	3 (21.4)	4 (28.6)	5 (35.7)	2 (14.3)	14
Laboratory	0 (0)	1 (7.1)	10 (71.4)	3 (21.4)	14
Field trip	0 (0)	0 (0)	3 (21.4)	11(78.6)	14
Excursion	0 (0)	0 (0)	3 (21.4)	11(78.6)	14
Collaborative learning	1 (7.1)	2 (14.3)	7 (50)	4 (28.6)	14
Problem solving	3 (21.4)	7 (50)	4 (28.6)	0 (0)	14
Project method	0 (0)	1 (7.1)	8 (57.1)	5 (35.7)	14

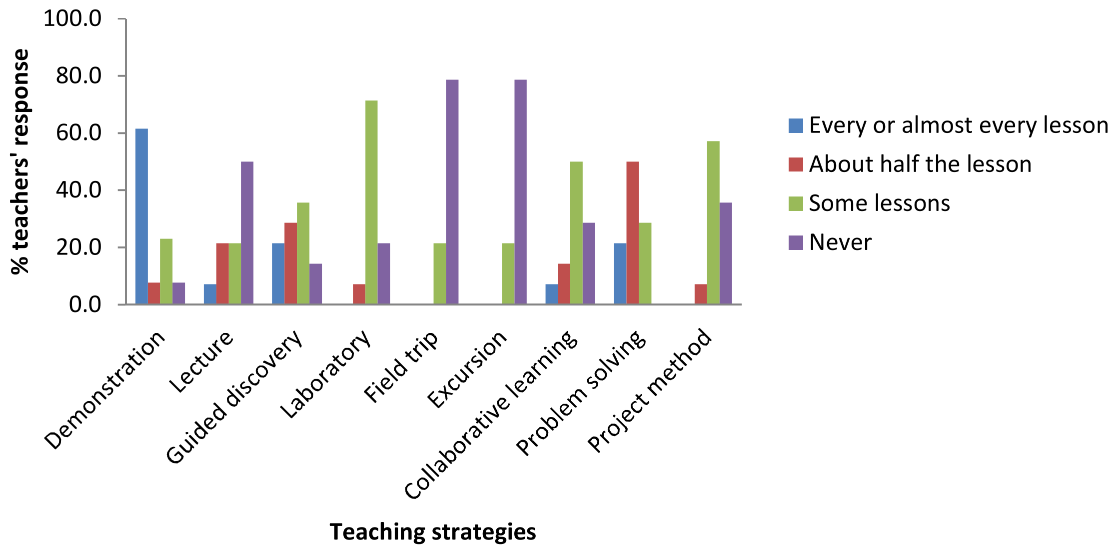


Figure 6.15: Teaching strategies usually used by physics teachers as reported

The teachers' self-reporting of strategies they commonly used for teaching physics shows that the most commonly used teaching strategy among physics teachers is 'Demonstration'. Most of the teachers (61.5%) indicated that they usually use the method in 'every or almost every lesson'. Also, 50% of physics teachers use 'Problem solving' method in 'about half the lesson' – that is, about 1 in every 2 lessons. Most teachers also indicated that they rarely use Laboratory, Collaborative learning and Project methods in 'some lessons' with 71.4%, 50% and 57.1 % respectively. The response of the teachers show that 'Field trip' and 'Excursions' are not usually used as a teaching strategy with most teachers (78.6%) indicating that they 'Never' use them. Interestingly, 50% of teachers also indicated that they 'Never' use 'Lecture' as a teaching strategy in their physics classes. Teachers have also reported that they seldom use students' collaborative learning approach in their physics lesson with just 14.3% indicating that they use the strategy in about half the lessons.

On the strategies adopted by teachers in teaching physics, qualitative data from the teachers' interview suggests that teachers commonly use lecture and demonstration methods in their teaching. This can be seen in the excerpts from the interview with some of the teachers in response to the question on the teaching strategy they commonly use in class.

> "…most times I use lecturing method, most times I use demonstration, I demonstrate, then most times I use question and answer, just for interaction sake,

> and most times too I do research, I give them work to go and research, a kind of project they should go and research on something and come back" (C2T, 122-125).

Teaching strategies used by this teacher, according to him are lecture, demonstration, Socratic (questioning) and project depending on the content of instruction. Another teacher responded very explicitly as presented below:

> "Ok, most a times I adopt the demonstration method of teaching. What do I mean by demonstration? I go with… most times the apparatus that are available, to demonstrate to students on the use of these apparatus while teaching, like when I was teaching SS I just this morning (18/2/2015) I went with the conductor, I went with the ammeter, the volt meter, the cell, I went with the key and the… all necessary materials to demonstrate to them the need to understand what we mean by a circuit or what we mean by close circuit, open circuit and short circuit. So most times I do use the demonstration method to teach for easy understanding of the students" (B1T, 102-109).

The inference from this teachers' expression is that the most common teaching strategy he uses is 'Teacher Demonstration' method. Incidentally, of the 7 physics classes observed, this was the only teacher that used a teaching resource in his lesson. He was teaching 'Heat Energy: Temperature and its measurement' in an SS2 class (about 15 year olds) and passed on a thermometer for them to 'see' and 'observe' although students' 'passing on thermometer' without actual materials for them to take real measurements and carry on some hands-on activities is obviously inadequate for the teaching of that topic. Probing further on how students get involved in demonstration, the teacher explained that:

> "The only students that… are… mostly allowed to come into the… say, made-shift laboratory is the SS III because of space, so most of the JSS students are not allowed until they are able to get to SS III before they can have a feel of this apparatus" (B1T, 114-116).

The above expression reveals that students do not have the opportunity to get involved with hands-on activities until they are in the final year of secondary education. It is also clear from the above expression of this teacher that what he understands 'demonstration method' to be is ‘teacher demonstration’ while the students simply watch. It is unlikely that students would learn science effectively in that way.

On the teachers’ response of their common use of ‘demonstration’, it is important to note that most teachers (64.3%), (see Table 6.13) indicated that ‘lack of lab equipment for demonstration and experiments’ was a major school-based factor that affects students’ choice of physics in their school. Also, 58.3% of teachers (see Table 6.14) revealed that ‘shortage of equipment for teachers’ use in demo’ was a limiting factor to the effective teaching and learning of physics. It is therefore surprising to observe that 61.5% of physics teachers usually use demonstration method in ‘every or almost every’ of their physics lessons. Teachers’ clear understanding of some of these teaching strategies that was not probed in this study may also account for some of the inconsistencies in their responses. For instance, the response of some teachers on ‘students’ participatory learning’ in physics classes during the interview may suggest that some teachers may have understood and interpreted the various teaching strategies in various ways. Presented below are excerpts of two responses of physics teachers to the question: ‘to what extent are students involved in participatory learning during your physics classes?’

> “The participation to physics students in physics classes is satisfactory. Sometimes I might be too busy, with administrative work forgetting that I have time with them in physics, they will be the ones to come and call me and tell me that, sir we need you, we want to learn physics, then sometimes too they might be so free not doing anything like free period most of them will just come, sir, come and occupy us with physics so if I am free I will still go even without my period, that is it” (B2T, 148-153).
>
> “Well, I think, e...h... I would say they are trying, they are coping. The only problem I have is this SS III, they had problem in their SS I and SS II because then they had no teacher, if not for the newly employed teachers that now filled up those gaps. So I am just trying to battle with them - you understand? Picking up things from SS I, SS II, just to make up but they are still trying” (C2T, 131-134).

The responses of these teachers to the question that was posed to them may suggest that they do not understand what ‘participatory learning’ was all about.

Some of the items in the students' questionnaire sought to get the opinion of students on how often they do certain activities in their physics lessons – 'listen to the teacher present new material', 'watch the teacher demonstrate an experiment or investigation', 'conduct an experiment or investigation', and some others (see items 7 and 9 of the QPS). The students' response is presented below and would be compared with that of their teachers. 248 physics students from the 8 schools involved in the study responded to the questions, although between 5 and 11 students did not respond to some of the questions. Their responses are presented in Table 6.16 and Figure 6.16. The figures in bracket are the percentages while the actual numbers of student respondents precede the brackets.

Student responses as shown in Table 6.16 reveal that 40.3% of physics students indicated that they 'work on problems together with other students'. Although that percentage is low, with no clear consensus of students' opinion, working on problems together with other students appears to be the commonest activity or how they learn physics. In terms of demonstrations in physics lessons, students were near unanimous in their responses with 94.6% indicating that they 'Never' watch their teachers demonstrate physics on a computer. As to whether they 'watch the teacher demonstrate an experiment or investigation', only 23.3% indicated its occurrence in 'every or almost every lesson', 6.7% in 'about half the lesson', 40.4% in 'some lessons' while 29.6% responded 'Never'.

Table 6.16: Students' response on how they learn in physics lessons

Responses / **Activities**	**Every or almost every lesson**	**About half the lesson**	**Some lessons**	**Never**	**Total response**
We listen to the teacher present new material	51 (21.8)	29 (12.4)	93 (39.7)	61(26.1)	234
We work problems on our own	82 (31.7)	50 (20.8)	101(42.1)	7 (2.9)	240
We work on problems together with other students	96 (40.3)	35 (14.7)	74 (31.1)	33(13.9)	238
We watch the teacher demonstrate physics on a computer	4(1.7)	4 (1.7)	5 (2.1)	229(94.6)	242
We watch the teacher demonstrate an experiment or investigation	56 (23.3)	16 (6.7)	97 (40.4)	71 (29.6)	240

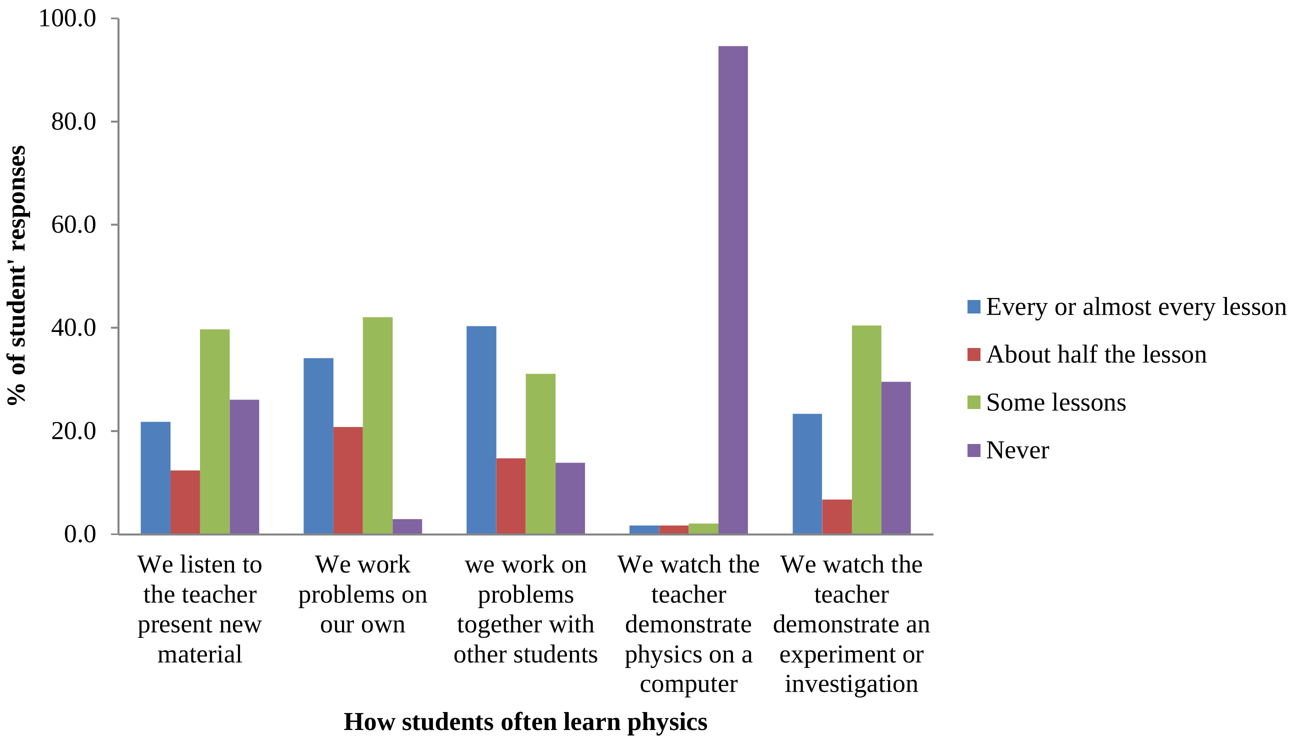


Figure 6.16: How students say they learn physics in classroom

It is evident from the foregoing that whereas teachers posited that 'demonstration' strategy was most commonly used for physics lessons, the response from the students has not suggested that that is what they experience in physics classrooms. More students indicated that the demonstration elements – 'We watch the teacher demonstrate physics on a computer' and 'We watch the teacher demonstrate an experiment or investigation' 'Never' occur often in physics lessons with 94.6% and 29.6% respectively, than those who posited that they occur in 'every or almost every' lesson with 1.7% and 23.3% respectively for the two demonstration elements. The understanding of some teachers on demonstration method as 'teacher demonstration' to the exclusion 'student demonstration' as discussed earlier may explain the difference between teachers and students responses on the use of demonstration method in physics lessons.

A look at Figure 6.16 would suggest that students' working together with other students is the commonest way students learn physics with 40.3% of the students indicating that they often work on problems together with other students in "every or almost every physics lesson". This does not agree with what physics teachers have claimed as can be observed from Table 6.15, where only 7.1% of the teachers have said they use "collaborative learning" which implies students' working together, for physics lessons and 14.3% using the strategy in "about half the lessons". From the contradiction between the students and teachers response on the use of 'collaborative learning' or students working on problems together with other students, It is possible that students understood the question to mean how they learn physics and not necessarily what happens during the physics lessons in school. For instance in one of the students' interviews, a participant described how those students assist one another to better understand what they could not understand in the classroom with their teacher:

> "there are some students that understand what the teacher is doing, just because they read their books or their text books, so they understand what the teacher is doing and they are flowing along… so immediately the teacher leaves, he can call the other of his colleague just like what my friend always do to me, he always comes to me and tell me that, do you know how…? I said no, and he showed me the details and how the thing is being done. Some of the students are afraid to ask the teacher in the class they do meet one on one with their fellow colleague and when heir colleague explain it will be better than when the teacher taught them" (A2P/5, 255-263).

The students in their interviews also gave some light on what happens in their physics lessons. In one school in zone 1, a student in describing how they learn physics stated that:

> "when the physics master gets into the class to teach us as physics students, the first thing he does, he will write down the topic on the board and then explain what that topic simply means, then after that, he goes over to the calculation…" (B1P/2, 177-179).

Another student in a school in zone 2 described what happens in their physics class this way:

> "The teacher normally… when he comes to the class, he writes the note and he will have to teach. In the aspect of teaching he explains the topic he is teaching and he breaks it down for our understanding, he breaks it down to the knowledge, to the understanding of what he is teaching and also in order for us to learn" (B2P/2, 282-286).

The description of how students learn physics in schools as illustrated by these students as stated above and few others as captured in the interviews tell more of the use of lecture method and not demonstration as claimed by most of the teachers.

Some students explained how the classroom interactions and teaching strategy adopted by their teachers affect their understanding of physics.

> "I study physics and I'm a physics student. Physics, I find it very interesting and the way my teacher teaches physics and he analyses it…if it is a topic, he brings out the things to show us and we understand it…the class flows when he teaches, so I just like it" (C2P/2, 6-8).
>
> "…and also our teacher, he makes us enjoy the subject very much, like she said, analysing it, showing us things, asking us questions, if we understood it or not and also contributing to what he has taught…" (C2P/1, 22-24).
>
> "In the aspect of teaching he explains the topic he is teaching and he breaks it down for our understanding, he breaks it down to the knowledge, to the understanding of what he is teaching and also in order for us to learn… when he is teaching he also ask questions to know if we are truly following or we are understanding what he is teaching and if we do not respond he tries to make us understand that it's good to ask questions in whatever we don't understand. So when we ask questions he clarifies us and we gain that knowledge… He encourages the students…" (B2P/1, 283-286, 292-295, 297).

The above quotes of students from the interviews illustrate positive effects of the teaching strategies and classroom interactions on students understanding of the subject.

There were also some students who expressed how they have been discouraged from continuing with the study of physics and how the teacher's style of teaching, by their claims, did not effectively support their learning.

> "…this is what we are saying, this is the problem we physics students are facing today, em.., when we look into the learning environment, we find out that there are no good things to back up em… the study of physics that is why most students run away; in fact there is no laboratory in which we conduct most practical, all

thing are theoretical which are not helping matters and this is one of the things that make students run away because they don't understand this, because practical makes you understand more, that is just the thing" (A2P/4, 300-305).

"…when we started learning physics, the first teacher that taught physics, he was doing very well, but when they changed the teacher to a female, I find it difficult to flow and the female teacher that was teaching us physics was not really good at physics. She was making it difficult for me that was why I don't choose physics" (C2NP/1, 51-55).

"…in SS I, the teacher, the male teacher that taught physics was a very good teacher but and I also believe that female teachers are not good in teaching science subjects like physics. The female teacher that took us physics was not that sound, she was not teaching very well to our understanding" (C2NP/2, 57-60).

"When I was in JSS our physics teacher is the basic science teacher, he always talk about... also the basic technology teacher… they talk of light, he talk of plus and minus, maximizing things and they don't do practical, they just do it, they just say it, they just say it theory and we don't even understand what they are saying and they don't even care, they just say it…" (B2NP/1, 328-331).

The excerpts above represent claims of mainly non-physics students and those who could not continue with the subject having lost interest in the subject as a result of the teaching strategies adopted by their teachers. All these suggest that whether positively or negatively, the classroom interactions and teaching strategies affect students' physics enrolment and attainment.

In the next section, the classroom observation report of the researcher will be presented for all schools observed. This is done to corroborate or otherwise, the claims of both the students and the teachers on how physics lessons are conducted in the schools. The lesson topic being observed together with the teachers' and students' activities of the observed lessons would be reported.

6.7.1 Classroom observation of physics lessons

Classroom observation of physics lessons was made in 7 out of the 8 schools used in the study. As explained earlier, the teacher in the 8th school was reluctant to have his lesson observed. The Science Classroom Observation Worksheet (SCOW), Classroom Observation Schedule (COS) together with field notes made in observation sessions were used to obtain data. In this section, the information and data regarding the topic taught, average age of the students, teaching resources that were used, both teacher and students' activities during the observed lessons and the duration of the classes observed are presented. Table 6.17 summarizes the observations of the 7 lessons in 7 schools.

The national physics curriculum as used in Nigeria at the time of the study would form the basis of the evaluation or assessment of the teaching and learning as observed for the lessons, especially in terms of the curriculum proposed teacher and student activities, together with the resources and facilities the curriculum suggests to be utilized for effective teaching and learning of the topics that were taught. Each of the lessons would be evaluated and at the end, what teaching strategy that has been used would be highlighted and compared with the claim of both teachers and students as presented above.

6.7.1.1 Classroom observation of lesson in school A1

This is school A in Zone 1. The school is a coeducational school. The topic taught was 'Types of waves'. Although this topic was expected to have been taught in the Senior Secondary 2 (SS2) class as could be observed from the physics curriculum for secondary schools in Nigeria, the SS 3 students in this school were taught the topic. The curriculum document suggests the use of rope or slinky as 'teaching and learning materials'. Under the teacher activities, the curriculum suggests the teacher 'provide rope and slinky to demonstrate transverse and longitudinal waves' while students were expected to 'use the rope and the slinky to demonstrate transverse and longitudinal waves' (FME, 2009:18). A look at Table 6.17 shows that the teacher neither used any of the suggested teaching and learning materials nor any other teaching resource to facilitate learning and students' understanding of the concepts. A resourceful teacher who strives to make a student learning-friendly classroom environment, would at least provide a rope (if the slinky is not available and could not be obtained) or possibly ask students to come with one with adequate permission and communication with parents and school authorities. Clearly as shown in the table, neither the teacher nor the students' activities reflect the suggested activities by the curriculum. The teacher was simply teaching by lecture method, while the students passively listened and took notes. Clearly, the teaching strategy used here is more of the lecture method and nothing of demonstration.

Table: 6.17: Classroom observation summary of physics lessons

School Code	Topic taught	*Resources used	Observed Activities	
			Teacher	**Student**
A1	Types of waves	-	Review of previous lesson, introduce new lesson, explaining, telling, questioning, note giving	Answer questions, passive, listening, note copying
B1	Heat energy: Temperature and its measurement	Thermometer	Questioning, review of previous lesson, introducing new lesson, explaining, illustrating (showed students a thermometer and passed on from one student to another), telling, writing key points, note giving	Answering questions, listening passively, observing thermometer, note copying
C1	Capacitor and capacitance	-	Recall previous lesson, introduce new topic, lecture (informing), Occasionally questioning, explaining, note giving	Listening, passive, answer questions, note copying
D1	Electromagnetic field	-	Review of previous lesson/Questioning, introducing new lesson, lecture (telling), explanation, Note giving	Answer questions, passive, listening, jotting, Note copying
B2	Simple AC circuit	-	Introducing new lesson, teaching (telling), Explaining, note giving	Passive, listening, note copying
C2	Resistors: Factors affecting resistance of a wire	-	Started with a math problem from previous lesson, introduced new topic, lecture-listing factors, explanations, dictating notes	Listening, answer questions, passive, asked question, listening, copying notes
SC	Waves: Characteristics, types and properties	-	Review of previous lesson/Questioning, explanation, problem solving	Passive, Answer questions, listen, take notes

(* As teachers are expected to use available materials in the classroom to facilitate learning, basic materials like the chalk and chalk board which are expected to be used by all teachers are excluded as teaching resources and are not listed)

6.7.1.2 Classroom observation of lesson in school B1

School B1 is school B in zone 1. The school is one of the coeducational schools that were used for the study. The teacher was observed teaching the Senior Secondary 2 (SS2) class on the topic: 'Heat Energy: Temperature and its measurement. The teaching and learning materials recommended by the curriculum for this topic are thermometers – different types of liquid-in-glass thermometers, container with moveable position e.g. Bicycle pump or round or flat bottomed flask with delivery tube connected to a water manometer, glass capillary tube, biro tube, coloured water, hot water, cold water, beaker and Bunsen burner. As part of the teacher activities, the teacher was expected among others to "demonstrate (1) how to calibrate a thermometer in Celsius scale (2) how to construct a resistance thermometer and a thermocouple", while students were expected to "Calibrate a thermometer in Celsius scale and to construct a resistance thermometer and a thermocouple and use them to measure the temperature of water and immediate environment" (FME, 2009:11). It is worth noting that part of the performance objectives for this lesson states that:

> "students should be able to: construct a device for measuring the temperature of a body, use the variation of: pressure of a gas with temperature, the expansion of solid, liquid or gas with temperature, electrical resistance of a material to measure the temperature of a body" (FME, 2009:11).

The teacher skipped the students' hands-on activities that would have exposed them to skills and knowledge necessary to meet that performance objective. The teacher simply came to class with a mercury-in-glass thermometer and passed it on to students at a point, who took turns as it was moved round to 'touch' and 'observe' the lower and upper fixed points. Teacher and student activities as prescribed by the curriculum document were not carried out in the lesson. The teacher theoretically explained and informed the students, for instance, of the effect of variation of pressure and electrical resistance on temperature. It is however important to observe that of the 7 lessons observed, it was only in this school that the teacher employed a resource – the thermometer, although not adequate, but somehow, to possibly facilitate learning. That notwithstanding, it is evident from the Table 6.17 considered in view of the expected teacher and student activities in class, that no demonstration activity took place in the class either by the teacher or the students. The lecture method could be used to best describe the teachers' approach.

6.7.1.3 Classroom observation of lesson in school C1

This is the girls' school in Zone 1. It was one of the two girls' schools that were used for the study. The Senior Secondary 3 (SS3) class was observed with the teacher teaching the topic: Capacitor and capacitance. The topic is a sub-topic under the topic 'Electric fields' that is grouped under the theme: Fields at rest and in motion in the SS3 physics curriculum. As teaching and learning materials, the school physics curriculum suggests the use of copper plates, connecting wires, centre-zero galvanometer, cells/accumulators and capacitors. On the teacher activity, the physics curriculum did not state any activity for the section covering 'capacitance and capacitor'. There were however 2 stated activities for the students: "Determine the equivalent capacitance for: series, parallel arrangements of capacitors" and to "Calculate the energy stored in a charged capacitor for given values of V, Q and C" (FME, 2009:8). Although there were no stated teacher activities, it may therefore be implied that if students were to 'determine the equivalent capacitance…' then the teacher should demonstrate that determination.

It was observed during the lesson that no teaching and learning material (as prescribed by the curriculum) was used for the lesson. Also, there were no activities that involved the students. If resources were available, one would imagine that the lesson would have been more interesting with better learning taking place if the teacher had exposed students to some hands-on activities of connecting capacitors in parallel and serial connections to determine for instance, the capacitance. The teacher was observed writing down relevant formulas and solving problems while the students occasionally answered questions from the teacher and 'watched' on with some, copying from the blackboard into their note books. There was no student-student interactions neither were students on individual basis given some tasks or problems to solve with the teacher facilitating the classroom experience of the students.

6.7.1.4 Classroom observation of lesson in school D1

School D1 is the school coded D in zone 1. It is the only single-sex boys' school in the zone and one of the two boys' schools that were used for the study. The physics teacher was observed teaching the topic: Electromagnetic field. To teach the topic, the curriculum suggests the use of the following teaching and learning materials or resources – solenoid, bar magnet, soft iron, DC source, galvanometer, plug key, connecting wires and a model transformer. As part of the activities for the teacher, he is expected to "show the relationship between the directions of the magnetic field, current and the force by using a current carrying wire in a magnetic field using Fleming's left hand rule". The teacher was also expected to "show the effect of passing current through two conductors: parallel in the same direction, parallel in the opposite directions, perpendicular to each other, at an angle to each other such that $0^o < \theta < 90^o$" (FME, 2009:10). For students' activities, they were required to "investigate the effect of passing current through a solenoid in a magnetic field, investigate the effect of rotating wire in magnetic field, investigate the effect of moving a magnet in a solenoid or coil carrying current near a solenoid" (FME, 2009:10).

As could be seen in Table 6.17, no teaching and learning material other than chalk and chalkboard was used in the teaching of Electromagnetic Field in this school. The curriculum suggested teacher and student activities were also not carried out as no demonstrations were observed during the lesson. The teacher stated the Faraday's and Lenz's laws, writing on the blackboard and making explanations to the students. Students on their part were observed to be passively listening and occasionally answering questions thrown at them by the teacher. The teacher was not seen showing 'the effect of passing current through two conductors' neither were the students seen carrying out 'investigations' as suggested by the curriculum document. At the end of the lesson, the teacher gave notes on the lesson to the students who were observed copying from the board into their note books. It is very likely that students taught with adequate resources as prescribed by the physics curriculum are more probable to show understanding of knowledge and skills than those taught by theory without hands-on activities or demonstrations.

6.7.1.5 Classroom observation of lesson in school B2

This is the coeducational school in zone B. The senior physics teacher who teaches the certificate class (SS 3) was observed for the lesson. The topic taught was 'Simple AC circuit'- that is, simple Alternating Current circuit. To facilitate the effective teaching and learning of the topic, resource materials that are prescribed for this lesson as contained in the curriculum document are: capacitors, inductors, resistors, voltmeter (0-500V), connecting wires, A.C source, and break and make switch. As activities for teachers during the lesson as contained in the curriculum, the teacher was expected to "use vectors to show the directions of resistance, inductance and capacitance in an A.C. circuit" students on their part were to "calculate current in a simple A.C. circuit" (FME, 2009:12). As part of the performance objectives both in the curriculum and as stated by the teacher, students at the end of the lesson “should be able to … determine current in circuits containing: resistance and capacitance, resistance, inductance and capacitance” (FME, 2009:12). By the provision of the curriculum, the suggested teaching and learning materials were expected to be utilized both by the teacher and the students at appropriate times during the lesson to ‘determine’ the current in circuits as students’ hands-on activities. As could be seen from Table 6.17, no resource was used in the classroom either by the teacher or the students in the course of the lesson. The teacher used the black board extensively writing formulas and drawing out relationships in the mathematical expressions between quantities. Students were generally passive, occasionally answering questions from the teacher. The teacher did not provide the forum for students to reflect on the content or interact with one another on the content. At the end of the lesson, the teacher asked for questions with no student asking any. The teacher then gave notes of the lesson and students were noticed copying from the board into their notes.

6.7.1.6 Classroom observation of lesson in school C2

School C2 is the only girls’ school in Zone 2. It is a senior secondary school and had only one physics teacher who teaches all the 3 classes. The teacher, who was observed in the SS3 class, taught the topic: Factors affecting resistance of a wire. This topic is one of the subtopics for the SS 1 class under the “Electric Field”. As the observations and indeed the data collection for the this study was carried out barely 2 months to the conduct of the senior secondary school certificate examination SSCE, it is very likely that the teacher may have revisited that topic as a way of revision. The teaching and learning materials expected to be used by the teacher and students for this lesson as specified by the physics curriculum include cells, resistors, ammeters, voltmeters, bulbs, keys and connecting wires. The physics curriculum also specified certain activities for both the teacher and students to “stimulate creativity and develop process skills and correct attitudes in students” (FME, 2009: iii). The teacher was expected to “illustrate the importance of fuses in electric circuits by setting up a short-circuit”. For student activities for the lesson, students were expected to “make electric circuit from an electric cell, key, ammeter, voltmeter and resistor in: parallel, series.” Also, they were required to “investigate factors affecting electrical resistance” (FME, 2009:10, 11). A look at Table 6.17 reveals that the required teaching and learning materials for the lesson were not utilized. Also, the teacher was not seen illustrating any aspect of the lesson with resources as required by the curriculum as he only went into the class with his lesson note book. The students also did not carry out any hands-on activity like ‘making an electric circuit’ or ‘investigating’ the factors that affect electrical resistance as suggested by the curriculum. Interestingly in this class, the teacher listed and attempted to explain the 4 factors that affect electrical resistance – material of the wire, length of wire, temperature and cross-sectional area of the wire. A student then asked the teacher to explain what cross-sectional area meant. The teacher drew a rectangle on the board and struggled to explain how the area of a rectangle is the product of its length and the breadth. That response of the teacher was indeed misleading and may not have helped the student as electrical wires are generally cylindrical. It may be thought that the use of wires of varying sizes or diameters by the teacher in illustrating his lesson would have better facilitated the students’ understanding of the concepts.

6.7.1.7 Classroom observation of lesson in the Science College

The SC is a specialist science college that is located in LGA16 of the state. The school had very well equipped science laboratories for Biology, Chemistry and Physics respectively. During the time of visit, it was noticed that all physics lessons were taught in the classroom. For the class observation, one of the three physics teachers in the school was observed teaching the SS 2 class in their classroom.

The topic the teacher was observed teaching was: Waves – characteristics, types and properties. For the effective teaching of this topic, the curriculum has suggested the use of teaching and learning materials to support and enhance students’ learning experiences. Materials required for this lesson are rope or slinky, ripple tank or wide transparent plastic bowl, thin horizontal bar ruler, water, ray box, plane mirror or concave mirror, screen, source of sound, reflector, hard surface, source of heat, optical pin, glass block and triangular prism. The physics curriculum document also has some activities specified for the teacher and students which are thought would enhance learning. The teacher was expected to “provide rope and slinky to demonstrate transverse and longitudinal waves” under the types of waves, while the students were expected to “use the rope and the slinky to demonstrate transverse and longitudinal waves” (FME, 2009:18). The curriculum also provided for teacher and student activities to investigate the aspect of the properties of waves. The teacher was expected to “set up the ripple tank to produce various waves, demonstrate reflection of sound from: wrist watch by a reflector, reflection of heat energy by a polished surface *and to* lead the class to discuss properties of waves" (FME, 2009:19). Unfortunately, during the class as observed, none of the demonstrative activities of the teacher was carried out during the lesson. The teacher was also not seen leading the class to "discuss" as was prescribed by the curriculum developers. The teacher was observed more of "lecturing" as he listed wave types and their properties and gave explanations with occasional recall questions which some students responded to.

Also the student activities were not carried out. The teacher did not provide any of the required teaching and learning materials for the topic. Students were also not encouraged to express their understanding or contribute in a way of discussion of the content other than responding to some recall questions from the teacher. The situation in this school is one in which the resources for teaching are available but not utilized. This is so as the researcher saw the equipped physics laboratory in the school. The senior physics teacher in the school during the interview also held that his school had enough resources for teaching and demonstration at that level.

> "As far as SC is concerned, we have enough material resources - in terms of text books, we have the textbooks, we have an available library stocked with books where the students… even if you… if there is any particular text you don't have, it's there in the library. In addition to that, we also have an e-library with all the facilities that the students can access for whatever materials they need. Also we have our laboratories, though built over the years and all that, but the fact still remains that we have the apparatus, enough apparatus to demonstrate at this level whatever they are supposed to know" (SCT, 126-132).

One therefore wonders why available resources are not utilized. Although only one teacher was formally observed in class, the researcher during visits to the school observed all three physics teachers teaching physics in class at different times without materials. Bothered by the observations and students' comments on non-usage of laboratory facilities, a follow-up interview was held with the senior physics teacher who attributed the perceived lack of usage of resources by students to the increasing number of students that do not match with the available resources which are not expanded to meet up the demands of the growing school population.

> “The only thing the students can say about the lab is that as we speak to you now, the lab is not as big as it should; because as the number of students is increasing, there is supposed to be a commensurate expansion. But in terms of setting up… having the materials to set up the practical, we have all that it takes. And when we are having especially an external exam like this, WAEC usually have their requirement, the apparatus they need in the school and if we do not have those, we go and buy and put in the lab so as to make sure that those apparatus are there” (SCT, 198-204).

When asked whether the students’ response was possibly as a result of late exposure to laboratory and practical work, the teachers responded:

> “Probably yes… probably that could be what they may be thinking. But there is no way we could expose the students to laboratory work from SS1… you don’t expect… because most of the topics in SS1 would not take them to the lab. It is in 2nd term in SS2 that we actually begin the laboratory work for SS2 and then SS3” (SCT, 209-212).

That was the explanation of the physics teacher. This explanation may not be valid as the class that was observed was an SS2 class and during the 2nd term yet, no teaching material was employed to facilitate learning. At other times during the visits to the school, the SS 3 class was observed being taught without resources. There are possibilities that teacher non-use of available resources may also be a problem of lack of teacher knowledge in usage of the facilities or inadequate teacher quality training in use of resources during training, which has not been investigated in the present study.

The evidence of the classroom observation as reported above does not seem to support the claim of most of the teachers (65%) that they use demonstration method in “every or almost every lesson”. The observation report shows that 6 out of the 7 teachers observed, which represents 85.7% did not utilize any teaching and learning material in their physics lessons even when the curriculum that guides their class activities had suggested the use of those resources to facilitate the understanding of the students. Students did not also have the opportunity to articulate their understanding of the concepts as they were generally not intellectually engaged.

What was observed in the classrooms does not conform to the ideals of the physics curriculum as specified in the document which states in part:

> "In order to stimulate creativity and develop process skills and correct attitudes in students, the course is student-activity oriented with emphasis on experimentation, questioning, discussion and problem solving" (FME, 2009: iii).

Unfortunately, in all the 7 lessons observed, this lofty objective of the curriculum developers to make physics teaching in schools to be "student-activity oriented" with key elements of experimentation, questioning, discussion, and problem solving were completely absent. It may only be assumed that the poor state of resource availability for physics teaching and learning in most of the schools may explain the mix-match between the curriculum provision and its actual implementation.

6.8 Effect of school climate and learning on teaching and learning

The opinion of both students and teachers was sought on how the quality of their school life affects their learning and teaching. Results from both quantitative and qualitative data on the effect of school climate on teaching and learning are presented below.

Students were asked to respond to the question on school climate related factors on a 5-point scale of *Strongly Agree, Agree, Disagree, Strongly Disagree* and *Can't say*. Their responses are presented in Table 6.18 and Figure 6.17.

Table 6.18: Students' responses to school climate related factors affecting their learning

	School Climate related factors (% Responses)					
Responses	Students get along well with physics teacher	Get help if I need from my physics teacher	School environment friendly for learning	My physics classmates are cooperative and friendly	Adults in my school listen to students' concerns	At close of school I look forward to another school day
Strongly Agree	27.9	28.2	27.3	36.4	15.8	46.2
Agree	45.0	48.6	45.5	44.3	48.9	40.6
Disagree	8.6	12.0	13.3	12.1	12.2	5.6
Strongly Disagree	3.6	4.2	9.8	3.6	7.9	3.5
Can't say	15.0	7.0	4.2	3.6	15.1	4.2

The result of students' response to issues that are related to school climate as presented in Table 6.18 indicates that 72.9% of students are of the opinion that 'students get along well with physics teachers' in their schools (strongly agree and agree responses are here considered together). 76.8% of the students expressed that they get help from the physics teachers when they need any, while 64.7% agreed that adults in their schools listen to students' concerns. Adults in this consideration include both teaching and non-teaching staff with whom the students daily interact possibly as lab attendants, library staff, cleaners, etc. in a friendly and welcoming school learning environment. The indication from these 3 elements of the school climate is that students are happy and get necessary learning support from their physics teachers and other members of staff within the school that in one way or the other have dealings with them as regards their life in the school.

On general school environment related factors that have to do with fellow students, 72.8% (both strongly agree and agree) of students were of the opinion that their school environment was friendly for learning. 80.7% of the student respondents said "My physics classmates are cooperative and friendly", while 86.8% of the students were of the opinion that "At close of school I look forward to another school day". These elements of the school climate are indicative that most students are happy to be school and that there was a reasonable level of cooperation among students in a friendly atmosphere that supports teaching and learning.

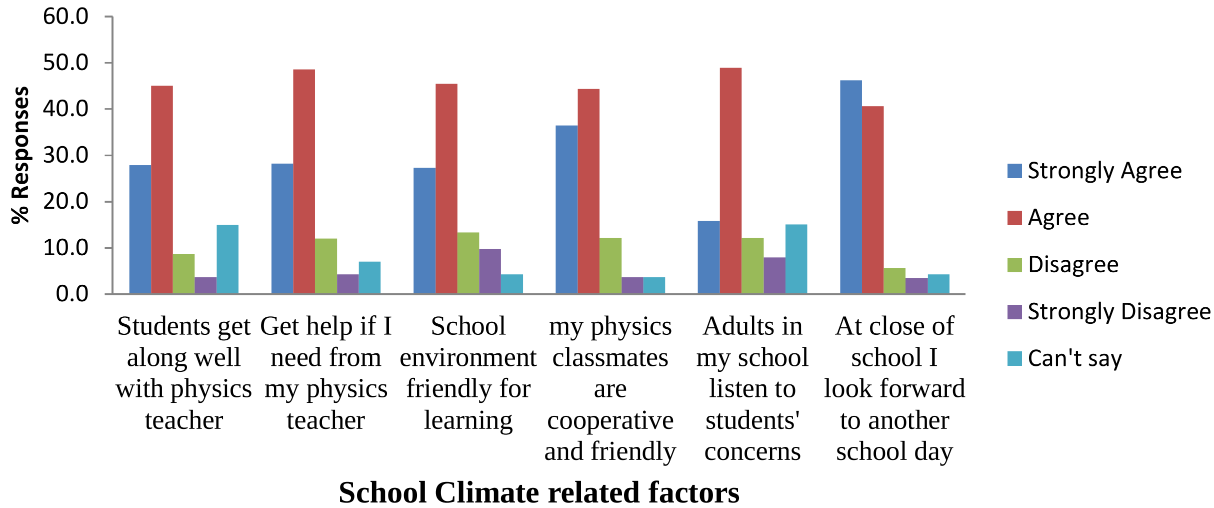


Figure 6.17: Students' responses on school climate factors

The opinion of teachers was sought on the effect of school climate related factors on teaching and learning in their schools. Some elements of school climate were listed and teachers were asked to respond to the question: "In your school, to what extent is the learning of students hindered by the following…" on a 4-point scale of 'A lot', 'To some extent', Very little' and 'Not at all'. The result of the analysis of the responses from the teachers is presented in Table 6.19 and Figure 6.18.

The result reveals that 41.7% of physics teachers were of the opinion that students' lack of respect for teachers hinders teaching and learning 'a lot'. 33.3% of teachers were also of the opinion that 'disruption of classes by students' hinders the learning of students 'a lot', while 50% of the teachers indicated that students' use of alcohol or illegal drugs affects the smooth running of school activities in the school. 58.3% were of the opinion that 'bullying of students' in school hinders the learning of students. On the effect of 'poor student-teacher relationships', only 8.3% of teachers agree that it hinders effective teaching and learning 'a lot'. However, as much as 41.7% of the teachers agree that it hinders students' learning 'to some extent'.

Table 6.19: Teachers' responses to school climate related factors affecting teaching and learning

	School Climate related factors (% Responses)				
Responses	Lack of Respect for teachers	Disruption of classes by students	use of alcohol or illegal drugs	bullying of students	Poor student-teacher relationships
A lot	41.7	33.3	50.0	58.3	8.3
To some extent	8	25.0	0.0	16.7	41.7
Very little	50	25.0	16.7	8.3	33.3
Not at all	0	16.7	33.3	16.7	16.7

The opinion of teachers on school climate factors as presented above would suggest that their school environments were not friendly and conducive for teaching and learning. This is however contrary to the opinion as expressed by the students. Interestingly, both students and teachers seem to agree that they enjoy a fairly good working relationship in school with only 8.3% of teachers indicating that poor student-teacher relationship affected students' learning 'a lot' and 72.9% of students agreeing that they 'get along well with their physics teacher'.

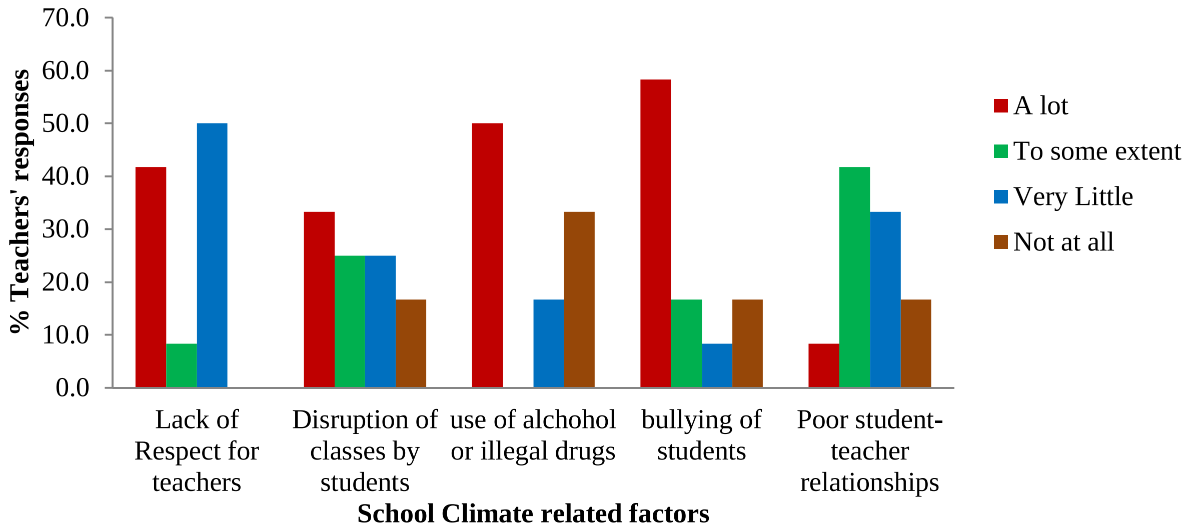


Figure 6.18: Teachers' responses on school climate related factors

Some qualitative data from the interviews also threw some light on the classroom climate of physics lessons in the participating schools in the study. For instance, on the question about their interactions in physics lessons some of the students expressed a friendly working relationship both with their peers and the physics teacher consistent with the quantitative data.

> "some of the students are afraid to ask the teacher in the class they do meet one on one with their fellow colleague and when heir colleague explain it will be better than when the teacher taught them, and some of them that also know it, when they are confused in a particular place, they will go to the teacher's staff room because the teacher always tell us that whenever we are confused in physics that we should meet him that he is going to teach us on how we are going to go on that place, so we also meet the teacher and the teacher correct us" (A2P/5, 261-267).

The above expression suggests that students work cooperatively in a friendly atmosphere and also have teachers who are friendly and supportive to the learning. The expression 'some students are afraid to ask' may not imply a poor student-teacher relationship, but possibly the lack of self-confidence and public speaking in good English which may be a problem of some students especially in the rural areas. This assumption is premised on the fact that the same student also stated that those students who 'know it' go to the teacher and that the teacher was always happy to assist and support their learning even outside the normal class periods.

On the school environment and its effect on teaching and learning, some students expressed that the poor infrastructure in the school and general poor environment do not promote effective learning.

> "well, all that I want to say is that the place that we learn is so … in our class, the place is so hot that you can't even concentrate - as you see I'm wearing tie, wearing jacket, wearing singlet, wearing shirt, long sleeve, so everywhere is hot, you can't even understand what they are teaching so that is a problem" (A2P/5, 354-357).

The view point of this student is that the poor state of infrastructure in the school – in this case, lack of cooling systems and electricity to power them affect their concentration and may not encourage effective teaching and learning. It is possible that under this scenario as described by this student, some less motivated students and teachers may find reasons to be truant in schools. The possible effect of the school physical environment on both enrolment and learning is probably captured in the expression of another student:

> "The environment is not nice and the environment may be harmful to students… so we have to as in beg the government to help us out in this kind of environment. And… some of the people that… as in we don't have many students is all about the environment because if the environment is so bushy… bushy, some of our parents will be afraid to send the students…em… the children to this school to come and learn because of the environment" (D1P/3, 224-229).

This student has attributed the low students' enrolment in the school to the poor school environment. It may be important to mention here that the researcher observed students' truancy as during his visit for data collection, the teacher had to send words across through those present in class at the time to assemble the students at a much later date both for the interview and the PAT.

6.9 Teachers professional development and teacher effectiveness

Teachers are important resource in the teaching and learning enterprise. According to Hanushek (2011), to influence students' attainment, teachers are the most important factors in the school system than any other measured variable of schools. Teachers' professional development and competence is related to the quality of instruction as one of the 9 productive factors of Walberg's educational theory. It is therefore very important that there are not just teachers in the classrooms, but that the teachers in the classrooms are those who are very highly qualified and are "worth their salt". There is research evidence that associates effectiveness with teacher-professional development. In the view of Wei, Darling-Hammond, Andree, Richardson & Orphanos (2009), "improving professional learning for educators is a crucial step in transforming schools and improving academic attainment". According to them, "to accomplish this, schools - with the support of school systems and state departments of education - need to make sure that professional learning is planned and organized to engage all teachers regularly and to benefit all students" (p. ii). This position assumes that if teachers are effectively trained professionally, then students they teach would 'benefit' from such quality of training in way of effective learning and better academic attainments. The National Center for Learning Disabilities, NCLD (2010), opined that the teachers' "understanding and mastery of pedagogy and subject matter, together with their ability to apply effective teaching practices, are the keys to learning for all students" (p.1). It further stated that "teacher performance and effectiveness must be measured with valid and reliable assessments of teacher knowledge and classroom performance that are linked to student learning" (p.2). It is therefore important that teachers receive good support from their employers for good classroom teaching practices that would ensure effective learning of students especially in science classrooms.

Considering the relevance of teacher professional development, the Questionnaire for Physics Teachers (QPT) contained an item that sought to capture teachers' participation in professional development activities in the past two years in the areas of physics content, physics pedagogy/instruction, physics curriculum, integrating Information Technology into physics, improving students' critical thinking or inquiry skills and physics assessment. The result of teachers' response is presented below.

Table 6.20: Teachers' participation in professional development activities in the past 2 years

	Areas of Teachers Participation in Professional Development					
Response	PD in Physics content	PD in Physics pedagogy/ instruction	PD in Physics curriculum	PD in Integrating information technology into physics	PD in Improving students' critical thinking or inquiry skills	PD in physics assessment
Yes	6 (42.9)	5 (35.7)	5 (38.5)	4 (28.6)	7 (50.0)	5 (38.5)
No	8 (57.1)	9 (64.3)	8 (61.5)	10 (71.4)	7 (50.0)	8 (61.5)
Total	14 (100)	14 (100)	13 (100)	14 (100)	14 (100)	13 (100)

Table 6.20 above shows the participation of teachers in continuing professional development activities in the past 2 years. The Table reveals that apart from professional development activities in 'improving students' critical thinking or inquiry skills' where 50% of teachers say they have attended in the last 2 years, most teachers do not attend CPD trainings or activities in the other areas as reflected in the Table with less than 50% of the teachers participating in professional development activities in those areas. The worst is in the area of 'integrating information technology into physics' with only 28.6% of teachers saying they have attended CPD activities in that area. Both teachers and students have expressed the lack of computer facilities and utilization in their physics lessons. For instance, 92.9% (See Table 6.8) of teachers say they "never use computer as a teaching or instructional material". Also, 98% of the students revealed that they "never" use DVDs and videos in physics lessons. Similarly, 91.7% of students said they never use computer simulations on physics in their lessons in school while 94.5% said they have never watched their teacher demonstrate physics on a computer (See Table 6.12).

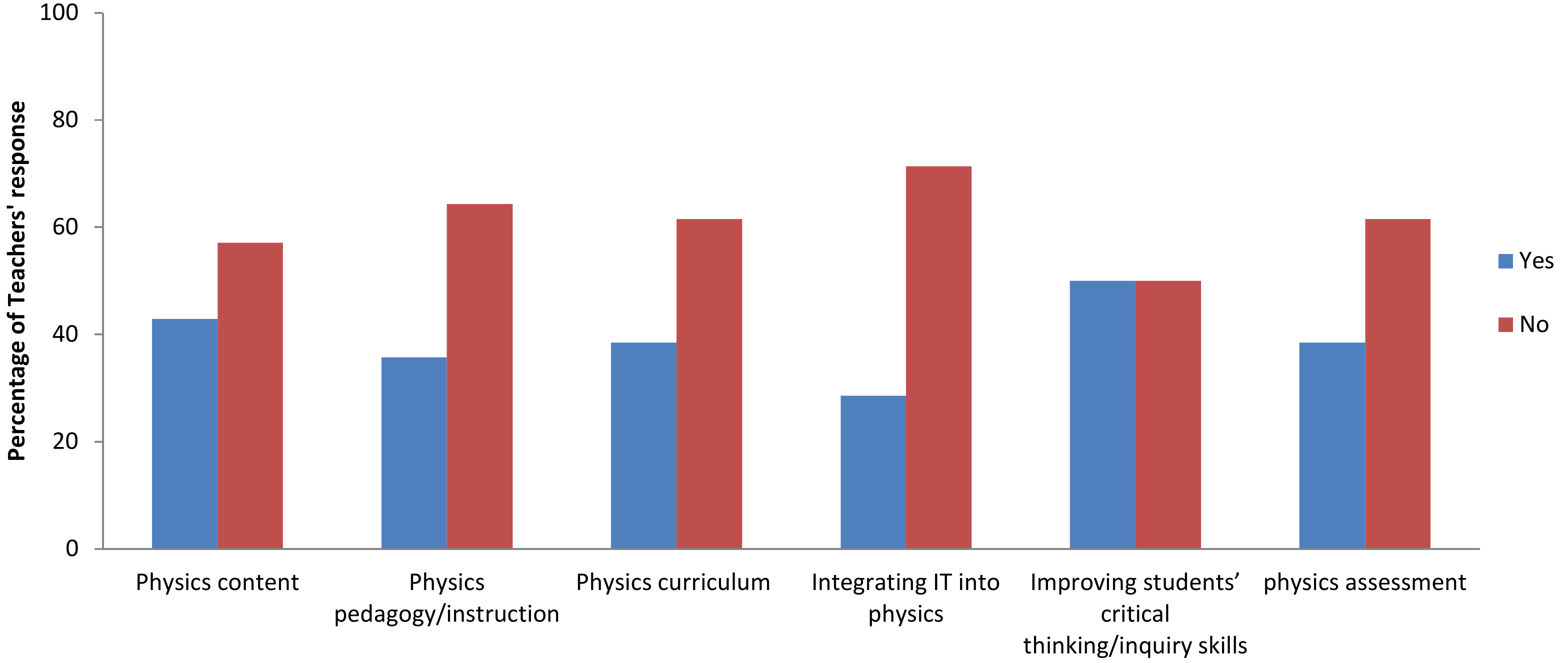


Figure 6.19: Areas of teachers' participation in Professional Development

The poor attendance of physics teachers to professional development activities as shown above may have been as a result of the attitude and modus operandi of school administrators and managers on the organization of such programmes. Responding to a question on teachers' continuous professional development as to whether or not physics teachers have enough training and retraining activities to enhance their effectiveness, the physics teacher in School B1 had this to say:

> "Yes, I, most times I take it upon myself to enrol to upgrade my knowledge in teaching of physics especially the sciences. I take out part-time studies. Recently I just finished a programme with Niger Delta University to do my PG in Technical Education so as to give me more knowledge and more ground on how to teach the technical sciences…the Ministry do organise refresher courses, but not for all science teachers per say, they normally call the most senior schools… at times, in a region like this, they can just call for 2 or 3 teachers and which does not augur well for all the other schools. If the 2 or 3 teachers from the zone go, they will not come back to impart the same knowledge which they have acquired to the other teachers which were not privileged to be part of that workshop, so it is not a welcome idea" (B1T, 143-146, 151-156).

It is possible that the level of attendance of teachers to professional development programmes and activities, may improve if school authorities realize the need to fund the training and re-training of their teachers especially in areas of current research findings and proven innovative science teaching and learning approaches, which the teachers may employ for effective classroom teaching and learning activities. All science teachers are supposed to gain from such training programmes so that students they teach would also ultimately not be disadvantaged and would benefit from the wealth of experience, knowledge and skills teachers would gain from such professional development activities.

Chapter 7: Discussion of findings

7.1 Introduction

The findings of the study and answers to research questions have been systematically presented in the previous chapters - 4, 5 and 6. Chapter 4 particularly provided contextual data and basis for the schools used in the research while in chapter 5, both quantitative and qualitative data and of students' enrolment and attainment in the senior secondary school physics were presented. In chapter 6, findings on the availability and utilization of resources for the teaching and learning of physics were reported. This chapter deals with the discussion of key findings from the study. The discussion of findings is discussed in this chapter under 9 main sections. In section 7.2, the chapter addresses the first sub research question on students' enrolment for physics in the senior secondary school certificate examination. The pattern of attainment in the certificate examination in relation to the second sub research question is discussed in section 7.3. The relationship of teacher qualification and experience to students' enrolment and attainment is discussed in section 7.4, while section 7.5 discusses the availability of resources for the teaching and learning of physics in secondary schools in Nigeria. Section 7.6 deals with the utilization of physics resources for teaching and learning. In section 7.7, the effect of availability and utilization of resources on physics students' enrolment and attainment in secondary schools is discussed. The teaching strategies and classroom interactions adopted by physics teachers are discussed in section 7.8 while in section 7.9, the influence of teachers' teaching strategies on physics students' enrolment and attainment is discussed. Finally, section 7.10 presents discussion on school climate and its effect on teaching and learning.

7.2 Physics enrolment in post compulsory secondary classes

Discussion in this section is guided by the sub-research question:

What is the level of enrolment for physics in the Senior Secondary Certificate Examination?

The enrolment data of students in physics, chemistry and biology for 10 years (2004-2013) in Nigeria has been shown in chapter 1, while that for Rivers State was presented in chapter 5. In Nigeria, students make choice of subjects at the beginning of the post-compulsory classes of their secondary education. In the 3rd year, which is also the final year of secondary education, students enrol for the senior secondary school certificate examination, SSCE.

On students' enrolment for physics in the senior secondary certificate examination in Nigeria, the finding of this study suggests that there is a low level of students' enrolment for physics after the compulsory years of secondary education in Nigeria. Also, that students prefer to choose biology to physics as a result of the nature of physics, perceived lack of relevance of most physics concepts to everyday life, perceived difficulty of physics compared to biology and the practical nature of biology. Findings from the study also suggest that students and teachers were of the opinion that the low popularity of physics among students in Nigeria is as a result of 'lack of qualified physics teachers', 'teaching physics by theory without practical work', 'lack of laboratory equipment for demonstration/experimentation' and 'lack of guidance/counseling services'. These findings are discussed in the paragraphs that follow.

The data as shown in Table 1(a) reveals that nationally, an average of 33.4% of students enrolled for physics at the senior secondary school certificate level. Chemistry had an average enrolment of 35.1% while biology had as high as 99.4% enrolment on the average. The trend of enrolment is not different in Rivers State as shown in Table 5.1 with physics having an average enrolment of 43.8%, chemistry, 44.7% and biology, 99.0%. The results also show a near consistent pattern of enrolment of students for the sciences in Nigeria. The number of physics students relative to the total number of students in the SS3 class used for the study in the participating schools is presented on Table 5.2 and shows that an average of 33.3% of the total number of students enrolled for physics after the post compulsory stage of secondary education. The science college was not used for that calculation as all students in the school compulsorily choose physics.

As may have been observed, nearly 100% of students enrol for biology both nationally and in the state. The National policy on Education in Nigeria before that of 2013, made it compulsory for students to choose at least one science subject: "Every student shall take all the six (6) core subjects in group A …" (FRN, 2004: 21). The policy went further to list subjects in the "core" classification as English Language, Mathematics, A major Nigerian Language, **one of Biology, Chemistry, Physics or Health Science**, one of Literature-in-English, History, Geography or Religious Studies and a vocational subject. Although the National Policy on

Education for Nigeria did not specifically justify the compulsion of students' choice of a science subject, it is thought by the researcher that, that is the government's effort to encourage scientific literacy among its populace.

On the preference of students for biology to physics, students involved in this study have attributed the reason to the nature of physics, perceived lack of relevance of most physics concepts to everyday life, perceived difficulty of physics compared to biology and the practical nature of biology. These findings are consistent with the findings of some other researchers as evidenced in literature that explain why students prefer biology to physics or chemistry when they are required to make a choice. For instance Williams, Stanisstreet, Spall, Boyes & Dickson (2003) reported that students perceive biology to be an interesting subject while physics is perceived as boring while Erinosho (2013) concluded that the reason why students prefer biology to physics at the post compulsory stage of secondary education is as a result of the more abstract nature of physics. Also, Lyons (2006) examined the declining enrolment in physics and chemistry in Australia and reported that must students perceived Junior high school science as irrelevant, difficult and uninteresting and so were reluctant to choose physics and chemistry. The link of students' interest and perception of the difficulty level of a subject to the choices they make at the post compulsory stage of education is significant as studies have shown that what students find interesting and understandable, they learn best and tend to choose for further studies (Erinosho, 2013, Williams *et al.*, 2003).

Also, the report of this study on the low enrolment of students for physics in post-compulsory secondary education in Nigeria agrees with the conclusions of some earlier researchers in Nigeria. For instance, Aina & Akintunde (2013) concluded that there was low choice of physics among secondary school students in Nigeria. Bukunola & Idowu (2012), Olufunke (2012) and Akanbi (2003) all concluded that when students have the option to choose their subjects, they drop physics for other science subjects.

The problem of low enrolment of students in physics after the years of compulsory secondary education seems not to be peculiar to Nigeria. In Kenya, Wambugu & Changeiywo (2008) and Musasia, Abacha & Biyoyo (2012), for instance, reported that the national enrolment in the final class of secondary education shows physics as the least studied science subject among students. The situation is similar in South Africa as Mundalamo (2006) observed a decreasing number of students who choose physics at the secondary school level.

The issue of low enrolment in physics has also been reported in developed countries of the world (See for instance, Osborne, Simon & Collins, 2003; Smithers & Robinson, 2009; Mullis, Martin, Robitaille & Foy, 2009; Woolnough, 1994; Bennett, Hampden-Thompson & Lubben, 2011). Osborne, Simon & Collins (2003) reported that in England and Wales, physics and chemistry were the two least popular subjects among post-14 students. Barmby & Defty (2006) reported a decline in the number of students choosing physics in England, Wales and Scotland with as much as 30% fall between 1985 and 2003 in Scotland. Sparkes (1995) had much earlier investigated and compared the supply of physics teachers and students' choice and attainment of physics in England and Scotland and reported that more young pupils in Scotland choose physics. Although his study was conducted in 1989 and reported in 1995, he cited OFSTED (1994) and stated that the proportion of students in England studying physics at post-16 had remained the same at about 5%. Also, citing The Scottish Examination Board, SEB (1992) and Croft (1992), he contended that for about 10 years (possibly, up to 1992), the number of young pupils opting to study physics increased from 13 to 17%. The story may have changed after over a decade and half as Smithers & Robinson (2009) agreeing with the earlier submission of Barmby & Defty (2006) reported a 50% decline in the A level physics entries in the UK between 1982 and 2006 and that there was also a decline in the choice of physics in Australia, Republic of Ireland, Finland, New Zealand and Scotland. However, a very recent report from the Office of Qualifications and Examinations Regulation (Ofqual, 2015a) revealed that there has been a consistent noticeable appreciation in the uptake of A level physics by young pupils in England between 2007 and 2014. Also in the United States of America, there are reports of an increasing numbers of physics enrolments among young high school pupils (Smithers & Robinson, 2009; White & Tesfaye, 2011). The situation in Chinese secondary schools also appears cheering with more than 50% of young pupils in year 12 choosing physics after the compulsory classes (Zhu, 2008; Bennett, Hampden-Thompson & Lubben, 2011).

This study also investigated the opinion of both teachers and students on the main school-based factors that affect the enrolment and teaching of physics in secondary schools in Nigeria. The responses of both students and teachers indicate that 'lack of qualified physics teachers', 'teaching physics by theory without practical work', 'lack of laboratory equipment for demonstration/experimentation' and 'lack of guidance/counselling services' were the main school-based factors that discourage students from choosing physics after the post compulsory school classes (see sections 6.2, 6.6, Table 6.13 and Fig. 6.13). The finding of this present study agrees with that of Aina & Akanbi (2013) and Erinosho (2013) who investigated the problem of students' low enrolment in physics and reported that lack of qualified teachers and instructional materials were some reasons why the enrolment of students for physics was low in Nigeria. The finding of this study is also consistent with that of Semela (2010) who investigated the factors the influence the choice of physics in Ethiopia and reported that poor teacher qualification and pedagogical content knowledge were some reasons cited by students why few students choose physics. Williams, Stanisstreet, Spall, Boyes & Dickson (2003) investigated why few year 10 secondary school pupils in the UK are interested more in biology than in physics. Their investigation revealed that most students opt out of physics in the post-compulsory classes because they generally perceive physics to be difficult and irrelevant. Similar findings were also reported in Netherlands when Stokking (2000) reported that perceived subject relevance and appreciation where predicting factors for students' choice of physics in Dutch secondary schools. Although the perception of difficulty and irrelevance of the subject by students is not overtly a school-based factor, teachers have a role in presenting the content of physics with applications and illustrations relevant to the everyday experiences of learners in the environment. Williams *et al*. (2003) suggested that to encourage more participation in physics, teachers should "extend the way in which *they* exemplify less popular areas of physics by reference to the more popular" (p 327). For instance, their study also reported topics in physics that students find boring such as 'forces' and others that the students find interesting such as 'space'. Explaining further on ways of presenting physics content as relevant and interesting to students, Williams, *et al*. (2003) suggested that "perhaps more could be made of a discussion of the forces applied to a spacecraft during take-off and in space, and the storage and use of energy sufficient for space travel" (p.327). Williams and his associates possibly had pupils in developed countries in mind who may be assumed to be familiar with simulations and video clips of space and space craft. This ingenuity of seeking for ways of illustrating physics concepts with familiar experiences of the learners is what is desired of physics and science teachers to inspire students' interest in the subject.

From the foregoing, it is therefore important to identify policies and strategies engaged in by government and concerned agencies on the popularization of not only physics but generally science education among the student populace so as to ensure a more science literate society. In this regard, the model in China where physics is made compulsory up to year 11with a specialized 'physics for art' course (see Zhu, 2008) for the non-science students is worthy of emulation. It is also worth mentioning that Chinese countries have been top in both mathematics and science in TIMSS and PISA conducted by the OECD on 65 countries that make up about 90% of the world economies (see Kelly, Xie, Nord, Jenkins, Chan, & Kastberg, 2013; NCES, 2013). Another model that may also be considered for possible emulation and trial is the 'physics decadal plan' proposed by the Australian Academy of Science for the Australian government (see Australian Academy of Science, 2012). The plan was a strategic vision for ten years from 2012 to 2021 with the goal of increasing the physics community in Australia and achieving a physics literate work force that is intended to be achieved by amongst others, focusing on the recruitment of suitably qualified physics teachers in all schools, seeking ways of attracting and retaining pupils into physics at all levels of education and the use of physics evidence base to inform the development of relevant policies in the country. It is hoped that if students are encouraged to take up physics not only at the secondary or college levels but also at graduate and post graduate levels with appropriate motivation and encouragement, the much needed quality physics teachers would be readily supplied to the school system; they would further inspire and motivate young pupils to choose the subject at the point of optional subject selection. Although the successes or otherwise of the plan could not be obtained presently in literature, there are possibilities that the implementation of such a policy could drive the uptake of physics among students and increase physics literacy among the populace.

7.3 Pattern of attainment of physics students in the senior secondary certificate examination

The discussion in this section on the pattern of attainment of physics students is guided by the second sub research question:

> What is the pattern of attainment of physics students who enrolled in the Senior Secondary Certificate Examination (SSCE)?

The findings of this study suggest that there has not been a consistent pattern in the attainment of students enrolled for physics and generally, the core science subjects in Nigeria and that the average attainment level of students enrolled for senior secondary school certificate examinations in Rivers State was higher than that of the national in all 3 core science subjects. The findings of the study also showed that although fewer students enrolled for physics than chemistry and biology, physics students on the average obtained better grades in the SSCE. On attainment in the senior secondary school certificate examinations, the results show that students' attainments in all 3 core science subjects were fair on the average. However, the result of students in the Physics Attainment Test, PAT shows a very poor performance. These findings are discussed hereunder.

The summary of students' percentage A-C grade attainment in physics, chemistry and biology at the senior secondary certificate examinations for Nigeria and Rivers State from 2004 to 2013 is shown in Tables 1b and 5.3. A look at these tables and Figure 5.3 shows that there is no consistent trend or pattern in attainment in all the core science subjects. The record of erratic attainments with unpredictable peaks and dips may be the result of lack of a deliberate and consistent government policy, interventions or strategy that is aimed at addressing the age long malady of poor attainment and participation of young pupils in the sciences in Nigeria. Marguerite Clarke, Senior Education Specialist to the World Bank lamented that the quality of learning outcomes in developing countries is poor and that only few of the countries methodically examine progress in their students' learning outcomes by participating in international assessments or assessing their students' attainment and that this makes it difficult for governments to determine the effectiveness of their policies or improve students' learning outcomes (Greaney & Kellaghan, 2008).

In Nigeria, although several studies in the literature have reported the problem of poor performance in the sciences among secondary school students, there are no reports or evidence of governments' concerted efforts to reverse the trend of poor attainment. The budgetary allocation to education in the country has continued to be far less than the minimum 26% of the total budget as recommended by UNESCO. The education budget for instance for 2013, 2014 and 2015 were only 8.7%, 10.7% and 8.9% respectively (FRN, 2016). In the UK in comparison, the governments' huge investment and involvement together with the research activities of other organizations like the Wellcome Trust among others in encouraging greater participation of school students in Science, Technology, Engineering and Mathematics, STEM (Wynarczyk & Hale, 2009) may have contributed to the increased enrolment in the STEM subjects including physics in recent times (Ofqual, 2015a) with a very high record of attainment in physics (over 90% A*-C grade) since 2012 (Science Learning Network, 2014).

A clear revelation from the tables 1(b) and 5.3 showing the National and Rivers State students' SSCE attainment in the science subjects for the period 2004-2013 is that the average percentage A-C grade attainments in Rivers State (60.5, 60.1 and 56.0) are higher than the national averages (50.8, 47.2 and 37.7) in physics, chemistry and biology respectively. This may not be surprising as Rivers State is classified among the 'educationally advantaged' states in Nigeria where higher attainment would normally be expected. This is consistent with the position of Lupton (2004) that "both educational attainment and school quality are typically lower in disadvantaged areas than others" (p. iii). What this has revealed is that students' attainment in Rivers State in the science subjects – physics, chemistry and biology, may not be as bad as has been reported in the literature, if judged from records of SSCE performance where the state averages are seen to be higher than the national. The finding of this study based on the SSCE records of students' attainment in science subjects in Rivers State is therefore opposed to the earlier position of Obomanu & Adaramola (2011) who had reported 'underattainment' of students in the science subjects in the Rivers State. Their position may have been informed by the use of the national results and not results that are specifically for students that are enrolled in Rivers State. A concern about this position of a 'fair' and not 'poor attainment' of science students in Rivers State is the issue of the reliability and credibility of the conduct of the examination by the West African Examination Council as has been argued previously (see section 5.4). The performance of physics students in the PAT, conducted by the researcher under strict examination conditions was relatively poor compared to the SSCE result and, this call for a consideration of a proper assessment of students' attainment for a more effective planning and intervention by government. According to Greaney & Kellaghan (2008), it is important that countries develop their assessment capacities that can be used to describe the learning attainments in important subject areas and subsets of the schooling population such as boys and girls, public and private school pupils and urban and rural areas which could provide information for government to make policies and decisions for functional educational system.

Another interesting revelation is that students obtain better grades in physics than in chemistry and biology. Although more students enrol in biology, the record of SSCE results shows that of the 3 core science subjects, students perform worse in biology. The poor performance of students in biology may be as a result of the mass enrolment for the subject by students to satisfy the National policy that every student must choose at least one science subject and students' preference for biology to physics or chemistry (see Erinosho, 2013) even when they have little aptitude and interest in the subject and more so, when biology as a subject may not be relevant to their future career aspirations. This assertion is consistent with earlier findings of Williams, *et al.* (2003) and Erinosho (2013) that students tend to achieve better grades in subjects they find interesting. The relatively lower attainment in biology may also be attributed to students who may have the interest in the subject but are not academically able to achieve good grades. This assertion agrees with the finding of Steinkamp & Maehr (1983) that students' attainments in the sciences have stronger correlations with their cognitive abilities than with their affection for the subject and particularly, Lawson, Banks & Logvin (2007) investigating the effect of factors on attainment in college biology reported that students' reasoning ability have very high correlation with their attainment in the subject. Despite the explanations for the poor performance of students in biology and the sciences generally, it is hoped that if the right teaching personnel with adequate qualification in the subjects are engaged in the teaching, with basic teaching and learning resources provided for all schools in Nigeria, there would be an appreciable attainment of students in the sciences.

The SSCE results from the schools used for the study do not seem to deviate significantly from the assumption used in the selection of the local government areas and schools for the study. For instance, the mean percentage A-C grade passes of schools selected for the study in Zone1, classified as one of the low performing areas from the record of results obtained from the West African Examinations Council, WAEC is 44.7% while the local governments' average was 42.9%. Also the mean percentage A-C grade passes of schools selected for the study in Zone 2, classified as one of the high performing areas based on the WAEC classification is 55.8% while the average for the local government area was 65.4%. Although these averages look a little fair, researchers are of the opinion that the performance of students in the sciences at the secondary school level generally in Nigeria has been unimpressive (Obomanu & Adaramola, 2011; Arokoyu & Aderonmu, 2013; Christian, 2014). Poor attainment in particularly physics has also been reported in Ghana (Ossei-Anto & Ampiah, 2014), South Africa (Gaigher, Rogan & Braum, 2006; SAIRR, 2013) and the United States of America (Bao et al., 2009; American Physical Society, 2010).

Again, the scores as shown in tables 1(b) and 5.15 (for the PAT attainments) reveal that the attainment level of students in physics is low in Nigeria. As was explained in section 3.4.4, the PAT was introduced partly to ascertain the attainment level of the students in physics independently and was conducted under strict examination conditions. Although both the SSCE and the PAT could be said to test the same construct of physics knowledge, the two are not necessarily compared in the sense of equating the tests or judging the two as tests of concordance (see Dorans, 2008). The scores are simply compared to have an understanding of physics attainment level of students in the study area considering the creditability challenges of the conduct of the SSCE (see for instance, WAEC, 2009; Tambawal, 2013). Thus, a mere comparison of the SSCE and PAT scores for the schools shows that students' scores are much lower in the PAT than in the SSCE (see Table 5.15 and Fig.5.4). As earlier presented, possible explanations for this difference could be that students placed high stake on the SSCE being a certification examination, and one that is a pre-requisite for further studies and job placements and so may have adequately prepared for the examination unlike the PAT which does not account for their assessment. There are some research evidence in the literature that suggest that some level of attainment has been associated with adequate examination preparation and hard work (Briggs, 2009; Howe & Berenson, 2003). Students may also generally derive more interest towards the SSCE than the PAT in relation to the relevance of the examinations to their future career and academic pursuits. According to Williams et al, (2003), students do better when they develop interest in what they do. Secondly, the level of difficulty for the PAT may have been higher than the SSCE as students in all schools scored much lower in the PAT than in the SSCE. Although the questions were validated by physics teachers as adequate for the age and class selected for the study, the low scores obtained by most of the students in the PAT may be indicative that the questions in the test are more difficult than the SSCE questions. Thirdly, the conduct of the PAT under strict examination conditions together with the low stake on the test relative to the SSCE may also have resulted in the poor attainment of students in the test. What is however important on the outcomes either in the SSCE or the PAT is that students' performance in physics is not impressive and something needs to be done to better the attainment of students in the subject. In the sections that follow, the school-based factors that may have affected physics students' enrolment and attainment in Nigeria will be discussed.

7.4 The relationship between teacher qualification and experience with students' enrolment and attainment

Discussion of results in this section on the effect of teacher qualification and experience on students' enrolment and attainment is guided by the research question:

> How do teacher qualification and experience relate to the enrolment and attainment of students in physics?

Results from quantitative data from the present study suggest that teacher qualification and teaching experience do not significantly correlate with the enrolment of students for physics. However, data from the interviews involving non-physics students, physics students and teachers suggests that students' interests and enrolment in physics may have been affected by some school-based factors such as the availability of qualified physics teachers, resources for teaching and learning physics including adequate laboratories, and lack of regular practical activities in physics lessons. On students' attainment and teacher qualification and experience, the study reveals a significant correlation between students' scores in the Physics Attainment Test and teacher qualification with no significant correlation between students' attainment and teachers' teaching experience. On teachers' participation in continuing professional development to enhance their skills and classroom experience, the study suggests that most physics teachers in Nigeria do not participate in regular CPD activities. These findings have been discussed in details in the next paragraphs of the section.

There is good evidence in literature that suggests that students' enrolment in school subjects is influenced by certain factors such as quality and quantity of instruction, classroom psychological climate, student' related factors such as ability and some home or family related factors such as economic and social comfort (Dick & Rallis, 1991; Blickenstaff ; 2006; Jaiyeoba & Atanda, 2011; Institute of Physics, 2012). In this study, a correlation of students' enrolment in physics with teacher factors shows that teacher qualification and teachers' years of teaching experience do not significantly correlate with the enrolment of students for physics (see Table 6.3). The result however shows a positive low correlation ($r = 0.346$) between students' enrolment in physics and teacher qualification with a very low positive correlation between students' enrolment and teachers' teaching experience. Also in terms of gender, no significant correlations were found between the enrolment of male and female students in physics with teacher factors (Tables 6.3(a) and (b)).

The finding of this study that show no correlation between gender and teacher factors does not agree with those of Blickenstaff (2006) and Institute of Physics, (2012) who reported that girls are discouraged from continuing with physics post-16 as a result of their unpleasant experiences in science and physics lessons in previous classes. Also, the finding of the present study that teachers' qualification and experience do not significantly correlate with students' physics enrolment in secondary schools, do not agree with those of Dick & Rallis (1991), Jaiyeoba & Atanda (2011), Aina & Akanbi (2013) and Erinosho (2013) who reported that science students' enrolment is influenced by lack of qualified teachers and instructional materials in schools. The difference in results from quantitative data of the present study and previous studies as stated above may be explained by the small sample size that was used for the analysis. The percentage of total students in the final class of the senior secondary in only 8 schools was used for this study. That number of schools is really a small sample for quantitative analysis and there are possibilities that the recruitment of a greater number of schools might affect the result so obtained especially for quantitative analysis. This view agrees with the assertion of Biau, Kerneis & Porcher (2008) that variability in sampling size has the likelihood of yielding different results and as Creswell (2012) put it, "the larger the sample, the less the potential error is that the sample will be different from the population" (p. 146). It is however worth mentioning that although the correlations were not statistically significant, students' enrolment positively correlated with teacher qualification, years of teaching experience and resource utilization. As explained in previous chapters, this study adopted a mixed methods approach to research with 16 interviews in all for physics teachers and students (both physics and non-physics students in groups) and generated sufficient data for the examination of the research questions. It is common in qualitative research to enhance the accuracy of a study by triangulating among different sources of data (Creswell, 2012; Powney & Watts, 1987). Thus, data from interviews is discussed hereunder on the opinion of students and teachers about some school-based factors that influence students' choice of physics after compulsory secondary education.

Data from the interviews involving non-physics students, physics students and teachers in this study suggests that students' interests and enrolment in physics may have been affected by some school-based factors such as the availability of qualified physics teachers, resources for teaching and learning physics including adequate laboratories, and lack of regular practical activities in physics lessons (see Section 6.2). The findings of this study from the qualitative data are consistent with those of Jaiyeoba & Atanda (2011), Aina & Akanbi (2013) and Erinosho (2013) who reported lack of qualified teachers and instructional materials as some of the reasons for students' low enrolment for physics in Nigerian secondary schools. Similarly, the finding of this study that students' choice of physics was influenced by teacher factors also agree with a similar report by Dick & Rallis (1991) who studied the factors that influence high school students' choice of career in the United States and reported that teachers were an influencing factor in students' choice of science and engineering as careers. Some participants in the interview stated that the lack of practical activities in the teaching of physics was part of the reasons why some students do not choose physics at the point when students choose subjects to continue their secondary education. In addition to the voice of teachers and students, during the classroom observations, 7 physics lessons were observed and none of the teachers deployed adequate and relevant resources as prescribed by the curriculum in their lessons (see Section 6.7.1and Table 6.14). This theoretical handling of the subject by teachers may have presented physics as abstract, boring and not relevant to everyday experience as posited by some participants in the interviews.

On students' attainment and teacher qualification and experience, the result of this study shows a statistically significant correlation between students' scores in the Physics Attainment Test and teacher qualification ($r = 0.552$, $p < 0.01$, $n = 171$) and no significant correlation between students' attainment and teachers' years of teaching experience ($r = 0.131$, $p > 0.05$, $n = 171$). Also in terms of gender, there were significant correlations for both boys' and girls' scores in PAT with teacher qualification and very weak positive correlation that were not statistically significant with teacher experience (Tables 6.2(a) and (b)). The finding that students' attainment does not correlate with years of teaching experience does not agree with those reported by Rice (2010) and Ilie, Jerrim & Vignoles (2016) that more experienced teachers who are not in the early years of the profession and have spent more time on teaching tasks with variety of teaching and assessment strategies were found to be more effective. However, Rice (2010) further reported that "the impact of experience is strongest during the first few years of teaching; after that, marginal returns diminish" (p.1). The implication here is that teachers' effectiveness increases with the years of teaching, up to some point which Rice (2010) did not define; but that as teachers gather more and more years in the classroom, the marginal gain in their effectiveness diminishes – possibly, as these well experienced teachers get absorbed into some school leadership and administrative roles. Some of the more experienced teachers in my study were also involved in many administrative functions for instance, vice principal, which may have affected their classroom effectiveness. In one of my visits to a school where the senior physics teacher was the vice principal, the class rep came to remind him of the physics class at that time. He asked the students the last topic that was treated and handed over the note of the next topic for the students to copy during the period as he could not attend the class. However, the finding of the present study on the significant effect of teacher quality on students' attainment is consistent with those of Sparkes (1995), Darling-Hammond (2000) Nye, Konstantopoulos & Hedges (2004), Rivkin, Hanushek & Kain (2005), Brok, Brekelmans & Wubbels (2004) and Clotfelter, Ladd & Vogdor (2007). In fact, Sparkes (1995) maintained that pupils in Scotland performed well in physics because they were taught by qualified physics teachers. Also, Nye, Konstantopoulos & Hedges (2004), for instance, investigated the effect of teacher quality pupils' attainment and reported a significant teacher effects on pupils' mathematics and reading attainment. Similarly, Darling-Hammond (2000) examined the effect of teacher quality on student attainment using data from 50 state surveys in America and concluded that both qualitative and quantitative data suggest a good relationship between the quality of teachers and student attainment. Clotfelter, Ladd & Vigdor (2007) conducted a statewide study in North Carolina of 4 cohorts on the end-of-course tests in 5 subjects – Algebra; Economic, Legal and Political systems; English; Geometry and Biology taken by 9th and 10th grade students. They reported that "We find compelling evidence that teacher credentials affect student attainment in systematic ways and that the magnitudes are large enough to be policy relevant" (p.2).

Another area to look at on the quality of the teacher is in those characteristics in the teacher that could influence and support students' learning and attainment. According to Mcber (2000), the teacher's skills and professional characteristics significantly contribute to the students' attainment. Some of these teaching skills are developed and nurtured with the attendance of teacher training and retraining programmes by professional bodies and institutions. The finding of the present study on teachers' participation in professional development activities suggests that most physics teachers in Nigeria do not participate in regular CPD activities in the areas of physics content knowledge, pedagogy and instruction, physics curriculum, integrating ICT into physics, improving students' critical thinking or inquiry skills and physics assessment (see Table 6.17). The finding of the present study on teachers' participation in CPD activities does not agree with those of UNICEF (2007) and Ememe, Aitokhueehi, Jegede & Ojo-Ajibare (2013) who revealed that Nigerian teachers reported that they have reasonable access to opportunities of professional development. A possible explanation for difference in the results of the present study with the country report by UNICEF (2007) and that of Ememe, Aitokhueehi, Jegede & Ojo-Ajibare (2013) could be that whereas the present study focused on physics teachers, the other studies generally involved all teachers in both primary and secondary schools. Also, whereas the present study highlighted specific areas of professional development of physics teachers, the other studies merely investigated teachers' participation in general professional development activities. For instance, Ememe, Aitokhueehi, Jegede & Ojo-Ajibare (2013) asked teachers on a 5-point scale if they have attended training in the last one, two or five years. The difference in the outcomes may also arise as a result of methodological approaches. Teachers may either have attended CPD programmes or not. The use of a 5-point scale of 'strongly agree', 'agree', 'disagree', 'strongly disagree' and 'don't know' for a question asking to know if teachers have attended training may possibly not generate a result that would show the participation of teachers.

7.5 Discussion on availability of physics teaching and learning resources

In this section, findings on the availability of resources for the effective teaching and learning of physics in secondary schools in Nigeria are discussed. The discussion is aptly guided by the research question:

> What is the extent of availability of physics resources for teaching and learning in secondary schools in Rivers State, Nigeria?

The finding of this study from teachers' self-report suggests that most schools in the Nigeria have laboratories for physics teaching and learning. However results of interviews from both students and teachers together with observation reports from the study suggest that most secondary schools in Nigeria do not have physics laboratory for teaching and learning. The study also revealed that most schools do not have enough resources for the teaching and learning of physics. Particularly, the findings of the study suggest that most schools do not have computers and teachers do not employ Computer Aided Instructions, CAI for their physics lessons. These findings are discussed below.

The place and relevance of educational resources for effective teaching and learning especially in the sciences cannot be overemphasized. Savasci & Tomul (2013) argued that the availability and utilization of teaching and learning resources facilitates the attainment of educational objectives and reduces the effects of social status on students' attainment. To start with, physics teachers were asked on their questionnaire - *Does your school have a physics laboratory?* 71.4% of the teachers indicated that their schools have a physics laboratory while 28.6% indicated that their schools do not have a physics laboratory. The problems of 'social desirability bias' and self-reporting clearly emerged in the response of the teachers to the question as different physics teachers even within the same school gave conflicting response with some, saying their school does not have a physics laboratory and others saying the school has. Apart from the problem of 'social desirability bias', the perception of the teachers on what a laboratory is may have resulted in the conflicting responses. This difference in teachers' responses as reported in this study as to whether or not their school has a physics laboratory is also expected as researchers, science educators and policy makers have failed to agree on a common definition of a 'laboratory' (NRC, 2006; Hofstein & Mamlok-Naaman, 2007). What some teachers and students that are involved in this study term a 'laboratory' has been aptly described for the different schools in chapter 4. White (1996) described laboratories in schools as "commonly large, well-equipped rooms, expensive to establish and maintain, served by specialist assistants" (p 761) and considering Hofstein & Lunetta's (1982:201) definition of laboratory activities "as contrived learning experiences in which students interact with materials to observe phenomena", one could infer that a laboratory is not just an empty classroom, building or space, but one that is well equipped with teaching and learning resources in which students learn and are taught as they interact with the available resources and specialized personnel to observe, discover and investigate scientific processes and theories. Whatever is deemed to be a laboratory, scholars however agree that students' laboratory experience where students carry out hands-on activities with relevant facilities and techniques that make them interact with the material world, acquire knowledge of the processes of science and develop their critical thinking skills is very basic for their effective learning of science (White, 1996; Hofstein, Shore & Kipnis, 2004; NRC, 2006; Abrahams & Reiss, 2012).

Considering the definition of a school laboratory and what is expected of students' activities in the laboratory as proffered by White (1996) and Hofstein & Lunetta (1982) as stated above, then data from both student and teacher interviews and observations as reported in section 6.4 (chapter 6), would suggest that most schools that were used in the study do not have physics laboratories which are 'equipped' and where students 'interact with materials' to develop critical skills and acquire knowledge of the process of science. This finding of the present study on the lack of science laboratories in schools for the teaching and learning of science is in agreement with those of Omosewo (1995), Alebiosu (2000), Onipede (2003) and Edomwonyi-Otu & Avaa (2011). For instance, Omosewo (1995) investigated the patterns of science laboratory management in Kwara State, Nigeria and reported that of the 5 schools sampled for her study; only 1 school had a laboratory for each of the science subjects. However, findings that are discordant with the present one were found in the studies of Adeyemi (2008) and Adeyemi (2005) who investigated the state and availability of science laboratories in Ondo and Ekiti States all in South-West Nigeria. For instance, Adeyemi (2008) in his study of the 168 secondary schools that where randomly sampled from the 257 which enrolled students for the senior secondary school examinations in 2003, reported that all 168 schools have at least 1 laboratory for the sciences and also, that 81 of the secondary schools which represents 48.2% of the 168 sampled schools, have 3 separate laboratories for biology, chemistry and physics respectively. However, both studies reported that the number of schools that have 3 separate laboratories for the science subjects in the urban areas were more than those in the rural areas while schools with less than 3 laboratories were more in the rural areas than in the urban areas in the respective states. The report of the concentration of laboratories in the urban areas as reported by Adeyemi (2005) and Adeyemi (2008) may partly explain the different outcomes between these studies and the present study. This is because of the 8 schools involved in the present study, 4 are urban areas while the other 4 are located in rural areas. Of 4 the schools located in urban areas, only 1 had 3 laboratories that are equipped with adequate facilities and materials for biology, chemistry and physics respectively. The other one had separate laboratories that are mainly used as staff room with little or no equipment. Apart from the location of the schools, it was also observed that most of the schools involved in the study that were established in the last three decades do not have built laboratory structures for the study of the sciences. The very old schools like A1 and D1 that participated in this study had dilapidated structures most of which have been taken over by trees and grasses. The remains of some equipment, most of which were not functional as reported and presented in chapter 4 are what have been stored in what some teachers and students refer to as ‘laboratories’.

On whether or not the schools have enough facilities and resources for the teaching and learning of physics, evidence from the data obtained from the teachers’ and students’ questionnaires, interviews from both students and teachers and observation suggests that schools do not have enough resources for the teaching and learning of physics in the schools (see sections 6.3 and 6.4). For instance, from the teachers’ response (Table 6.5) on the availability of teaching and learning resources for the core physics topic areas of the curriculum, none of the schools that participated in the study had enough resources that have been prescribed for the teaching and learning of concepts on ‘energy quantization and duality of matter’. Also 57.1% of teachers revealed that materials not available to conduct physics experiments or investigations were a ‘serious problem’ in their schools (Table 6.6). Similarly, students’ response to the question ‘my school has enough facilities for conducting experiments or investigations in physics’ corroborated that of the teachers with 66.5% of the students disagreeing with the question (Table 6.8). Interview and observation data also agree with those obtained from the questionnaires that schools did not have enough facilities for the effective teaching and learning of physics in secondary schools.

The finding of the present study on the lack of adequate resources and facilities for the teaching and learning of physics in secondary schools in Nigeria is in consonant with those of Omosewo (1995), Onwioduokit (2001), Adeyemi (2008) and Bello (2012) who reported the poor state of science laboratories and resources for the teaching and learning of sciences in most public schools in Nigeria. For instance, Bello (2012) studied how resource availability and utilization for the teaching of physics affect the attainment of secondary school students in Nigeria and reported that public schools lacked adequate physics laboratory equipment and that students in public secondary schools obtained lower attainment in the subject than students in private and federal government owned schools with more laboratory facilities for teaching and learning.

Also, the finding of the present study agrees with those of Black, Atwaru-Okello, Kiwanuka, Serwadda, Birabi, Malinga & Rodd (1998), Ejidike & Oyelana (2015), Centre for

Science Education (n.d) on studies in some African countries, for instance, Uganda, South Africa and Ghana. The state of laboratory facilities in the teaching and learning of science subjects in most African countries is aptly described in the report of the Centre for Science Education (n.d) that "the challenges in using practical work in Ghanaian schools will be familiar to many teachers: a lack of funding, large class sizes, unsuitable classrooms and lack of specialist knowledge. In Ghana these challenges are intensified. Many schools have no laboratory facilities, no technician support and class sizes of 40-60 pupils" (https://www.shu.ac.uk). Similarly in India, a developing country, Varma (2014) of The Times of India reported a survey conducted on the state of science laboratories in India which revealed that 75% of classes 11 and 12 secondary schools lacked well-equipped science laboratories and that in the lower classes of 9 and 10 where science is taught as 'integrated science module', more than 58% do not have the required laboratories for teaching and learning. That many schools "have no laboratory facilities" for the teaching and learning of science in Ghana as stated above and other African countries like South Africa (Mundalamo, 2006; Ejidike & Oyelana, 2015), Uganda (Black, *et al*., 1998), India (Varma, 2014) and Nigeria as is reported, tend to agree with the conclusion of Fuller (1986) that school-based factors with poor provision of learning facilities were identified as influencing factors to students attainment in developing countries. It is somewhat disturbing that about 3 decades after Fuller's (1986) study and report to the World Bank, the state of infrastructure and basic facilities for teaching especially in the sciences in most developing countries as in Africa has not quite changed.

Several studies have highlighted the relevance of Computer Assisted Instruction (CAI) and use of computer simulations in enhancing the cognitive development of pupils especially in the science subjects (See for instance, Jong & Joolingen, 1998; Cepni, Tas & Kose, 2006; Vogel, Vogel, Cannon-Bowers, Bowers, Muse & Wright, 2006; Tekbiyik, Konur & Pirasa, 2008; Adeyemo, 2010b; Smetana & Bell, 2012). Despite the importance and relevance of computers and internet facilities for the study of physics especially at the lower or foundational stages of education, the finding of this study reveals that most schools do not have computers and teachers do not employ CAI for their physics lessons. For instance, on how often they use computer as a teaching aid or instructional material in their physics lesson delivery, 92.9% of physics teachers indicated that they have 'never' used a computer for their physics lessons (Table 6.5, Fig. 6.5). This revelation of the teachers was also affirmed by observation data (presented in chapter 4) and students' report, both in their interviews and questionnaires (See Table 6.11 and Fig. 6.9). The finding of the present study aligns with those of Aduwa-Ogiegbaen & Iyamu (2005), Adomi & Kpangban (2010), Adeyemi & Olaleye (2010), Adeosun (2010) and Abubakar & Adebayo (2014) conducted in Nigeria and those of Nganji, Kwemain & Taku (2010) and Amenyedzi, Lartey & Dzomeku (2011) of schools in Cameron and Ghana respectively. For example, Adeyemi & Olaleye (2010) investigated the state of ICT availability and other related matters in secondary schools in Ekiti State, Nigeria and reported that the level of provision of ICT equipment in secondary schools was low. Similar findings in public schools have been reported in the south-south states of Delta and Edo and Lagos in the south-west of Nigeria. However, finding discordant with the present one was found by Adeyemo (2010b) who investigated the impact of ICT on the teaching and learning of physics. His study involved 2 senior secondary schools from each of 5 educational districts out of the present 6 in Lagos State, Nigeria. He reported that all schools in his study were "equipped with electronic computer system connected to internet" (p.59). Although a study carried out in the same Lagos State (Adeosun, 2010) reported that schools in the state lacked computers and ICT tools, it is difficult to have a true picture as both studies have their limitations that would have guided any reader to a fine conclusion. For instance, Adeyemo (2010b) did not state the ownership of the schools that were involved in his study. Most studies have reported that public schools in Nigeria have poor state of infrastructure and funding behind federal government owned schools and private schools (Aduwa-Ogiegbaen & Iyamu, 2005; Bello, 2012). Similarly, it was also not clear how Adeosun (2010) selected his sample – the school types and the localities. Another possible explanation for the different reports could also be on the location of the schools that were selected for the studies. Some studies have reported that schools in the urban areas tend to be favoured with the provision of facilities for teaching and learning than schools located in the rural areas (See for instance, Adeyemi, 2008). The state of electricity supply in rural areas is especially poor with most rural communities without electricity and it is unlikely that public schools that are located in rural areas of the state would be equipped with electronic computer system that are connected to the internet.

7.6 Utilization of physics resources for teaching and learning

Findings on the utilization of resources for teaching and learning of physics in secondary schools are discussed in this section. The discussion is guided by the sub-research question:

To what extent are available physics resources utilized for teaching and learning in secondary schools?

The finding of this study on the utilization of available resources for teaching and learning suggests that most teachers who have laboratory and or lab facilities do not utilize them in their teaching. The detailed discussion of the finding is presented below.

As there are possibilities of available teaching and learning resources not utilized for the enrichment of students' learning experiences in the classroom, teachers were asked on the frequency of their use of laboratory and its facilities in teaching physics. Their response suggests that most teachers who have laboratory and or lab facilities do not utilize them in their teaching. Result of analysis in Table 6.9 reveals that 53.9% of physics teachers 'rarely' or 'never' use the laboratory and its facilities in teaching. The finding of this study on teachers' non-use of available resources in teaching and learning is consistent with those of Magno (2007), Hanuscin (2007), Stephen (2011) and Dike & Halima (2015). For instance, Dike & Halima (2015) investigated the problem of laboratory facilities and utilization in Nigeria and found that even where the laboratory facilities were available, some teachers rarely or never utilize them for their science lessons. Similarly, Stephen (2011) investigated the utilization of available resources for the teaching and learning of physics in secondary schools in Akwa-Ibom state, Nigeria. His study, itemized available physics resources and reported that only "16.1% of the available resource materials are often used in physics lessons by the teachers" (p.26). In the US, Hanuscin (2007) investigated teachers' use of specialized laboratory facilities teaching elementary school science and reported that "although each class was scheduled for a laboratory session, the laboratory was not being used on a regular basis" (p.62). However, the finding on non-utilization of available resources by teachers does not agree with that of Olagunju & Abiona (2008) who investigated the improvisation and utilization of resources for biology lessons in south-west Nigerian secondary schools and concluded that "biology material resources are available and used in schools" (p.54). The conclusion of Olagunju & Abiona (2008) on teachers' usage of available biology teaching resources may be explained in the light of the teachers improvising resources for the teaching of their subject. The study revealed that over 40% of biology teachers improvised materials for their teaching. The present study is particularly on physics and did not investigate the improvisation of teaching resources by physics teachers to make a fair comparison. Also, the simple type of the resources – microscope, magnifying glasses, hand lens, preserved specimen, chemicals, measuring cylinders, wall charts and models they reported were available in schools, may explain why teachers utilized them for their lessons. Most physics laboratory equipment would require a greater deal of technical skill and knowledge to use and teach. The explanation of the physics teachers for not utilizing available resources as reported in Section 6.5, may simply suggest that they may not have appreciated the place of labs and resources in the enhancement of students' learning experiences in physics and generally, the science subjects. Another possible explanation for teachers' non-use of available facilities for teaching may be their lack of adequate knowledge and skill in the use and operation of such equipment. Although some teachers have claimed that their school had no laboratory, it is doubtful that any school that had enrolled students for the senior schools certificate examinations at least for once would have no lab facility that should have been used in teaching as reflected in the teachers' responses (Table 6.5). This is because of the practice of providing lab equipment and facilities for schools for the conduct of the SSCE every year in Nigeria as reported by some physics teachers and presented in chapter 6 (section 6.5).

The explanation of teachers' non-use of available laboratory resources for teaching and learning to enhance students' learning experiences is consistent with those put forward by Vorsino (1992), Magno (2007) and Hanuscin (2007). For instance, Vorsino (1992) posited that the lack of adequate background knowledge in scientific content and unfamiliarity with laboratory facility are possible explanations to teachers' non-utilization of available laboratory resources. Similarly, Magno (2007) investigated the state of science education in developing countries with a focus on Asia and reported that practical work to enhance students' work skills in many developing countries has been hindered by amongst others, inadequate subject content knowledge of many teachers, lack of science equipment, so much content to cover and extra work needed by the teachers to prepare materials for the practical sessions. Teachers who are confident and have adequate knowledge and skills in the content of the subject and who are trained in the use of relevant laboratory facilities are not likely to avoid the use of resources to enhance the learning experience of their students. Some teachers also highlighted the issue of the content load of the physics curriculum that makes it difficult for them to cover the work load before students are made ready for the external senior school certificate examination. This may also explain why teachers concentrate on covering the syllabus theoretically without recourse to practical work. Whatever may be the reasons by teachers for their non-utilization of available resources for teaching and learning as has been reported, it is evident from literature that students' learning is enhanced and that students acquire and develop skills in the process of science, critical thinking and problem solving when exposed to practical work (Blosser, 1990; Chang & Lederman, 1994; Hofstein, Shore & Kipnis, 2004; NSTA, 2007; Bello, 2012). It is therefore important that teachers be encouraged and adequately supported with necessary training and re-training activities, workshops and conferences to be able to utilize available resources for the enhancement of students' learning experiences.

7.7 Effect of resource availability and utilization on physics students' enrolment and attainment

In this section, results on the effect of the availability and utilization of resources on physics students' enrolment and attainment are discussed. The discussion here is guided by the sub-research question:

To what extent does the availability and utilization of physics resources influence students' enrolment and attainment in physics?

Data from school physics enrolment and resource factors computed from teachers' responses suggests that there was no significant correlation between student enrolment and resource availability and enrolment with resource utilization. However, the questionnaire response of the physics teachers on the main school related factors that affect students' choice of physics, show that 'lack of qualified physics teachers', 'teaching physics by theory without practical work', and the 'lack of lab equipment for demonstration and conducting experiments' were the main school-related factors that affect students' choice of physics in secondary schools. Also, qualitative data from the interviews of both teachers and students suggests that availability and utilization of physics resources influence students' enrolment for the subject. On the effect of resource availability and utilization on students' attainment in physics, the findings show that there were significant correlations between students' attainment in physics with resource availability and utilization. The study also shows that students achieved better in less resourced content areas than those that are more resourced in the PAT. These findings are discussed in the next paragraphs.

On enrolment and resource availability and utilization, result of quantitative data using physics enrolment figures and resource factors computed from teachers' responses show that there was no statistically significant correlation between student enrolment and resource availability ($r = -0.024$, $p>0.05$) and enrolment with resource utilization ($r = 0.157$, $p>0.05$). The correlations are very low and negative (for resource availability) and positive (for resource utilization). However, the questionnaire response of the physics teachers on the main school related factors that affect students' choice of physics, analysed by use of simple percentages reveal that 'lack of qualified physics teachers' (57.1%), 'teaching physics by theory without practical work' (64.3%), and the 'lack of lab equipment for demonstration and conducting experiments' (64.3%) were the main school-related factors that affect students' choice of physics in secondary schools (see section 6.6). The qualitative data from the interviews of both teachers and students also suggest that availability and utilization of physics resources influence students' enrolment for the subject (see section 6.2).

It was difficult to find any study in literature conducted by either quantitative or qualitative research method that agrees with the finding of the result of the correlation analysis of quantitative data on the present study that showed no significant correlation between resource availability and utilization and students enrolment. On the contrary, the finding based on quantitative data generated from teachers' opinion in percentages and the qualitative data from the present study are in consonance with those of Anyanwu &Erhijakpor (2007), Maoga & Sureiman (2011), Bello (2012) and Azubuike & Azubuike (2014) who reported that school resources significantly influence students' enrolment. For instance, Bello (2012) investigated the effects of physics lab availability and utilization on physics students' enrolment and attainment in senior secondary schools in Nigeria and concluded that parents enrol their children and wards in schools with better equipped laboratory and adequate teaching resources. In another study, Maoga & Sureiman (2011) examined the factors that influence students' enrolment in geography in Kenyan public secondary schools using correlational techniques. Their results showed that the availability of teachers and teaching resources correlated positively with students' enrolment. In a multi-national African study, Anyanwu & Erhijakpor (2007) investigated the relationship between government spending and educational enrolment in South Africa, Algeria, Nigeria and

Egypt and found that at both primary and secondary school levels in Africa, government education expenditure had a positive and significant effect on students' enrolment.

The disparity in the results from the qualitative and quantitative data of the present study may be explained by the small sample size of 8 schools that was used in the study (see Table 6.3). 8 schools were used and for an analysis on school-by-school basis, a sample size of 8 is considered too small in a quantitative analysis for statistical significance. Literature suggests that the reliability of results of quantitative studies is stronger with large sample sizes than with small sample sizes (Cohen, Manion & Morrison, 2011; Creswell, 2012). This therefore implies that there are possibilities of obtaining different reliability values or stronger effect sizes with larger sample sizes of the same study than with smaller samples. Another factor that could explain the disparity in the results of the qualitative and quantitative data may be the problem of self-reporting and social desirability effect in completing the questionnaires that generated the quantitative data for resource availability and utilization unlike the focus group interviews, for instance, that featured the interaction of both physics and non-physics students on school-related factors why they choose (or not choose) physics. Several researchers have acknowledged the benefits of interaction between participants and generation of group feelings and opinions from focus group interviews (Kitzinger, 1994; Sim, 1998; Wilkinson, 2004). Again, there are possibilities that the non-significance and low correlation between resource availability and students' enrolment may have been as a result of the problem of operationalization of the resource variables such as laboratory, laboratory assistants and lab resources in terms of the measure assigned to them for the quantitative analysis. The foregoing and limitations of the quantitative data generated in this study therefore calls for a further investigation in a large scale study of the possible influence of resource availability, resource utilization, teacher qualification and experience, and other school related factors on students' enrolment in physics or generally science subjects in Nigeria.

On the effect of resource availability and utilization on students' attainment in physics, the findings of the present study shows that there were statistically significant correlations between resource availability and students' attainment in physics ($r = 0.534$, $p < 0.05$, $n=171$) and resource utilization and students' attainment ($r = 0.423$, $p < 0.05$, $n=171$). The results were similar to those obtained separately for boys and girls. Interestingly in terms of gender, the result shows a stronger correlation between attainment and resource availability index for the girls than the boys (see Figure 6.2c). The implication is that girls are more sensitive to the use of appropriate resources in teaching and are more likely to achieve better when teachers use resources than the boys. This finding is consistent with those of Murphy & Whitelegg (2006) and Musasia, Abacha & Biyoyo (2012) which suggest that girls are more engaged in physics when constructivist approaches that encourage project and investigative work are employed in classrooms. For instance, Musasia, Abacha & Biyoyo (2012) found that girls' participation in practical work enhanced their performance in the relevant topics compared to the girls who were not exposed to practical work. These findings are also consistent with expressions from the qualitative data from both students and teachers that availability and utilization of available teaching and learning resources enhances better understanding and attainment (see section 6.2).

The implication of the above finding is that students' scores or attainment are likely to be enhanced when taught by teachers with better qualification and with available physics teaching and learning resources adequately utilized to support students' learning. The finding of this study agrees with those of Sparkes (1995), Hedges, Laine & Greenwald (1994a, 1994b), Krueger (2003), Pan, Rudo, Schneider & Smith-Hansen (2003) and OECD (2015) who reported that there was a strong relationship between school resources and students' attainment. For instance, OECD in its report of the 2012 PISA posited that the availability and utilization of teaching and learning resources in schools were found to be associated with students' attainment in many OECD countries (OECD, 2015).

The finding of this present study however does not support those of some other researchers who had argued that variations in school resources do not have a consistent relationship with students' attainment (see for instance, Hanushek, 1994a, 1994b, 1997, 2006; Glewwe, Hanushek, Humpage & Ravina, 2011). For instance, Hanushek (1997) conducted a review of about 400 studies on students' attainment and averred that there was no significant relationship between school resources and students' attainment. Apart from the fact that analytical and methodological flaws may result in varying outcomes researchers obtain from similar studies as in the argument and counter argument of Hanushek (1994a) and Hedges, Laine & Greenwald (1994a, 1994b), on the effect of school resources on students' academic attainment (see section chapter 2, section 2.2), the places where the studies were conducted may also have informed their conclusion. For instance, Hanushek and his colleagues did their studies in the US where at the time, schools may not have faced the paucity of basic teaching resources unlike the case in most under-developed or developing countries like Nigeria. Some earlier studies have reported that school-based factors strongly affect students' academic attainment in developing countries while socio-economic factors were stated as influencing factors in determining pupils' academic attainment in developed countries (see for instance, Fuller, 1986; Heyneman & Loxley, 1983). This is because in most developed countries, it may be unlikely to find schools that teach science without laboratories and appropriate provision of teaching and learning resources including computers with internet for simulations that could facilitate students' learning. It is likely on the contrary to find schools in most developing and under-developed countries without electricity, adequate classrooms, laboratories and other teaching and learning facilities. The argument of Hanushek may be understood in the context of a system or economy where basic school resources are adequately provided and high quality teachers engaged. In such an economy, the continual spending on schools may imply for instance, hiring of overqualified teachers, the acquisition of higher sophisticated facilities and other school infrastructure which may not necessarily produce corresponding improvement of students' learning experiences and attainment. This is not the case in most developing countries where science is taught without the required exposure of students to practical demonstration with most schools having no laboratories, insufficient numbers of qualified physics teachers and lack of teaching and learning facilities (See for instance, Onwioduokit, 2001; Dayal, 2007; Alamina, 2008; Erinosho, 2013). Another possible explanation for varying outcomes of similar studies may be in the scale of the study and corresponding sample size. The same study conducted on a larger scale with considerably larger samples is most likely to yield varying outcomes. This view is consistent with those of Biau, Kerneis & Porcher (2008) and Cresswell (2012) that varying the scale of study and sample size is most likely to yield a different conclusion of a similar study as lesser potential errors may be occasioned in large scale studies than in small scale ones. From the foregoing therefore, it is the conclusion of the present study that the findings of the study suggest that the availability and utilization of physics resources significantly affect students' academic attainment in physics.

A further probe on the association between resourcing and students' attainment, suggests that students obtained higher scores in topics under 'conservation principles' that is least resourced, than for instance, 'fields at rest and in motion' and 'interaction of matter, space and time' that were relatively more resourced as reported by the teachers. Although this finding of the present study is consistent with the those of Hanushek (1994, 1997, 2006) and Glewwe, Hanushek, Humpage & Ravina (2011) who argued that school resources do not significantly affect students' attainment, the relatively better performance of students in contents under 'conservation principles' that appeared to be less resourced may be as a result of the relevance of concepts under the area to the everyday experience of students both at home and in society. For instance, questions 2 and 3 in the PAT that carry contents under 'conservation principles' deals with home appliances – fan, pressing iron, hair dryer, vacuum cleaner, table lamp, kettle and water tank. Students are likely to be familiar with the energy use, transformation and conservation of these appliances at home even when there are no teaching resources in their schools. The other topic areas tend to have more contents that appear abstract for which students may need appropriate resources in physics lessons to show better understanding of the related concepts. This assumption is consistent with the report of the National Research Council (2009) that science can be learnt by school pupils outside the school in their every day experiences. Similar position of the positive effects of science learning at home and out-of-school context have been canvassed by Braund & Reiss (2006) when they argued that school pupils learn scientific phenomenon from a wide range of experiences and in different places and that although the school laboratory is important, it is not the only place where science can be learnt.

However, the finding of the present study on students performing better with less school resources for teaching and learning does not agree with those reported by Hedges, Laine & Greenwald (1994a, 1994b, 1996); National Research Council (2006) and Odubunmi & Balogun (1991) whose findings suggest that more resources for teaching and learning enhances students' attainment. For instance, Hedges, Laine & Greenwald (1994a) conducted a meta-analysis of 38 articles and studies on the effects of school inputs on students' attainment and reported a clear and systematic pattern of positive relationship between students' attainment and resourcing. This underscores the importance of adequate resources for effective teaching and learning, especially of the sciences in schools. There is need therefore for further studies on the state and effect of resources for the teaching and learning of the science subjects in Nigeria in view of its implication for policy and practice.

7.8 The teaching strategies and classroom interactions adopted by physics teachers

The discussion of findings on the teaching strategies and classroom interactions that are used by teachers in physics classroom is discussed in this section. The sub-research question that guides the discussion is:

What are the teaching strategies and classroom interactions adopted by physics teachers?

Findings of this study from the perception of teachers suggest that demonstrations and problem solving are the most common strategies they adopt for teaching physics with field trips, excursions, lecture, laboratory, project method, and collaborative learning as the least used strategies. However, most students reported that they do not see their teachers using demonstrations to teach them. Also, findings from the classroom observations suggest that teacher-centered more than learner-centred strategies are used by physics teachers in Nigerian secondary schools. These findings are discussed below.

The response of teachers, both on the questionnaire and in the interviews suggest that the most common teaching strategies employed by them in teaching physics are Demonstration and Problem solving; while Field trips, Excursions, Lecture, Laboratory, Project method, and Collaborative learning are the least utilized methods for teaching physics in secondary schools (see section 6.7). The national physics curriculum advocates a student-activity oriented teaching of the subject with the use of experimentation, questioning, discussion and problem solving by physics teachers (FME, 2009). Interestingly, students seem to differ from their teachers on the common use of demonstrations in physics classrooms. Most students (94.6%) agree that they 'Never' watch their teachers demonstrate physics on a computer while only about 30% agree that they watch their teacher demonstrate an experiment or investigation in about half the lessons or almost every lesson. On the teachers' response of their frequent use of 'demonstration method', it is pertinent to note that most teachers were of the opinion that lack of resources for conducting demonstrations and experiments was a major factor for the low popularity of physics among secondary school students (see section 6.7, Table 6.10) and that the shortage of resources for the use of teachers in carrying out demonstrations in class was a major limiting factor in the effective teaching and learning of physics in schools. One therefore wonders how most of the teachers then use demonstration in half their lessons or almost in every of their physics classes. The classroom observation evidence as reported in chapter 6 does not also support the teachers' claim of frequent use of demonstration method for their physics lessons. Majority of the teachers observed were found not to have used any resource to facilitate their teaching even when the curriculum has prescribed the use of certain equipment and resources for the teaching of topics that were observed (see Table 6.14).

The finding of the present study from the classroom observations is consistent with those of Buabeng, Ossei-Anto & Ampiah (2014), Faremi (2014), Modebelu & Nwakpadolu (2013), Mehmood & Rehman (2011), UNICEF (2009) and Hardman, Abd-Kadir & Smith (2008) who also found that teaching strategies and teachers' classroom interactions in secondary schools are mostly teacher-centered with lecture and discussion methods. For instance, UNICEF (2009) in its country report for Nigeria on the Child Friendly Schools Evaluation, reported that "…teacher-centred pedagogy was still predominant in most classrooms. For example, most teachers believed that lectures were the most effective way to teach students…" (p. iv). Also, Hardman, Abd-Kadir & Smith (2008) investigated classroom interactions and discourse practices involving 42 lessons and 59 primary school teachers from 10 states in Northern Nigeria and reported that there was "a high prevalence of rote and teacher-led recitation' (p.65) and that the classroom discourse paid little attention to securing the understanding of the pupils. These conclusions do not however agree with the results of both quantitative and interview data from the teachers' in the present study which suggests that teachers commonly use demonstration and problem solving approaches in their physics classes. The possible variation of the teachers' understanding and perception of the different teaching approaches as illustrated in chapter 6 (see section 6.7) may account for the different results from the methods used in the data collection for the present study. There is however a need for a further investigation of the teaching approaches used by physics teachers so as inform policies and planning for teacher training and development in Nigeria.

7.9 The influence of teachers' teaching strategy on physics students' enrolment and attainment

Findings on the influence of teachers' teaching strategy on the enrolment of students for physics in the post compulsory secondary school classes are discussed in this section. The discussion is guided by the sub-research question:

To what extent does the teaching strategy and classroom interactions adopted by teachers influence the students' enrolment and attainment in physics?

Findings on the influence of teachers' teaching strategy on students' enrolment for physics, suggest that teacher-centered teaching strategies commonly used by teachers have not encouraged students to enrol for the subject at the senior secondary school level and may also have contributed to the poor attainment of students in physics as evidenced in the physics attainment test. The findings are discussed below.

On the influence of teachers' teaching strategy on students' enrolment for physics, findings from the present study suggest that teachers commonly use teacher-centered teaching strategies such as lecture and discussion (see section 6.7, Table 6.14) and that the adoption of such approaches has not encouraged students to enrol for the subject in the post compulsory classes of secondary education. The finding of the present study agrees with those of Haladyna, Olsen & Shaughnessy (1982), Ebenezer & Zoller (1993), Sundberg, Dini & Li (1994), Woolnough (1994), Hendley, Parkinson, Stables & Tanner (1995), Cooper & McIntyre (1998), Osborne, Simon & Collins (2003) and Aina & Akanbi (2013) who reported that the quality of teaching was a major factor in students' determination to choose physics after the compulsory years of secondary education. For instance, Ebenezer & Zoller (1993) investigated the perception of Grade 10 pupils and their attitudes towards science teaching in British Colombia using mixed methods research and concluded that the way in which science was taught contributed significantly to students' choice of continuing to study science post-16. Similarly, Aina & Akanbi (2013) studied the students' views on the causes of low science enrolment in Nigerian secondary schools and reported that the inability of science teachers to teach properly either as a result of lack of commitment on their part or bad teaching approaches was among major factors that influenced the low enrolment of students in science.

On the effect of teachers' teaching approach on students' enrolment, students have in the present study desired an appropriate use of laboratory and other teaching facilities that could inspire their motivation and facilitate effective learning. These aspirations of the students to have a better experience of physics teaching and learning is consistent with the finding of Sundberg, Dini & Li (1994) that teachers use of 'content-intensive' approach was not effective and that the rate of withdrawals from science classes could be controlled as students' evaluation showed that laboratory experience strengthens the understanding of core concepts from the lectures with the provision of positive learning experiences to students than in class discussions and lectures. Woolnough (1984) in same vein reported that “those schools which encouraged extra-curricular activities and student science projects, through clubs, competitions, projects and school-industry links, were the ones which sent a large proportion of their students on to higher education to continue with their sciences or engineering” (p. 29). The essential part of Woolnough’s finding is that the physics teacher’s versatility in identifying relevant activities and resources both within and outside the classroom to enrich the learning experiences of students is key to sustaining their interest in the subject.

Unfortunately, findings from the present study show that most physics teachers do not employ out-of-classroom experiences in their teaching with close to 80% of teachers saying that they have ‘never’ utilized ‘field-trips’ and ‘excursions’ in their teaching. It is important that science teachers employ appropriate pedagogy that would make science classes appealing to majority of the students. According to Osborne, Simon & Collins (2003), science teachers may have a good content knowledge of their subject but may fail to support the effective learning of their students and make them less interested in the subject when they not effectively communicate their lessons by drawing from a rich variety of learning opportunities as a result of their teaching styles. All these show that the teaching strategy adopted by teachers and the ability of teachers to explore all possible resources, personnel and avenues both within and outside the school and classroom goes a long way in presenting physics interestingly to students and could encourage students enrolment and continuity in the subject.

On the effect of teachers’ teaching strategy on physics students’ attainment, the result of students in the Physics Attainment Test that was used in the present study shows that students’ attainment in physics was low (see Table 5.15). Also the classroom observation report of the present study indicates that most teachers adopted teacher-centered approaches in their physics classrooms that are known not to facilitate effective students’ learning (see Table 6.14). Interview data from most students suggest that the teacher-centered approaches adopted by most teachers do not support students’ understanding of physics. It is therefore possible that among other factors (some of which have not been investigated in the present study, for instance, parents’ socio-economic status), the poor attainment of students in physics may be associated with the teaching strategy adopted by physics teachers. This assumption is supported by the findings of Wise & Okey (1983), Wise (1996), Uside, Barchok & Abura (2013), Musasia, Abacha & Biyoyo (2012) and Akanwa & Ovute (2014) who concluded that alternative science teaching strategies that are student centered in which students get more active and involved in the learning process were more effective than the traditional science teaching strategies. For instance, Wise (1996) reported that at the secondary schools level, the alternative science teaching strategies which included questioning, enhanced materials, instructional media strategies amongst others were found to be more effective than the traditional strategies at improving the attainment of students in the sciences. Similarly, Akanwa & Ovute (2014) compared the effects of conventional and constructivist teaching approaches on the attainment of secondary school physics students in Nigeria and found that those taught with the constructivist approach achieved significantly higher scores than those who were taught with the conventional didactic approach.

The findings of the present study and those of previous researche on the role of teachers' teaching strategies on students' enrolment and academic attainment have clearly underscored the importance of teacher training and retraining on the knowledge and utility of relevant pedagogical strategies that could present physics and generally science as interesting and enjoyable by school pupils and that could improve students' attainment. This is considered relevant for policy planning, teachers' continuing professional development programmes and curriculum developers in institutions that are involved in the training and certification of teachers in Nigeria.

7.10 Effect of school climate on teaching and learning in schools

In this sub-section, the quality of school life – the character of students and staff among themselves and with school facilities and how that affects teaching and learning will be discussed. To guide the discussion is the research question:

To what extent does the school climate affect teaching and learning in the school?

Findings on the effect of school climate on teaching and learning of physics in schools from the opinion of students suggest that they enjoy a friendly and supportive school environment both with their peers and physics teachers which promotes effective teaching and learning. However, teachers' opinion suggests that students' use of alcohol, drugs and bullying negatively affects teaching and learning. The findings are discussed in detail in the next paragraphs of the section.

The result from the analysis of the students' questionnaire on the effect of school climate on teaching and learning tend to suggest that students enjoy a friendly and supportive school environment both with their peers and with the physics teachers and other staff in their schools as shown in Table 6.15. However, teachers seem to have expressed a different opinion with that of the students with most of the teachers holding the view that the 'use of alcohol or illegal drugs' and 'bullying of students' for instance, negatively affect teaching and learning activities in the school (see Table 6.16). The factors in the school environment that teachers have said affect the teaching and learning negatively in the schools, are associated with students. Social desirability effect on the part of students may have influenced their response to questions on their relationship with their physics teachers and among themselves to account for the disparity between the opinion of the teachers and that of the students. Also, it is possible that teachers may have responded to the questions with the generality of the student population in mind and not just the physics students; whereas the physics students in their response and as restricted by the questions gave answers with the consideration of only what happens in their physics classes, with their fellow physics students and their physics teachers. Considering the importance of such factors that could affect teaching and learning in the schools for policy, teacher training and development and school management, these differences call for a further investigation into the effect of the school climate on teaching and learning. On the physical school environment, students also expressed the problem of inadequate infrastructure that could negatively influence effective teaching and learning.

The finding of this present study on the friendly and supportive roles of teachers to students in schools agrees with those of Duze & Ogbah (2013) who investigated school climate challenges in Nigeria and reported that teachers give adequate support to students in their studies and that there was a cordial, friendly atmosphere among students that make them happy with their school life. This is very heartwarming within the limits and harsh infrastructural circumstances in which Nigerian teachers operate. This may suggest that with improved working conditions, students are very likely to have better and enriched classroom experiences that would support effective learning. The finding of the present study on the opinion of physics teachers on bullying and other student-related vices in schools, agrees with that report by UNICEF (2009) that bullying and instances where passers-by failed to help attacked students were of concern to many students and that some students stay away from school so as to keep safe as a result of such unwholesome behaviors. Also, the finding on the poor state of the physical school environment in Nigerian schools agrees with those of UNICEF (2009) and Duze & Ogbah (2013). For instance, the UNICEF (2009) country report for Nigeria revealed that most secondary schools in Nigeria had inadequate teaching and learning resources, classroom space, furniture, health, water and sanitation facilities. Research has shown that the quality of school life and climate affects students' learning and attainment (Marshall, 2004; Uline & Tschannen-Moran, 2008; UNICEF, 2009; Thapa, *et al.,* 2013; Duze & Ogbah, 2013). As discussed earlier, the findings of the present study suggest that students' attainment in physics was low. It is possible that the unruly behavior of some students like bullying and use of alcohol that disrupts normal learning activities as perceived by some teachers with the effect that some students stay out of school for fear of their safety, may have affected students' learning and attainment. This explanation is consistent with the conclusion of Thapa *et al.,* (2013) that students' attainment, graduation rates together with both teacher and student retention in schools was enhanced by a positive school climate. According the OECD (2013) report of the 2012 PISA, secondary schools that had high record of students' indiscipline were noted to have a paucity of qualified teachers. It is likely that effective teaching and learning may be impeded in schools were qualified science teachers are lacking which possibly could result in low students' attainment. Considering the importance of school climate in the overall objective of the school system to provide a conducive environment for teaching and learning, it is important that the findings on the conflicting views of both students and teachers be further investigated to establish the true state of school climates in Nigerian schools so as to proffer adequate solutions for safer schools in the country that would encourage and support student learning.

7.11 Summary of discussion

The finding of the study is therefore consistent with both the Walberg's theory of educational productivity and the Von Bertalanffy's input-output system theory that were set as theoretical basis for the study. In the context of this study, recruiting more qualified physics teachers, equipping the schools with adequate teaching and learning resources with teachers trained on the know-how of the facilities and actually using them to support students' learning would most likely enhance students' attainment as propounded by Walberg (1981) in his educational theory. Also in the view of Von Bertalanffy's system theory, the school is a system where students and teachers interact with themselves and with the available resources in a friendly and learning support environment; teacher training and continuing professional development are all in-put into the system with the expectation of a worthwhile out-put – better attainment which society expects from the products of the school to meaningfully contribute to its well-being.

The findings of this study suggest that students' physics 'out-put' or attainment is poor. Also, the state and quality of resources for physics teaching and learning seem to be grossly inadequate and may not sufficiently support and spur students' to higher attainment in the subject. The findings on the participation of teachers in continuous professional development activities suggest that teachers are not adequately supported to develop and improve on their teaching and subject knowledge skills with little or no consistent teacher professional development engagements as revealed in this study. These as input factors may have resulted in the poor output of low students' attainment as has been reported and so to obtain desired output, there is need to strengthen the input variables into the system in Nigerian secondary schools.

Chapter 8: Conclusion and Recommendations

8.1 Overview of the study

This study has critically examined the practice of teaching and learning of science in general and particularly physics in senior secondary schools in Nigeria. The main purpose of the study was to investigate the effect of school-based factors on enrolment and attainment of senior secondary school students in physics in Nigeria. The objectives of the research together with their related research questions have been stated in chapter one and followed through as guides for the methodology adopted for the study, collection of data, analysis and discussion of the findings. The principal research question formulated to guide this study is:

> What school-based factors influence enrolment and attainment in physics in the senior school certificate examinations in Rivers State, Nigeria?

The study has provided some insight into the state of science teaching and learning in Nigerian schools, status of resources for teaching and learning of science subjects in schools, quality of physics teachers, teaching strategies common among physics teachers in Nigeria, the nature of school climate in most schools and the state of teachers' participation in continuous professional development programmes. To undertake an in-depth study of the problem, a mixed method research design was adopted for the study with the use of questionnaires, interviews, classroom observations, attainment test and secondary data.

The study was based on Walberg's (1981) theory of educational productivity and the Von Bertalanffy (1968) input-output systems theory. Three of the nine productive factors that were identified by Walberg (1981) as having effect on learning outcomes – quality of instruction, quantity of instruction and classroom psychological climate were investigated in the study. The teaching strategies that teachers adopt in teaching school physics and the school and classroom learning environments were investigated in the study. Von Bertalanffy's system theory is considered in the sense in which the school acts as an educational system where the teachers, students and school resources interact as component parts within the wider society as its own environment. The products of the educational system are plowed back into the society for the actualization of the set societal goals. On the other hand, the school receives information on what is expected in society regarding school outcomes such as employability skills, knowledge and general problem solving abilities to contribute meaningfully to the development of the society. To enable the products of schooling to meet expected goals, the teaching and learning activities, classroom interactions and other activities that take place under the supervision of the school are considered the processing tools of the system and focus of the present study. The study has therefore explored school related factors such as teachers' characteristics, teaching and learning resource availability, opportunities for continuous professional development of physics teachers and class room climate and their effect on the enrolment and attainment of secondary school students in physics.

The study may be classified as school effectiveness research. Reynolds, *et al.*,(2014) have described school effectiveness research as studies that examine the effect of factors within the school that could influence that learning outcomes of students. Several research studies have been conducted on school effectiveness (Hedges, Laine & Greenwald, 1994; Hanushek, 1997; Lips, Watkins & Fleming, 2008; Reynolds, *et al.*,(2014). One of the goals of education in Nigeria as contained in the National Policy on Education is the development of relevant skills and abilities that would enable citizens who are products of the school system to contribute meaningfully to societal goals and aspirations (FRN, 2013). This in essence makes demands on the effectiveness of Nigerian schools. This study has explored school related factors and their effects on students' choice to continue with the study of physics and also on the development of their cognitive competencies.

In Nigeria, compulsory schooling which is referred to as basic education ends after the Junior Secondary School (JSS) class 3 at which point students make choices of subjects to study and continue with in their secondary education beginning from the 4th year of secondary education (Senior Secondary School, SSS) for another 3 years. At the end of the last 3 years of secondary education, students sit for the Senior School Certificate Examination, SSCE conducted by the West African Examinations Council (WAEC) at the end of their secondary education. In Nigeria as in many other countries, the decline in the number of young pupils wishing to continue with the study of physics after the compulsory years of schooling has been of concern to many researchers (Erinosho, 2013; Bennett, Lubben & Hampden-Thompson, 2013; Semela, 2010; Smitters & Robinson, 2009; Williams *et al.,* 2003; Stokking, 2000). Akin to the problem of low enrolment in physics among students is the problem of poor attainment of students in certificate examinations (Osborne, Driver & Simon, 1998). One reason that may have provoked the interest of researchers and other stake holders in the education industry regarding the state of teaching and learning of physics in schools the world over is the relevant role physics plays in major careers that drive the economy especially in this age of technological revolution. The present study is therefore an attempt to investigate factors within the school that could affect students' enrolment and attainment in physics so as to suggest ways of enabling students to have good school and classroom experiences that would engender and support their interest in the subject and also enhance their attainment.

The study investigated some teacher characteristics and teaching strategies commonly used by teachers for physics lessons and how they may have influenced students' enrolment and attainment in the subject. Some studies (Wise, 1996; Raine & Collett, 2003; Thomas & Israel, 2013) have reported a link between teachers' teaching approaches and the enrolment and attainment of students. The availability and utilization of resources for the effective teaching and learning of physics and how they could influence students' enrolment and attainment in schools were investigated. The study also investigated the quality of school life in schools and how that may have affected teaching and learning. Studies have shown that the quality of school life or school climate significantly affects students' learning and attainment (McBer, 2000; Marshall, 2004; Macneil, Prater & Busch, 2009; Thapa, Cohen, Guffey & Higgins-D'Alessandro, 2013). It is important that school administrators, policy planners, teachers and parents know the elements within the school that could facilitate or inhibit students' experiences in school in order to secure worthwhile and expected outcomes. Suggestions and recommendations from this study, it is hoped, would enable teachers and others to ensure that students are sufficiently supported in school with adequate exposure to school and classroom experiences that may encourage their participation in school and possibly enhance their attainments.

8.2 Answers to research questions

In earlier chapters of this thesis, the sub-research questions that were derived from the principal research question have been addressed in detail. In this section of the concluding chapter, I intend not to repeat the detailed report but to address succinctly and answer the research questions and highlight the major findings of the study. Again as presented in chapter 7, brief answers to the sub-research questions are first presented with a review of the literature, at the end of which the main research question of the study is addressed and answered concisely.

8.2.1 What is the level of enrolment for physics in the senior secondary certificate examination?

Secondary data obtained from the West African Examinations Council for the period 2004 - 2010 and analyzed for use in the present study reveals that an average of 33.4% of secondary school students in Nigeria enrol for physics and sit for the senior secondary school certificate examinations. During the same period, the average enrolment figures nationally for biology and chemistry were 35.1% and 99.4% respectively. The trend of enrolment for the same period in Rivers State where the study was conducted was not different from the national picture with an average enrolment of 43.8% for physics and 44.7% and 99% for chemistry and biology respectively. The result of physics enrolment of the participating schools in the study also indicated that 33.3% of the total number of students enrolled in physics for the senior school certificate examination in 2015.

The result of the study reveals that physics was the least popular science subject among the 3 core school science subjects – biology, chemistry and physics. This finding agrees with that of Osborne, Simon & Collins (2003) who reported that physics and chemistry were the two least popular subjects after compulsory secondary classes in England and Wales. Findings from teachers and students who were involved in the study suggest that the nature of physics, the perceived lack of relevance of most physics ideas to what students experience every day, the teaching approach of teachers, lack of qualified physics teachers, lack of laboratory equipment for demonstration/experimentation during physics lessons, lack of guidance/counseling services and learning of the subject mainly by theory were the major school-based factors that affect the low enrolment of students for the subject. These findings are similar to those reported by Williams *et al.*,(2003) that students find physics to be a boring subject and Erinosho (2013) that physics was perceived as abstract in nature as a result of which most students after the compulsory years of secondary education do not wish to continue with the subject.

In answer to the research question: What is the level of enrolment for physics in the Senior Secondary Certificate Examination? - the study found that the level of enrolment of students for physics at the senior secondary certificate level is low in Nigeria.

8.2.2 What is the pattern of attainment of physics students who enrolled in the senior secondary certificate examination?

The finding of the study suggests that the result of physics students who are enrolled for the senior secondary certificate examination in Nigeria has not followed a consistent pattern. Also, although physics was the least popular core science subject among students, those who choose the subject at the certificate examination level, obtain better grades than in chemistry and biology. The study also revealed that the average attainment of students in all 3 core science subjects in Rivers State – classified as educationally advantaged, was higher than the national average. Generally, the study reveals that students' physics attainment as demonstrated in the Physics Attainment Test that was used in the study was poor.

The lack of consistency in the pattern of attainment may be suggestive of a lack of successful government's policy, programme or intervention in the area of science education in Nigeria. This assumption is consistent with the views of the World Bank as reported by Greaney & Kellaghan (2008), that many developing countries do not systematically assess progress in the learning outcomes of their students and so are unable to ascertain policy and programme effectiveness in their countries. Data from the study suggest that schools are poorly funded and lack adequate resources for effective teaching and learning of science subjects.

Although the present study did not investigate reasons for the relatively poor performance of students in biology than in physics (or chemistry), the situation may be attributed to the mass enrolment for the subject in the certificate examination to satisfy the registration requirement of at least one science subject, irrespective of candidates' aptitude or interest for the sciences. Students interviewed in this study were of the view that most students opt for biology rather than physics as it appears to be more relevant to their everyday life and that physics was taught usually theoretically as a result of lack of teaching and learning resources. Also, students who may have the interest but lack the aptitude for the subject are not likely to achieve better grades. These assumptions agree with those of Erinosho (2013) and Williams, *et al*.(2003) who opined that students are likely to obtain better grades when they have interest in what they study or learn. Also, Steinkamp & Maehr (1983) reported that students' attainment in science subjects have strong correlations with their mental ability more than their attitude to the subject. The study has also shown that students' attainment in physics is poor considering their performance in the PAT examinations. This result is congruent with the findings of earlier studies in Nigeria that have reported poor students' attainment in the sciences (Obomanu & Adaramola, 2011; Arokoyu & Aderonmu, 2013).

To answer the research question on the pattern of attainment of physics students who enrolled in the Senior Secondary Certificate Examination (SSCE), the study found that there is not consistent pattern in the attainment of students in all 3 core science subjects in Nigeria.

8.2.3 How do teacher qualification and experience relate to the enrolment and attainment of students in physics?

The findings of this study from quantitative data on the association between teacher qualification and teacher experience with students' enrolment in physics do not agree with the result of the qualitative data from the study. Whereas the quantitative data suggests that teacher qualification and teaching experience do not significantly correlate with students' physics enrolment, qualitative data of interviews both with students and teachers suggests that students' enrolment in physics is affected by teacher factors. The difference between the outcomes of the quantitative and qualitative data suggests that further research needs to be done possibly with much larger sample size and number of schools. However, the result of the qualitative data is in agreement with those of Blickenstaff (2006) and the Institute of Physics (2012) who maintained that the unpleasant experiences of girls in science classes dissuade them from continuing with the subject after the compulsory years of education. Similar findings have been reported by Dick & Rallis (1991) and Erinosho (2013) that the shortage of qualified science teachers influences the enrolment of students to study science.

The study also found that students' attainment in physics correlated significantly with teachers' qualification. This finding is consistent with those of Sparkes (1995), Darling-Hammond (2000) and Nye, Konstantopoulos & Hedges (2004) whose findings suggested that physics students taught by qualified teachers are most likely to perform better. However, the study also found that students' attainment in physics did not correlate significantly with teachers' years of teaching experience. This finding does not agree with those of Rice (2010) and Ilie, Jerrim & Vignoles (2016) who found a positive association between years of teaching experience and teachers' effectiveness. Rice (2010) however stressed that the effect of the teachers' experience is strongest during the first few years in the career. In the present study, it is probable that the involvement of experienced physics teachers in administrative roles may have affected their classroom effectiveness or that once they have a certain amount of experience, getting more makes little difference.

To answer the question on how teacher qualification and experience relate to the enrolment and attainment of students in physics, the study found that students' attainment in physics correlates significantly with teacher qualification and that there is no significant correlation between students' attainment and teachers' years of teaching experience. Also, whereas quantitative data suggests that teacher qualification and teaching experience do not significantly correlate with students' physics enrolment, qualitative data suggests that teacher factors affect student enrolment for physics.

8.2.4 What is the extent of availability of physics resources for teaching and learning in secondary schools in Rivers State, Nigeria?

On availability of physics laboratory, self-report by teachers on questionnaires suggests that schools have laboratories for physics teaching and learning. However, results from interviews and observations in the study suggest that most secondary schools do not have a physics laboratory for teaching and learning. The findings of this study also suggest that most schools in Nigeria do not have enough resources and laboratory facilities for teaching and learning and that most schools do not have computers with teachers not using online demos and simulations in their physics classes. These findings on the poor state of resources for physics teaching is consistent with those of Omosewo (1995), Alebiosu (2000), Onipede (2003) who conducted their studies in South West Nigeria and reported that most schools do not have laboratories for the teaching and learning of science. The finding on the availability of a laboratory as reported by the teachers is similar to that of Adeyemi (2005, 2008) who conducted his studies in Ondo and Ekiti states of South West Nigeria, and reported that 48.2% of schools in his study have 3 separate laboratories for physics, chemistry and biology. However, Adeyemi (2005, 2008) also reported that most of the schools with laboratories were concentrated in the urban areas. 4 of the 8 schools that were used in this study are located in rural areas and may explain the difference in the findings between the presented study and those of Adeyemi (2005, 2008).

In answer to the research question therefore, findings from the study suggest that the availability of resources for the teaching and learning of physics in secondary schools in Nigeria is poor.

8.2.5 To what extent are available physics resources utilized for teaching and learning in secondary schools?

The study found that most teachers do not readily utilize available resources for the teaching and learning of physics in their schools. This finding on the teachers' low level of utilization of available resources for the teaching of physics in schools in Nigeria is in agreement with those of some studies that were conducted elsewhere and in Nigeria, for instance, Hanuscin (2007), Stephen (2011) and Dike & Halima (2015) who reported that some teachers rarely utilize resources for teaching science even where there are available laboratory resources. In Nigeria, Dike and Halima (2015) studied the problem of laboratory facility provision and utilization and reported that some teachers do not often use or sometimes never use available science resources for their teaching. However, Olagunju & Abiona (2008) in Nigeria conducted research on resource improvisation and utilization for biology lessons and found that available resources were used by teachers in their teaching. Apart from the simple type of resources that were identified as available and used by teachers, the present study is focused particularly on physics and not biology and so, could not make any fair comparison. Further on resources, the study found that most teachers do not use online resources to facilitate their teaching through enhanced imagery and interactivity with scientific models.

Some physics teachers who participated in the study expressed their views on utilization of resources in teaching. Some do not see the need to use resources, others consider the vastness of the physics curriculum and prefer to cover the content theoretically before exposing students to practical work if time allows, while some teachers simply trivialize lab work and so make it optional. All these findings suggest that students have not been adequately exposed to laboratory and hands-on activities in the study of physics in schools. The lack of teachers' appreciation of the place and use of relevant facilities in teaching physics may be suggestive that teachers lack sufficient knowledge and familiarity in the use of laboratory resources. According to Vorsino (1992), teachers' lack of adequate background knowledge in scientific content and lab resources could be responsible for their non-use of available resources.

To answer the research question on the extent of utilization of available physics resources for teaching and learning in secondary schools, findings from the study suggest that available resources are not adequately employed by physics teachers in Nigeria to facilitate learning in their physics lessons.

8.2.6 To what extent does the availability and utilization of physics resources influence students' enrolment and attainment in physics?

Findings from the study using school physics enrolment data and resource factors computed from teachers responses suggest that availability and utilization of physics resources correlate significantly with students' attainment in physics but not with physics enrolment. However, other questionnaire responses from physics teachers on school-related factors that influence physics enrolment and attainment alongside qualitative data from the interviews with both students and teachers suggest that, availability and utilization of resources for teaching significantly influence the enrolment and attainment of students in physics.

The finding associating students' enrolment and attainment with resource availability and utilization is consistent with those of Hedges, Laine & Greenwald (1944a, 1994b, 1996), Kruegar (2003), Bello (2012), Savasci & Tomul (2013) and OECD (2015) whose findings suggest that students' enrolment and attainment are influenced by resource availability and utilization. For instance, Bello (2012) investigated the effects of physics lab availability and utilization on physics students' enrolment and attainment in senior secondary schools in Nigeria and found that parents enrol their children and wards in schools with better equipped laboratories and adequate teaching resources. Also, OECDreported that the availability and utilization of teaching and learning resources in schools were found to be associated with students' attainment in many OECD countries (OECD, 2015). What these findings suggest is that schools that are well resourced are more likely to attract students and that the use of adequate resources and laboratory experiences for science lessons have the potential of enhancing students' understanding of scientific concepts.

To answer the research question on the influence of resource availability and utilization on physics students' enrolment and attainment, this study found a significant correlation between resource availability and utilization with students' attainment in physics. Also, whereas qualitative data and some data from teachers' questionnaire responses suggest an association between resource factors and students' enrolment, direct computation of school physics enrolment with resource factors does not seem to suggest any significant correlation. This suggests the need for some further research with possibly an enlarged scope to investigate the association of resource factors with physics enrolment in schools in Nigeria.

8.2.7 What are the teaching strategies and classroom interactions adopted by physics teachers?

Findings from the opinion of teachers in this study suggest that demonstration and problem solving are the strategies they commonly used for their physics lessons while field trips, excursions, lecture, laboratory, project method, and collaborative learning strategies are not frequently used. However, most students did not agree with their teachers that teachers use demonstration strategy frequently in their physics classes. Similarly, findings from the classroom observations in this study suggest that most teachers use lecture - 'talk-chalk'-method more commonly to teach physics.

Teachers' use of teacher-centered approaches in the teaching of physics is inconsistent with the demand of the national physics curriculum in use in Nigeria that advocates a student-activity teaching orientation (FME, 2009). The finding from classroom observations and the opinion of most students that teachers commonly use teacher-centered approaches for the physics lessons agrees with those of UNICEF (2009), Modebelu & Nwakpadolu (2013), Buabeng, Ossei-Anto & Ampiah (2014) and Faremi (2014) whose findings suggest that most teachers adopt traditional, teacher-centered, talk-chalk teaching methods for their classes. For instance, Buabeng, Ossei-Anto & Ampiah (2014) studied physics teaching and learning in Ghanaian high schools and found that most physics teachers use teacher-centered approaches in their classroom interaction such as lecture and discussion methods. Studies have shown that the use of student-centered approaches in the teaching of science, where students' classroom experiences are enriched by experimental, hands-on and activity based instructions, were more effective than the traditional teaching approaches. For example, Wise (1996) carried out a secondary meta-analysis to examine how the use of an experimental teaching approach affects students' attainment in secondary schools in the United States and found that experimental teaching strategies were more effective at enhancing students' attainment than the traditional teaching approaches.

In answer to the research question therefore, on the teaching strategies and classroom interactions adopted by physics teachers in schools in Nigeria, whereas teachers' opinions suggest that demonstration and problem-solving strategies are most commonly used, students and classroom observation reports suggest that teachers commonly use teacher-centered, traditional teaching strategies for teaching physics. Generally, the study also found that teachers do not often use field trips, excursions, laboratory collaborative learning and project teaching approaches for their physics lessons.

8.2.8 To what extent does the teaching strategy and classroom interactions adopted by teachers influence the students' enrolment and attainment in physics?

Findings from the study suggest that teacher-centered strategies that teachers adopt for the teaching of physics in schools in Nigeria do not encourage more students to enrol for physics at the non-compulsory stage of secondary education and that such teacher-centered strategies may have affected the attainment of physics students.

The findings of this study on the effect of the teaching strategy and classroom interactions that teachers adopt on physics students' enrolment, support those found by of Ebenezer & Zoller (1993), Sundberg, Dini & Li (1994), Osborne, Simon & Collins (2003) and Aina & Akanbi (2013) for instance, whose findings suggest that the quality of teaching correlates significantly with students' willingness to continue with the study of physics after the compulsory years of secondary education. For example, Sundberg, Dini & Li (1994) investigated the effect of teachers' approach in biology and found that teachers' use of content-intensive approach was ineffective and that students' participation in laboratory work supports their understanding more positively than in lectures and class discussions. Similarly, the finding of this study that suggests that the teaching strategy of the teacher affects students' understanding and attainment is congruent with those of Wise (1996) and Akanwa & Ovute (2014) who found that teachers' use of a variety of teaching strategies that expose students to diverse ways of learning and get them involved actively in the learning process, enhances their understanding better than traditional teacher-centered approaches. For instance, Wise (1996), found that the use of a variety of teaching approaches like the use of instructional media, questioning, adequate resources and facilities at the secondary school level, were more effective at improving students' attainment in science than the traditional 'talk-chalk' method.

To answer the research therefore, findings of this study suggest that the teaching strategy and classroom interactions adopted by teachers significantly influence the students' enrolment and attainment in physics.

8.2.9 To what extent does the school climate affect teaching and learning in the school?

On the effect of school climate on teaching and learning of physics in schools, findings from the opinions of most students suggest that there exists a friendly and supportive environment in schools in Nigeria that encourages effective teaching and learning in their schools. However, teachers differed in their opinion as most of them claimed that students' unwholesome behaviors such as bullying and use of drugs in schools negatively affect the effective teaching and learning in schools, with incidences of class disruption. On the state of the physical school environment that could support teaching and learning activities, both students and teachers were of the opinion that their schools have inadequate infrastructure that may negatively affect learning activities.

The finding of this study on friendly and supportive school environment from the view point of the students, is in agreement with that of Duze & Ogbah (2013) who studied the challenges of school climate in Nigeria and found that teachers in Nigerian schools sufficiently support students' learning and that students with their peers enjoy adequate cordial relationships that enable them to enjoy their school life. The opinion of physics teachers on the unfriendly lifestyle of some students that affects teaching and learning in schools is consistent with the country report of UNICEF (2009) for Nigeria that bullying of students in schools by fellow students was a concern to many students in Nigerian schools who sometimes stay away from school to keep safe. Students' learning and attainment in schools has been associated with the school climate and quality of school life by many studies (UNICEF, 2009; Thapa, *et al.*, 2013; Duze & Ogbah, 2013).

In answer to the research question therefore on the extent to which the school climate affect teaching and learning in schools in Rivers State, Nigeria, the findings in this study from the viewpoint of students suggests that students enjoy a friendly, helpful and supportive environment both with their peers and students which encourages effective teaching and learning. However, teachers' opinion suggests that, students' anti-social activities in schools result in unhealthy school climate and an environment that does not support effective teaching and learning in schools. In the light of the importance of school climate for effective teaching and learning, the different viewpoints of teachers and students indicate the need of further studies on school climate in Nigerian schools with a view of establishing the *status quo* for policy and planning.

8.3 Contribution to knowledge

This thesis has contributed to knowledge in three ways. First, most studies have investigated general factors that affect students' enrolment and attainment in science subjects. This study has focused on school-based factors that affect students' enrolment and attainment not generally in science subjects, but specifically in physics. The findings of my research which has focused on physics will therefore extend the frontiers of knowledge on school-based factors that affect students' enrolment and attainment in physics.

Secondly, a search in literature on school-related factors affecting students' enrolment and or attainment in Nigeria will show that most studies have been conducted using questionnaires. My use of both quantitative and qualitative methods and the results therefrom has provided a more in-depth understanding of the effects of school-based factors and the general state of teaching and learning of physics on students' enrolment and attainment in physics at the secondary school level in Nigeria.

Finally, the findings of this study have contributed to the understanding of the poor state of resource availability for teaching and learning of physics in Nigerian schools, the lack of teachers' participation in Continuing Professional Development Programmes to update and upgrade their knowledge and skills both in pedagogy and subject knowledge and lack or inadequate checking and control of teachers' activities amongst others. It is hoped that the findings and recommendations of this study will provide some baseline data and information for future researchers to carry out studies in the area and also provide government and other stake holders with knowledge of the current state of physics teaching and learning, enrolment and attainment in the schools so as to examine policies and practice that would guarantee good support to teachers and students with a view to enhancing teaching and learning in the schools.

8.4 Implications of the findings

The findings of this present study on school-based factors that affect the enrolment and attainment of students in the senior secondary school physics have implications for policy makers, practitioners and future researchers in the area. These implications are discussed below.

8.4.1 Implications for policy and planning

The findings of the present research indicate that students' enrolment and attainment in physics are low both at the National and state levels. The implication of this finding is that physics is becoming more unpopular among secondary school students. Considering the relevance of physics in national and technological development, it is important that policy makers device ways of popularizing the study of physics among school children. This can be done by making the study of science compulsory in schools and also by designing a 'science for art' module in physics, chemistry and biology for the art students as practiced in China and mentioned in chapter 7 of this thesis.

Similarly, the finding of this study on the students' perception of the nature of physics and the lack of relevance of most physics ideas to students' experiences (for which the subject is becoming unpopular) has implications for curriculum developers and policy makers. The finding implies that students are more likely to choose physics if the content is presented in concrete and illustrative ways that connect physics ideas with the everyday experiences of the students.

Also, the findings that lack of qualified physics teachers, lab equipment for demonstration and experimentation, and guidance/counselling services affect the enrolment of students for physics and attainment, have implications for policy makers. They are to ensure that quality teachers are recruited and retained in public schools, possibly by enhancing their wages and welfare packages with ample opportunities for training and re-training on the job.

Furthermore, the finding that students' attainment in physics correlated significantly with teachers' qualification and resource availability and utilization has some implications for policy and planning. The provisions of adequate guidance/career counselling services in all secondary schools, regular employment of qualified physics teachers for the schools and conscientious and consistent government policy to equip schools laboratory facilities are likely to improve the popularity of physics and attainment in the subject among students after the compulsory years of schooling.

Also, the finding of this study indicates that physics teachers do not regularly attend continuing professional development programs. The implication here is that physics teachers may not be abreast of current research-informed teaching and learning strategies that would facilitate student learning. It is therefore important that policy makers make provisions for and fund the regular training and re-training of in-service teachers, and the inclusion of continuing professional development activities as mandatory career growth route for teachers in Nigeria.

The finding of the present study indicates that the results of physics students and generally the sciences have not followed a consistent pattern for the 10 year period as reported. This is suggestive that there may not have been a consistent policy of monitoring the progress of students' attainment. It is important that government should consistently evaluate its policy and programmes on science education to monitor their effectiveness or otherwise with a determination to sort out and fix problematic areas to ensure the successful implementation of such policies.

The finding of this study that some physics teachers do not attend school regularly and that most physics teachers employ more teacher-centred teaching approaches in their teaching, have some implication for policy and planning. It is important that government agencies tasked with the responsibility of quality assurance in schools carry out their oversight functions of monitoring the activities of teachers in schools. Impromptu visits and the use of anonymous feedback questionnaires for students about their class experiences and the teacher may be useful to get some information and to curtail the excesses of such teachers.

8.4.2 Implications for practitioners

The findings of this research on the effects of school-based factors on secondary school students' enrolment and attainment in physics have some implications for practice that shall be discussed hereunder.

The finding of this research, that physics teachers adopt more teacher-centred approaches and that the approach that teachers adopt affects students' enrolment and attainment in the subject, has implications for practice. Teachers' use of teacher-centred approaches that do not actively engage and involve students in the learning process is likely to showcase physics as a dry, abstract and uninteresting subject for students to enrol in. It is therefore recommended that physics teachers adopt more student-friendly approaches with appropriate hands-on activities and that physics content be made relevant to the everyday life experiences of the learners with suitable illustrations so as to make physics relevant and interesting to the learners.

The finding of this study that students' attainment correlated significantly with teachers' qualification implies that students who are taught by more qualified teachers are likely to have their students achieve better. It is therefore important that teachers improve on their qualification by enrolling in in-service training and continuing professional development programmes on content and pedagogical areas to enhance their qualifications for better effectiveness.

Also, the finding on teachers' low level of utilization of available resources for physics teaching and learning in schools, and their perception on the utilization of resources for teaching implies that the teaching of physics will continue to suffer with the resultant effect of more and more students opting out from the subject and those who dare to choose the subject may not be successful if nothing is done to intervene. It is therefore recommended that teachers update their knowledge by regularly attending CPD programmes, workshops and seminars on current research studies on effective teaching and classroom practices and the use of appropriate resources for their lessons. This is so as Vorsino (1992) averred that teachers' non-use of resources when available was as a result of their lack of adequate knowledge in scientific content and use of relevant laboratory resources. It is therefore hoped that teachers' attendance of Continuing Development Programmes on subject content, pedagogy and instrumentation may improve their understanding and usage of available resources for the best classroom and learning experiences of students.

8.4.3 Implications for future research

The findings of this study have some implications for future researchers both in the area of school-based factors and in Nigeria. This research found that the enrolment and attainment of students in physics is generally poor at the national level and in Rivers State. The implication of this finding for future researchers is the fact that it is important to conduct a nation-wide survey on the effect of school-based factors which may assist the nation in the effective monitoring of its policies and plans on science education. Also, this study focused on physics enrolment and attainment. It may be important to carry out the same study for biology, chemistry, mathematics and other STEM subjects so as to holistically investigate the effects of school-based factors and, generally, the state of teaching and learning of STEM subjects in secondary schools in Nigeria.

Again in the present study, whereas quantitative data suggests that teacher qualification and experience do not significantly affect physics enrolment, qualitative data suggests the contrary. There was also disagreement in results from quantitative and qualitative data and between teachers and students on the effects of school resource availability, utilisation and effects of school climate on students' enrolment. The implication here is that the contrasting findings suggest the need for further studies in those areas.

8.5 A critique of the study

With hindsight and reflection on my research, although the research strategy adopted for this study has worked well, there are certain aspects that could have been improved. Some of these areas of strengths and weaknesses are discussed below.

The use of mixed methods for the study has helped in methodological triangulation in which different methods have been utilised to study the same aspect of the research design. For instance in the present study, teachers and students were investigated using questionnaires, interviews and classroom observations. If not for constrain of time, the quality of the outcomes of the study may have been improved with a more systematic data collection procedure in stages in which, say, questionnaires are administered, retrieved and analysed before follow-up interviews (to thoroughly probe areas that may have been highlighted or brought to the fore by questionnaire responses) are conducted and analysed and then followed up by classroom observations. Alternatively, conducting classroom observations followed by questionnaire administration and then interviews with data from the preceding stage analysed before proceeding to the next stage.

In the present study, a cross-sectional approach has been used to investigate the effect of teacher quality on students' enrolment and attainment in physics. In the circumstance and time frame for a PhD research, the research strategy has worked well with valid outcomes of the understanding of teacher factors in physics students' enrolment and attainment in secondary schools in Nigeria. However, it is possible that the results and arguments of the study would have been more strengthened if it was feasible to conduct a longitudinal study to compare the teacher effects on students' enrolment and attainment by systematically monitoring the enrolment and attainment trends of students passing through several teachers with different qualifications and experience over some years.

Finally, in terms of the sample size of teachers and number of schools, all 14 teachers in the 8 schools that were selected for the study were used for the study. For the qualitative data analysis, the use of mixed methods with interviews and class observations and the enormous data so generated posed no serious problem with the small sample sizes of teachers and the number of schools. However, for quantitative analysis, the small sample sizes were inadequate for any robust statistical analysis involving the teachers and the number of schools. It is possible that the results and arguments would be more strengthened if it was feasible to include say about 30 schools with much more teachers in a large scale research.

8.6 Concluding comments

Physics is one of the three core science subjects that is taught in secondary schools across the globe. Many research studies have also reported that the subject is one of the least popular among school children in the post-compulsory classes of secondary education. Although many studies have investigated factors that affect students' choice and attainment in science subjects, not many have particularly focused on school-based factors affecting students' enrolment and attainment in physics, particularly in Nigeria. The current study has highlighted the state of teaching and learning of physics in Nigerian schools and how that has affected the interest, motivation and attainment of students in the subject at the senior secondary school level.

The study has found that the enrolment and attainment of students in secondary school physics is poor with suggestions made to stem the trend, popularise physics intake among students and enhance student attainment in the subject. The study has also identified school-based factors that affect the teaching and learning of secondary school physics in Nigeria. Particularly, this study has found that teacher and school resource factors affect students' enrolment and attainment in physics. The study has also suggested ways by which physics teachers can be effectively motivated so that students get the best experiences in schools that would adequately support their learning and encourage them to continue with the subject in their post-compulsory years of secondary education.

Appendices

Appendix A: Questionnaire for Physics Teachers (QPT)

Time taken to complete this questionnaire
Started: **Finished:**

About the school

1. Name of School:.............................

2. What is the location of your school?
*(Fill in **one** circle only)*

Rural ○ Urban ○

3. School type *(Fill in **one** circle only)*

Single sex: Male ○ Female ○
Mixed ○

About the Teacher

4. Are you female or male?
*Fill in **one** circle only*

Female ------------------------------------○
Male ---------------------------------------○

5. How old are you?
*Fill in **one** circle only*

Under 25 ----------------------------------○
25–29 -------------------------------------○
30–39 -------------------------------------○
40–49 -------------------------------------○
50–59 -------------------------------------○
60 or older --------------------------------○

6(a) By the end of this school year, how many years would you have been teaching altogether? ________________________

(b) For how many years would you have taught Physics by the end of *this* school year? ____________________________

7. Which qualification(s) do you currently have? *(Fill in **circle(s)** as appropriate)*

a. NCE (Physics with any combination)---○
b.B.Ed/B.Sc (Ed) (Physics)------------------○
c. B.Ed/B.Sc(Ed) (Any Science)------------○
Specify subject ------------------------------
d. B.Sc(Physics) -----------------------------○
e. B.Sc (Any Science) -----------------------○
Specify subject ------------------------------
f. B.Sc or B.Engr(Engineering)-------------○
Please specify area.........................
g. Post Graduate Diploma in Education --○
h. M.Ed/M.Sc ---------------------------------○
Specify area of specialty---------------------
i. PhD---○
Specify area of specialty-----------------------

Laboratory resources

8(a) Does your school have physics laboratory?

Yes **No**

*Fill in **one** circle only* ----------------------○--○

(b) If yes, how would you rate the level of equipment? *(Fill in **one** circle)*

Very high ---------------------------------------○
High ---○
Moderate ---------------------------------------○
Low --○
Very low --○

(c) Does your school have Lab assistant(s)

Yes **No**

*Fill in **one** circle only* ----------------------○--○

9. How often do you use the laboratory and its facilities in teaching Physics? *(Fill in **one** circle only)*

Almost every lesson ---------------------○
One of every two lessons----------------○
About once in a term --------------------○
Rarely ---------------------------------------○
Never ---------------------------------------○

9(b) Since this term, have your students conducted any experiment or demonstration themselves?

Yes **NO**

*Fill in **one** circle only* ----------------------○--○

If No, Please give reason(s) _______________
____

10(a)In the topic area - **Interaction of Matter, Space and Time**, the curriculum suggests that you need some apparatus for demonstrations like measuring instruments, retort stands, circular motion apparatus, G-Clamp, magnets, force boards, resonance tubes, turning forks. **To what extent does your school have these apparatus?**

Don't have **Don't have enough** **Have enough**

*(Fill in **one** circle only)* -------○ ----○ -----○

(b) In the topic area – **Conservation principles**, the curriculum suggests that you need some apparatus for demonstrations like thermometers ball and ring apparatus, bar breaker apparatus, bunsen burners, linear expansivity apparatus, calorimeter, electroscope and Boyle's law apparatus.
To what extent does your school have these apparatus?

Don't have / **Don't have enough** / **Have enough**

(*Fill in **one** circle only*) -------○ ----○ -----○

(c) In the topic area – **Fields at rest and in motion,** the curriculum suggests that you need some apparatus for demonstrations like magnets, batteries, solar cells, ammeter, voltmeter, galvanometer, resistors, potentiometer, Wheatstone bridge and electrolysis apparatus.
To what extent does your school have these apparatus?

Don't have / **Don't have enough** / **Have enough**

*(Fill in **one** circle only)* -------○ ----○ -----○

(d) In the topic area – **Energy quantization and duality of matter**, the curriculum suggests that you need some apparatus for demonstrations like black box, smoke cell, microscope, steel balls and solar panels.
To what extent does your school have these apparatus?

Don't have / **Don't have enough** / **Have enough**

(*Fill in **one** circle only*) -------○ ----○ -----○

(e) In the topic area – **Wave motion without material transfer**, the curriculum suggests that you need some apparatus for demonstrations like ripple tank and accessories, ray box, mirrors, prisms, lenses, sonometer, electric bell and oscilloscope.
To what extent does your school have these apparatus?

Don't have / **Don't have enough** / **Have enough**

*(Fill in **one** circle only)* -------○ ----○ -----○

School interactions/professional training

11. In your school, how often do you have the following types of interactions with other teachers?
*Fill in **one** circle for each row*

Never or almost never / **2 or 3 times per month** / **1-3 times per week** / **Daily or almost daily**

a) Working or preparing instructional materials----- ○ --○ -- ○ --○
b) Visits to another teacher's classroom to observe his/her teaching ----------- ○ -- ○ -- ○ -- ○
c) Informal observation of my classroom by other teachers --○ --○ -- ○-- ○

(b) In your school, do teachers have a forum of sharing classroom experiences and how to teach particular concepts?

Yes / **No**

*Fill in **one** circle only* -------------- ------- ○--○

12(a) Are you a member of professional organization for physics teachers?

Yes / **No**

*Fill in **one** circle only* --------------------○-- ○

(b) In the past two years, have you participated in professional development in any of the following?

*Fill in **one** circle for each row*

	Yes	No
a) Physics content	○	○
b) Physics pedagogy/instruction	○	○
c) Physics curriculum	○	○
d) Integrating information technology into physics	○	○
e) Improving students' critical thinking or inquiry skills	○	○
f) Physics assessment	○	○

Your School

13. In your current school, how severe is each problem?

*Fill in **one** circle for each row*

	Not a problem	Minor problem	Serious problem
a) The school building needs significant repair	○	○	○
b) Classrooms are overcrowded	○	○	○
c) Teachers do not have adequate workspace outside their classroom	○	○	○
d) Materials are not available to conduct physics experiments or investigations	○	○	○

14a) Do you use a textbook as the basis for instruction in teaching physics?

	Yes	No
*Fill in **one** circle only*	○	○

(b) Does each student have his or her own textbook?

	Yes	No
*Fill in **one** circle only*	○	○

15(a) In teaching physics to the students how often do you usually ask them to do the following?

*Fill in **one** circle for each row*

	Every or almost every lesson	About half the lessons	Some lessons	Never
a) Watch me demonstrate an experiment or investigation	○	○	○	○
b) Conduct experiments or investigations	○	○	○	○
c) Use laws and formulas of physics to solve routine problems	○	○	○	○
d) Give explanations about something they are studying	○	○	○	○
e) Relate what they are learning in physics to their daily lives	○	○	○	○
f) Have students memorize formulas and procedures	○	○	○	○
g) Read their textbooks or other resource materials	○	○	○	○

16. In teaching physics to the students how often do you usually use the following strategies?

*Fill in **one** circle for each row*

	Every or almost every lesson	About half the lessons	Some lessons	Never
(a) Demonstration	○	○	○	○
(b) Lecture	○	○	○	○
(c) guided discovery	○	○	○	○
(d) Laboratory	○	○	○	○
(e) field trip	○	○	○	○
(f) Excursion	○	○	○	○
(g) collaborative learning	○	○	○	○
(h) Problem solving	○	○	○	○
(i) Project	○	○	○	○
(i) Any other	○	○	○	○

17. During physics lessons, how often do you use a computer as a teaching aid or instructional material?

Never
Some lessons
About half the lessons
Every or almost every lesson

*Fill in **one** circle only*------------○---○---○--○

18 (a) How often do students use calculators in their physics lessons for the following activities?
*(Fill in **one** circle for each row)* **Never**
Some lessons
About half the lessons
Every or almost every lesson

a) Doing scientific procedures or experiments ----------------------○--○--○--○
b) Modeling and simulations------○--○--○--○
c) Solving equations ---------------○--○--○--○
d) Processing and analyzing data-○--○--○--○
e) Research aspects of physics on the internet ----------------- -○--○--○--○

18 (b) How often do students use computers in their physics lessons for the following activities?
*(Fill in **one** circle for each row)* **Never**
Some lessons
About half the lessons
Every or almost every lesson

a) Doing scientific procedures or experiments ----------------------○--○--○--○
b) Modeling and simulations------○--○--○--○
c) Solving equations ---------------○--○--○--○
d) Processing and analyzing data-○--○--○--○
e) Research aspects of physics on the internet ----------------- -○--○--○--○

19. Physics appears to be the least popular science subject among SSS students. What do you think are the main school-related factors affecting students' choice of Physics?
*(Fill in **one** circle for each row)* **Can't say**
Strongly Disagree
Disagree
Agree
Strongly Agree

a) Lack of qualified physics teachers -----------------------○--○--○--○-○
b)Teaching physics by theory without practical work-------○--○--○--○-○
c) Lack of lab equipment for Demonstration/experiments-○--○--○--○-○
d) Lack of career guidance/ counseling services-----------○--○--○--○-○
e) Unsocial lifestyle of some Physics teachers -------------○--○--○--○-○
f) Others, please specify………………………
……………………………………………..

20. In a typical double period of a physics lesson of 80 minutes, how many minutes do you or your students spend on each of the following activities? (*Write in minutes)*
The total should add to 80 minutes

a) Teacher teaching new material to the whole class ------------------------ ---------
b) Students sharing ideas from new material to the whole class------------------- ---------
c)Students working problems on their own or with other students ----- ----------
d) Teacher reviewing and summarizing what has been taught for the whole class---- ----------
d) Teacher reviewing homework ------ ---------
e) Re-teaching and clarifying content/procedures for the whole class ----------
f) Classroom management tasks not related to the lesson's content/purpose (e.g.interruptions and keeping order--- --------
Total -------------------------------- 80 minutes

21. In your view, to what extent do the following limit your teaching of physics?
*Fill in **one** circle for each row*

	Not at all	A little or some	A lot
a) Shortage of computer hardware	○	○	○
b) Shortage of computer software	○	○	○
c) Shortage of textbooks for students' use	○	○	○
d) Shortage of other instructional equipment for students' use	○	○	○
e) Shortage of equipment for your use in demonstrations and other exercises	○	○	○
f) Inadequate physical facilities	○	○	○
g) High student/teacher ratio	○	○	○
h) unavailability of computers with internet access (for on-line resources)	○	○	○

School climate

22. In your school, to what extent is the learning of students hindered by the following phenomena?

	A lot	To Some extent	Very little	Not at all
a) Student truancy	○	○	○	○
b) Students arriving late for school	○	○	○	○
c) Students not attending compulsory school events (e.g., school assemblies) or excursions	○	○	○	○
d) Students lacking respect for teachers	○	○	○	○
e) Disruption of classes by students	○	○	○	○
f) Student use of alcohol or illegal drugs	○	○	○	○
g) Students intimidating or bullying other students	○	○	○	○
h) Students not being encouraged to achieve their full potential	○	○	○	○
i) Poor student-teacher relations	○	○	○	○
j) Teachers having to teach students of heterogeneous ability levels within the same class	○	○	○	○
k) Teachers' low expectations of students	○	○	○	○

Thank you very much

for your cooperation in completing this questionnaire.

Appendix B: Questionnaire for Physics students

Time taken to complete this questionnaire
Started: **Finished:**

School information/Gender

1. Name of School:…………………………………………………………………..
2. What is the location of your school? *(Fill in **one** circle only)*
Rural ○
City ○
3. School type (*Fill in **one** circle only*)
Single sex: Male ○ Female ○
Mixed ○
4. Are you a female or a male? *(Fill in **one** circle only)*
Female ○
Male ○

About Physics enrolment

5. What do you think are the main school-related reasons for your choosing to study physics at the Senior Secondary School level? *(Fill in **one** circle only in each row)*	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**	**Can't Say**
a. The way physics contents in Basic science was taught motivated me to choose physics	○	○	○	○	○
b. Physics lessons are interesting and stimulating	○	○	○	○	○
c. My school has enough facilities for conducting experiments or investigations in physics.	○	○	○	○	○
d. My school has qualified physics teachers and that gives me the confidence to choose the subject.	○	○	○	○	○
d. The guidance counselor in my school said I should do physics because he/she thinks I can.	○	○	○	○	○
e. I enjoy my physics teacher. He shows great interest in the subject	○	○	○	○	○
Any other? (Please state) ……					

About your physics lessons

6. Please indicate your level of agreement to the following questions about your physics lessons *(Fill in **one** circle only in each row)*	**Strongly Agree**	**Agree**	**Disagree**	**Strongly disagree**	**Can't Say**
a) I am always excited to go for my physics classes.	○	○	○	○	○
b) In my physics lessons, my teacher explains how a physics idea can be applied to a number of different situations.	○	○	○	○	○
c) In my physics lessons, I have the opportunity to discuss my ideas about physics.	○	○	○	○	○
d) My physics lessons are always interesting so I enjoy them	○	○	○	○	○
e) I find it easy to apply most physics concepts to everyday problems.	○	○	○	○	○
f) I always learn new skills and ideas when studying Physics.	○	○	○	○	○
g) In my physics lessons, we are given the opportunity to do an experiment or demonstration to test our own ideas.	○	○	○	○	○
h) Students are allowed access to laboratory facilities for experiments and practical investigations.	○	○	○	○	○

7. How often do you do these activities in your physics lessons?

*(Fill in **one** circle only in each row)*	**Every or almost every lesson**	**About half the lessons**	**Some lessons**	**Never**
a) We listen to the teacher present new material	○	○	○	○
b) We work problems on our own	○	○	○	○
c) we work on problems together with other students	○	○	○	○
d) We review what has been taught	○	○	○	○
e) We review homework	○	○	○	○
f) We have oral or written tests or quizzes	○	○	○	○

8. How often do you use the following in your physics lessons?

*(Fill in **one** circle only in each row)*	Every or almost every lesson	About half the	Some lessons	Never
a) Calculator	○	○	○	○
b) Computer	○	○	○	○
c) Other technology (DVD, Video,etc)	○	○	○	○

9. How often do you do the following in your physics lessons?

*(Fill in **one** circle only in each row)*	Every or almost every lesson	About half the lessons	Some lessons	Never
a) We watch the teacher demonstrate an experiment or investigation	○	○	○	○
b) We conduct an experiment or investigation	○	○	○	○
c) We use laws and formulas of physics to solve problems	○	○	○	○
d) We give explanations about what we are studying	○	○	○	○
e) We relate what we are learning in physics to our daily lives	○	○	○	○
f) We memorize formulas and procedures of physics	○	○	○	○
g) We read our physics textbooks and other resource materials	○	○	○	○
h) We watch the teacher demonstrate physics on a computer	○	○	○	○
i) We use computer simulations on physics ourselves	○	○	○	○

About your physics teacher

10. Please indicate your level of agreement to the following questions about your physics teacher

(Fill in ***one*** *circle only in each row)*	Strongly Agree	Agree	Disagree	Strongly Disagree	Can't Say
a) My physics teacher has high expectations of what the students can learn.	○	○	○	○	○
b) My physics teacher believes that all students can learn physics.	○	○	○	○	○
c) My physics teacher gives us homework.	○	○	○	○	○
d) My physics teacher marks and returns homework quickly.	○	○	○	○	○
e) My physics teacher is interested in what the students think.	○	○	○	○	○
f) My physics teacher ensures that students complete their homework.	○	○	○	○	○
g) My physics teacher treats all students fairly regardless of their abilities in physics.	○	○	○	○	○
h) My physics teacher is good at teaching physics.	○	○	○	○	○
i) Students get along well with my physics teacher.	○	○	○	○	○
j) My physics teacher is interested in students' well-being.	○	○	○	○	○
k) If I need extra help, I always get it from my Physics teacher.	○	○	○	○	○

Your school environment

11. Please indicate your level of agreement to the following questions about your school School environment.

(Fill in ***one*** *circle only in each row)*	Strongly Agree	Agree	Disagree	Strongly Disagree	Can't Say
a) My school environment is friendly for learning	○	○	○	○	○
b) My physics classmates are cooperative and friendly	○	○	○	○	○
c) Adults in my school seem to listen to students' concerns.	○	○	○	○	○
f) At the close of school I always look forward to another school day	○	○	○	○	○
h) I am comfortable talking to teachers about problems in this school.	○	○	○	○	○

Future study

12. If you plan to continue your education, which of the following comes closest to the area you intend to study most?
*(Fill in **one** circle only)*

a) SCIENCE (e.g., physics, chemistry, biological, earth science) ○
b) HEALTH SCIENCES (e.g., dentistry, medicine, pharmacy, veterinary medicine) ○
c) ENGINEERING (chemical engineering, civil engineering, electrical engineering, mechanical engineering) ○
d) COMPUTER and INFORMATION SCIENCES (e.g., systems analyst) ○
e) MATHEMATICS (e.g., calculus, statistics) ○
f) ENVIRONMENTAL SCIENCES (e.g. Architecture, Survey, Estate Management) ○
g) OTHER FIELD OF STUDY (Please mention ……………………………………..) ○
h) I DO NOT WISH TO CONTINUE MY EDUCATION ○

12b. Please explain your choice above in terms of your career aspiration.
(*e.g. I plan to study …………(one above) because I want a future career in ……………….)*

Thank You

for completing this questionnaire

Appendix C: Questionnaire for Non-physics students

Time taken to complete this questionnaire
Started: **Finished:**

School information/Gender

1. Name of School:…………………………………………………………………..

2. What is the location of your school? *(Fill in **one** circle only)*

Rural ○
City ○

3. School type (*Fill in **one** circle only*)

Single sex: Male ○ Female ○
Mixed ○

4. Are you a female or a male? *(Fill in **one** circle only)*

Female ○
Male ○

About Physics enrolment

5. What do you think are the main school-related reasons for you NOT TO choose to study physics at the Senior Secondary School level? *(Fill in **one** circle only in each row)*	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**	**Can't Say**
a. The way physics contents in Basic science was taught made me NOT to choose physics	○	○	○	○	○
b. Physics lessons are boring.	○	○	○	○	○
d. I do not enjoy conducting experiments or investigations in physics.	○	○	○	○	○
e. The school guidance counselor and or the physics teacher advised I should not do physics because he/she thought I couldn't.	○	○	○	○	○
f. My school does not have qualified physics teachers.	○	○	○	○	○
g. Physics is not relevant for my future career	○	○	○	○	○
h. There is no physics laboratory in my school so I was afraid to choose the subject	○	○	○	○	○
i. There are no laboratory facilities for practical work in physics in my school.	○	○	○	○	○
k. My physics teacher did not show interest in the subject.	○	○	○	○	○
n. Physics is taught by theory without practical work	○	○	○	○	○
Any other? (Please state) ……………………………………………………………………… …………………………………………………………………………………………………					

Thank You

for completing this questionnaire

Appendix D: Interview schedule (for teachers)

Categories of inquiry

- Achievement/enrolment
- Physics resource availability for teaching and learning
- Physics resource utilization for teaching and learning
- Teaching strategies, emphasis on homework
- Classroom interactions

INTRODUCTION: I am Mr. Telima Adolphus. I am carrying out a study on **school-based factors that affect the achievement of senior secondary school physics students**. As a physics teacher, I consider that your invaluable experience will contribute to the success of this research. **D**ue to the difficulty of writing down all our discussions and at the same time concentrate on the interview (that is listening and understanding your views), I have a tape recorder to record our discussion. The tape can only be used for transcribing the discussion. No person will be privy to the content of records as the confidentiality and anonymity of responses is assured. The transcribed copy can be made available to participants for vetting before inclusion into my work.

<table>
<tr>
<td>
01 I am interested in the achievement of physics students in the senior secondary school examinations. What has been your observation in physics results of past Senior School Certificate Examinations in your school?

02 Records show that physics is the least popular subject among the core sciences. Is there any intervention your school is particularly doing to encourage more students to choose physics and to improve students' performance in the subject?

03 Available records show that nationally, although more boys enroll for physics than girls, girls achieve better grades than the boys. What in your opinion could explain this?

04 Let's please talk about resources for teaching physics. What would you say about the extent of availability of physics resources for teaching and learning in your school?

05 What do you think about utilization of available resources and students' achievement?

06 What teaching strategies do you frequently adopt in teaching?

07 To what extent are students involved in participatory learning during your physics classes?

08 Is there any factor that has hindered (incapacitated) the effective teaching and learning of Physics in your school?

09 Is there anything else about what we have been discussing you think I should have asked? Do you have any point(s) to raise or contribution to make?
Thank you very much for your time. I have very well enjoyed our discussion.
</td>
<td>
<u>For Researcher's view only</u>
Prompts and probes to be applied appropriately
• 01-relative to other sciences, gender(own school), school type. Note other possible explanations
• 02 –

• 04-Check availability-specifically –lab, technicians, equipped? electronic models, online, DVDs, etc, utilization

• 05- Probe opinion on relationship, Do teachers need training to use some?

• 06-Use check-list of teaching strategies. Probe reason for choice. Probe how topics that require demo are taught
07-probe students' tasks-group,individual,collaborative.
08 –Probes & prompts
</td>
</tr>
</table>

Appendix E: Interview schedule (for students)

(Students will be interviewed in a group of 5 per school)

Categories of inquiry

- Achievement/enrolment
- Physics resource availability for teaching and learning
- Physics resource utilization for teaching and learning
- Teaching strategies, emphasis on homework
- Classroom interactions

INTRODUCTION: I am Mr. Telima Adolphus. I am carrying out a study on **school-based factors that affect the achievement of senior secondary school physics students**. As a physics teacher, I consider that your invaluable experience will contribute to the success of this research. **During the main study**, the session will be audio recorded due to the difficulty of writing down all our discussions and at the same time concentrate on the interview (that is listening and understanding your views). The tape can only be used for transcribing the discussion. No person will be privy to the content of records as the confidentiality and anonymity of responses is assured. The transcribed copy can be made available to participants for vetting before inclusion into my work.

<table>
<tr>
<td>
01 As we start, I would want to know why you find yourself (not) offering physics. Most people have reasons why they do what they do. Can you tell me why you are (or not) a physics student?

02 Available record shows that physics is the least chosen among the core science subjects. What is your view on this? Why?

03 We shall now talk about the performance of boys and girls in physics. How is it like in your class? Which group leads the class? Why do you think girls (or boys) do better?

04 Let us talk about how we learn physics. Can you please narrate to me what happens in a typical physics class?

05 Is there a physics laboratory in your school?

06 How frequently do you utilize physics laboratory facilities and other resources in learning?

07 Before we conclude, what do you think can be done to make the learning of physics interesting so as to improve students' performance?

08 From what we have been discussing, Is there any issue you think we should have discussed that has not been raised?

Thank you very much for your time – It has been a wonderful time being with you!
</td>
<td>
<u>For Researcher's view only</u>
Prompts and probes to be applied appropriately
• 01-probes-interest, teacher, Intelligence, peers, parents, demand of future career

• 02-probe-teacher, teaching subject nature,

• 03-probe reason, check beliefs, stereotypes, teachers' attitude, school type

• 04-check-teacher-talk, student-participatory, teaching strategies, group, individual, teacher's role
• 05Check availability of learning resources-specifically –lab, technicians, equipped? electronic models, online, DVDs, etc,
• 06-probes/prompts

Probes/prompts
</td>
</tr>
</table>

Appendix F1: CLASSROOM OBSERVATION

- The teacher is the focus of the observation while the classroom where teaching and learning is on-going is the ‘situation’ for observation.
- The following variables shall be considered for observation:
  - ✓ The teacher’s social/personal interaction with the students
  - ✓ The teaching strategies/approaches utilized in relation to the topic taught
  - ✓ Resources utilized during the teaching session
  - ✓ Teacher/students-talk time duration (stop-watch to be used)
  - ✓ Students’ hands-on activities
  - ✓ Teacher demonstrations
  - ✓ Students’ demonstrations
  - ✓ Teachers’ role while students work
  - ✓ Form of students’ involvement in class (independent/group)
  - ✓ Question types/styles – open/closed/reflective, open or directed to boys, girls.
- Observation shall be recorded in 5 minutes interval through the lesson period.

CLASSROOM OBSERVATION SCHEDULE

<table>
<tr><th colspan="3" rowspan="2">Time duration (minutes)</th><th colspan="2">Activities</th><th rowspan="2">comments</th></tr>
<tr><th>Teacher</th><th>Students</th></tr>
<tr><td>0 - 5</td><td rowspan="8">For a single period of 40 minutes</td><td rowspan="16">For a double period of 80 minutes</td><td></td><td></td><td></td></tr>
<tr><td>5 - 10</td><td></td><td></td><td></td></tr>
<tr><td>10 – 15</td><td></td><td></td><td></td></tr>
<tr><td>15 – 20</td><td></td><td></td><td></td></tr>
<tr><td>20 – 25</td><td></td><td></td><td></td></tr>
<tr><td>25 – 30</td><td></td><td></td><td></td></tr>
<tr><td>30 – 35</td><td></td><td></td><td></td></tr>
<tr><td>35 – 40</td><td></td><td></td><td></td></tr>
<tr><td>40 – 45</td><td rowspan="8"></td><td></td><td></td><td></td></tr>
<tr><td>45 – 50</td><td></td><td></td><td></td></tr>
<tr><td>50 – 55</td><td></td><td></td><td></td></tr>
<tr><td>55 – 60</td><td></td><td></td><td></td></tr>
<tr><td>60 – 65</td><td></td><td></td><td></td></tr>
<tr><td>65 – 70</td><td></td><td></td><td></td></tr>
<tr><td>70 – 75</td><td></td><td></td><td></td></tr>
<tr><td>75 - 80</td><td></td><td></td><td></td></tr>
</table>

Appendix F2 : **Science Classroom Observation Worksheet**

School & District: ______________________ **Date:** ______________

Teacher: ______________________ **Grade/Subject:** ______________

Observer: ____

Learning Objectives

Rationale for Rating **Rating**

1. Stated Objectives

0 1 2 3 4 5 6

2. Alignment of Lesson Activities

0 1 2 3 4 5 6

3. Understanding of Purpose

0 1 2 3 4 5 6

Developing Understanding

Rationale for Rating **Rating**

4. Elicitation of Prior Understanding

0 1 2 3 4 5 6

5. Intellectual Engagement

0 1 2 3 4 5 6

6. Use of Evidence

0 1 2 3 4 5 6

7. Application of Science

0 1 2 3 4 5 6

8. Formative Assessment

0 1 2 3 4 5 6

Sense-Making

Rationale for Rating **Rating**

9. Making Connections

0 1 2 3 4 5 6

10. Constructing Understanding

0 1 2 3 4 5 6

11. Reflection and Meta-cognition

0 1 2 3 4 5 6

Classroom Culture

Rationale for Rating | **Rating**

12. Classroom Discourse

0 1 2 3 4 5 6

13. Motivation

0 1 2 3 4 5 6

Physics Attainment Test (PAT)
For Researcher's response please
Name of School:……………………………………………… Location: Rural ○ City ○ School type Single sex: Male ○ Female ○ Mixed ○

Start Here Please

Are you a female or a male? *(Fill in one circle only)*

Female ○ Male ○

Instructions: Answer all questions	Time allowed: 40 minutes

QUESTION 1(a) State the equation linking the density of a substance with its mass and volume.

(1 mark)

(b) When oil leaks out of a damaged oil-tanker, it forms a very thin layer of oil, known as an oil slick, on the water.

One such oil slick covers an approximately rectangular area measuring 2.5 × 104 m by 6.0 × 103 m.

The oil slick is 3.0×10^{-6} m (0.0000030 m) thick.

(i) Calculate the volume of the oil slick.

volume = ... m3 (3 marks)

(ii) The density of the oil is 900 kg / m3.

Calculate the mass of oil in the slick.

mass = ... kg (2 marks)

[Total: 6 marks]

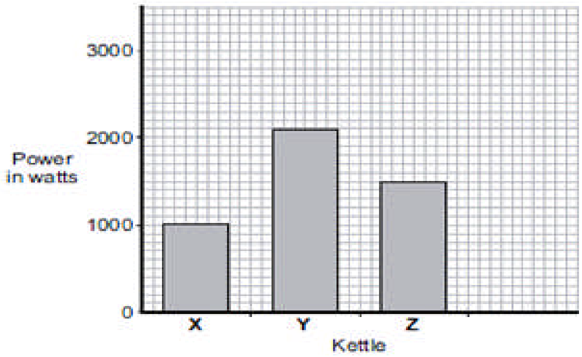
QUESTION 2. The pictures show six different household appliances.

QUESTION 2 (a) Four of the appliances, including the fan heater, are designed to transform electrical energy into heat. Name the other three appliances designed to transform electrical energy into heat.

1 ……………………………2 …………………………… 3 ……………………………

(3 marks)

QUESTION 2 (b) The bar chart shows the power of three kettles, X, Y, and Z.



QUESTION 2 (b) (i) In one week, each kettle is used for a total of 30 minutes.
Which kettle costs the most to use?
Put a tick (✓) next to your answer.

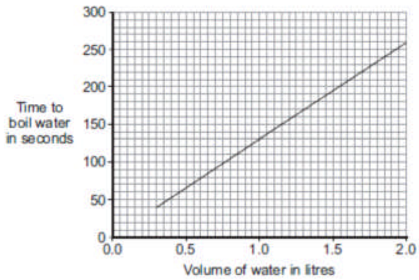
X ☐
Y ☐
Z ☐

(1 mark)

QUESTION 2(b) (ii) A new 'express boil' kettle boils water faster than any other kettle.
Draw a fourth bar on the chart to show the possible power of an 'express boil' kettle.

(1 mark)

QUESTION 2(c) The graph shows how the time to boil water in an electric kettle depends on the volume of water in the kettle.



A householder always fills the kettle to the top, even when only enough boiling water for one small cup of coffee or tea is wanted.
Explain how the householder is wasting money.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

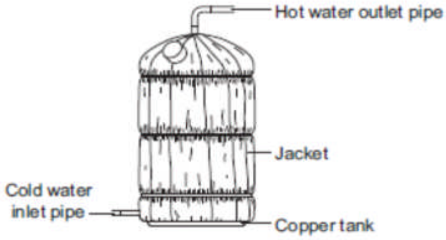
……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

(3 marks)
[Total 8 marks]

QUESTION 3. The diagram shows a jacket fitted to a hot water tank.



Match words, A, B, C and D, with the numbers 1 – 4 in the sentences.

A conduction

B convection

C insulation

D radiation

Heat will travel through the copper wall of the tank by ….. 1 ………

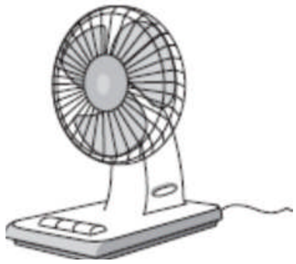
The jacket helps to keep the water warm because the fiberglass inside the jacket provides … 2 ….

The hot water outlet is at the top of the tank because hot water will rise to the top by …. 3 ………

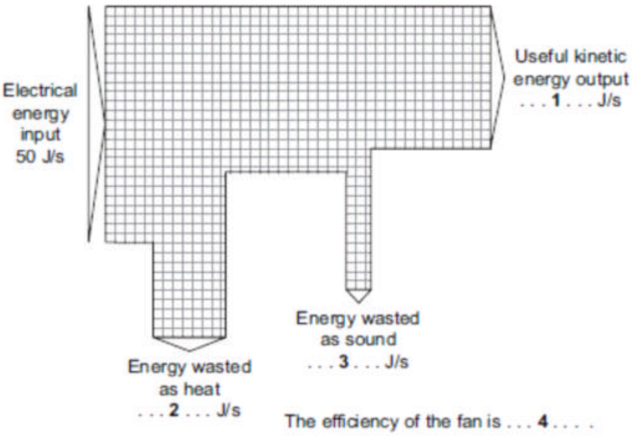
Heat is lost from the surface of the tank by ….. 4 ………..

[Total: 4 marks]

QUESTION4. The diagram shows an electric fan.



The Sankey diagram gives the energy transformations for the fan.



$$\text{efficiency} = \frac{\text{useful energy transfered by the device}}{\text{total energy supplied to the device}}$$

Match numbers, A, B, C, D, with the labels 1 – 4 on the Sankey diagram.

A 0.6
B 5
C 15
D 30 [Total: 6 marks]

QUESTION 5. Fig. 5.1 shows four runners at the start of an 80 m race on a school sports day.

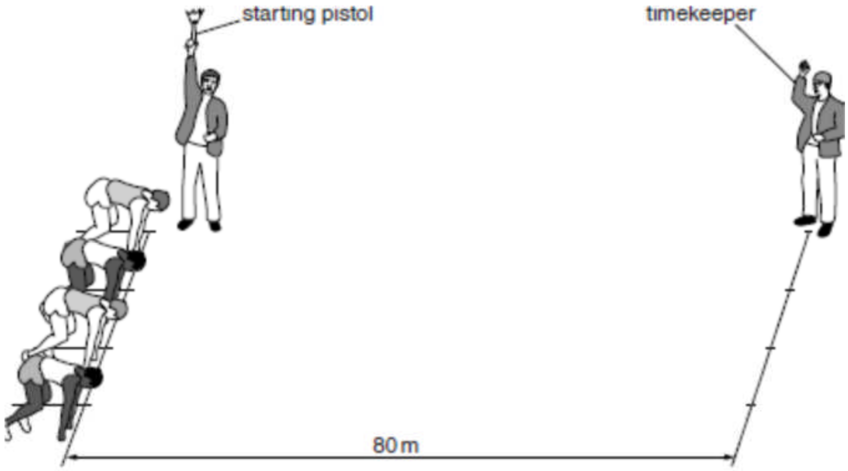


Fig. 5.1 (not to scale)

(a) Sound travels at 320 m / s.
Calculate the time taken for the sound from the starting pistol to reach the timekeeper.

time = ... s (3 marks)

(b) The timekeeper takes 0.20 s to react after hearing the sound and then starts the stopwatch.
He makes no other experimental inaccuracies.

(i) By how much will his time for the race be in error?

time error = ... s (2 marks)

(ii) Suggest how he can reduce this error, whilst still using the same stopwatch.

....

....

.... (1 marks)

(c) When he stops the stopwatch as the winner crosses the finishing line, the appearance of the stopwatch is as shown in Fig. 5.2.

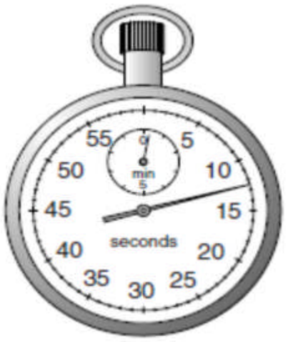


Fig. 5.2

How long did the winner actually take to run the race?

time = ... s (2 marks)

[Total: 8marks]

QUESTION 6. Fig. 6.1 shows a cell.

Fig. 6.1

(a) What does the 1.5 V indicate about the cell?

.... (2 marks)

(b) Three cells identical to the cell in Fig. 8.1 make up a 4.5 V battery. The battery is connected in series with a 180 Ω resistor.

Calculate the current in the circuit.

current = ...(4 marks)

(c) A second 180 Ω resistor is connected in parallel with the 180 Ω resistor from **(b).**

(i) In the space below, draw the circuit diagram of the two resistors in parallel, connected to the battery. Use standard symbols.

(3 marks)

(ii) State the value of

1. the potential difference across the second 180 Ω resistor, ...
2. the current in the second 180 Ω resistor. ....

(2 marks)

[Total: marks11]

Appendix H: Instruments and Research Questions they aim at answering

Research Questions	Source of Data						
	Secondary data	Questionnaires		Interviews		Observation	Resource Check-list
		For teachers	For students	For teachers	For students		
i. Achievement/enrollment	✓	Q19	Q5,	Q1,Q2,Q3	Q1,Q2,Q3		
(ii) Availability of Resources		Q8, Q10.Q13, Q14,Q17,Q18 ,Q19,Q21	Q5	Q4,Q8	Q4,Q5	✓	✓
(iii)Utilization of Resources		Q9,Q19	Q6,Q8,Q9,	Q5	Q4,Q6	✓	✓
(iv)Effect of availability, utilization & Achievement	✓	Q8, Q9, Q10. Q13, Q14, Q17,Q18,Q19	Q5, Q6, Q8,Q9	Q4,Q5			✓
(v) Teaching strategies/ Classroom interactions		Q11, Q15, Q16,Q20,Q22	Q5,Q6,Q7,Q9 Q10,Q11	Q6,Q7	Q4	✓	
(vi)Teacher qualification/ Experience		Q6.Q7,Q12	Q5,Q10	Q5			
GENERAL		Q1-Q5	Q1-Q4, Q12	Q9	Q1,Q7,Q8		

Appendix I:Development of Research Instruments – source of items and reasons for inclusion

I1: Questionnaire for Physics Teachers (QPT)

(Non-Demographic part)

<table>
<tr><th colspan="3">Question on QPT</th><th rowspan="2">Source of Questionnaire item</th><th rowspan="2">Reason for inclusion/Modification</th></tr>
<tr><th colspan="2">Question root</th><th>Question Stem</th></tr>
<tr><td></td><td colspan="4">About the Teacher</td></tr>
<tr><td>6a</td><td colspan="2">By the end of this school year, how many years would you have been teaching altogether?</td><td>TIMSS 2008 School Questionnaire</td><td>1. TIMSS instruments have high reliability and validity.
2. TIMSS instruments have been used for similar studies in international surveys.
3. Literature suggests the appropriateness of the selected items to investigate the focus of the study.</td></tr>
<tr><td>6b</td><td colspan="2">For how many years would you have taught Physics by the end of this school year?</td><td>TIMSS 2008 School Questionnaire</td><td>As above</td></tr>
<tr><td>7</td><td colspan="2">Which qualification(s) do you currently have? (Fill in circle(s) as appropriate)
a. NCE (Physics with any combination)---○
b.B.Ed/B.Sc (Ed) (Physics)------------------○
c. B.Ed/B.Sc(Ed) (Any Science)------------○
Specify subject ------------------------------
d. B.Sc(Physics) -----------------------------○
e. B.Sc (Any Science) -----------------------○
Specify subject ------------------------------
f. B.Sc or B.Engr(Engineering)-------------○
Please specify area………………………
g. Post Graduate Diploma in Education --○
h. M.Ed/M.Sc ---------------------------------○ Specify area of specialty----------------
i. PhD--○ Specify area of specialty</td><td>TIMSS 2008</td><td>As above.
Also, the qualification types were modified to suit the Nigerian context</td></tr>
</table>

Question on QPT		**Source of Questionnaire item**	**Reason for inclusion/Modification**
Question root	**Question Stem**		
	About Laboratory resources		
8a	Does your school have physics laboratory?	Designed by the Researcher	1. This question is considered appropriate to bring out information from respondents that could be used to answer the research question. 2. The question is also considered appropriate for use in the Nigerian context
8b	If yes, how would you rate the level of equipment?	As above	As above
8c	Does your school have Lab assistant(s)?	As above	As above
9	How often do you use the laboratory and its facilities in teaching Physics?	As above	As above
9b	Since this term, have your students conducted any experiment or demonstration themselves? If No, please give reason(s)	Designed by the Researcher	1. This question is considered appropriate to bring out information from respondents that could be used to answer the research question.
10a	In the topic area - **Interaction of Matter, Space and Time**, the curriculum suggests that you need some apparatus for demonstrations like measuring instruments, retort stands, circular motion apparatus, G-Clamp, magnets, force boards, resonance tubes, turning forks. **To what extent does your school have these apparatus?**	As above	1. This question is considered appropriate to bring out information from respondents that could be used to answer the research question. 2. The question is also considered appropriate for use in the Nigerian context
10b	In the topic area **– Conservation principles**, the curriculum suggests that you need some apparatus for demonstrations like thermometers ball and ring apparatus, bar breaker apparatus, bunsen burners, linear expansivity apparatus, calorimeter, electroscope and Boyle’s law apparatus. **To what extent does your school have these apparatus?**	As above	As above

Question on QPT			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
10c	In the topic area – **Fields at rest and in motion,** the curriculum suggests that you need some apparatus for demonstrations like magnets, batteries, solar cells, ammeter, voltmeter, galvanometer, resistors, potentiometer, Wheatstone bridge and electrolysis apparatus. **To what extent does your school have these apparatus?**		As above	As above
10d	In the topic area – **Energy quantization and duality of matter**, the curriculum suggests that you need some apparatus for demonstrations like black box, smoke cell, microscope, steel balls and solar panels. **To what extent does your school have these apparatus?**		As above	As above
10e	In the topic area – **Wave motion without material transfer**, the curriculum suggests that you need some apparatus for demonstrations like ripple tank and accessories, ray box, mirrors, prisms, lenses, sonometer, electric bell and oscilloscope. **To what extent does your school have these apparatus?**		As above	As above
School Interactions/professional training				
11	In your school, how often do you have the following types of interactions with other teachers?	a) Working or preparing instructional materials b) Visits to another teacher's classroom to observe his/her teaching c) Informal observation of my classroom by other teachers	TIMSS 2008 School Questionnaire	1. TIMSS instruments have high reliability and validity. 2. TIMSS instruments have been used for similar studies in international surveys. 3. Literature suggests the appropriateness of the selected items to investigate the focus of the study.

Question on QPT			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
11b	In your school, do teachers have a forum of sharing classroom experiences and how to teach particular concepts?		TIMSS 2008 School Questionnaire	As above
12a	Are you a member of professional organization for physics teachers?		TIMSS 2008 School Questionnaire	As above
12b	In the past two years, have you participated in professional development in any of the following?	a) Physics content b) Physics pedagogy /instruction c) Physics curriculum d)Integrating information technology into physics e) Improving students' critical thinking or inquiry skills f) Physics assessment	TIMSS 2008 School Questionnaire	As above
	Your School/Physics teaching			
13	In your current school, how severe is each problem?	a) The school building needs significant repair. b) Classrooms are overcrowded. c) Teachers do not have adequate workspace outside their classroom. d) Materials are not available to conduct physics experiments or investigations.	TIMSS 2008 School Questionnaire	1. TIMSS instruments have high reliability and validity. 2. TIMSS instruments have been used for similar studies in international surveys. 3. Literature suggests the appropriateness of the selected items to investigate the focus of the study.

Question on QPT			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
14a	Do you use a textbook as the basis for instruction in teaching physics?		TIMSS 2008 School Questionnaire	As above
14b	Does each student have his or her own textbook?		TIMSS 2008 School Questionnaire	As above
15a	In teaching physics to the students how often do you usually ask them to do the following?	a) Watch me demonstrate an experiment or investigation. b) Conduct experiments or investigations. c) Use laws and formulas of physics to solve routine problems. d) Give explanations about something they are studying. e) Relate what they are learning in physics to their daily lives. f) Have students memorize formulas and procedures. g) Read their textbooks or other resource materials.	TIMSS 2008 School Questionnaire	As above
16	In teaching physics to the students how often do you usually use the following strategies?	(a) Demonstration (b) Lecture (c) guided discovery (d)Laboratory (e) field trip (f) Excursion (g) collaborative learning (h) Problem solving (i) Project	Designed by the Researcher	The question is considered appropriate to bring out information from respondents that could be used to answer the research question.

Question on QPT			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
		(i) Any other -------		
17	During physics lessons, how often do you use a computer as a teaching aid or instructional material?		TIMSS 2008 School Questionnaire	1. TIMSS instruments have high reliability and validity. 2. TIMSS instruments have been used for similar studies in international surveys. 3. Literature suggests the appropriateness of the selected items to investigate the focus of the study.
18a	How often do students use calculators in their physics lessons for the following activities?	a) Doing scientific procedures or experiments. b) Modeling and simulations. c) Solving equations d)Processing and analyzing data e) Research aspects of physics on the internet	As above	As above
18b	How often do students use computers in their physics lessons for the following activities?	a) Doing scientific procedures or experiments. b) Modeling and simulations. c) Solving equations d)Processing and analyzing data e) Research aspects of physics on the internet	TIMSS 2008 School Questionnaire	1. TIMSS instruments have high reliability and validity. 2. TIMSS instruments have been used for similar studies in international surveys. 3. Literature suggests the appropriateness of the selected items to investigate the focus of the study.
19	Physics appears to be the least popular science subject among SSS students. What do you think are the main school-related factors affecting	a) Lack of qualified physics teachers. b) Teaching physics by theory without practical work. c) Lack of lab equipment for Demonstration/ experiments.	Designed by the Researcher	The question is considered appropriate to bring out information from respondents that could be used to answer the research question.

Question on QPT			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
	students' choice of Physics?	d) Lack of career guidance/counseling services. e) Unsocial lifestyle of some Physics teachers. f) Others, please specify		
20	In a typical double period of a physics lesson of 80 minutes, how many minutes do you or your students spend on each of the following activities?	a) Teacher teaching new material to the whole class. b) Students sharing ideas from new material to the whole class. c) Students working problems on their own or with other students. d) Teacher reviewing and summarizing what has been taught for the whole class. d) Teacher reviewing homework. e) Re-teaching and clarifying content/ procedures for the whole class. f) Classroom management tasks not related to the lesson's content/purpose (E.g interruptions and keeping order.	TIMSS 2008 School Questionnaire	1. TIMSS instruments have high reliability and validity. 2. TIMSS instruments have been used for similar studies in international surveys. 3. Literature suggests the appropriateness of the selected items to investigate the focus of the study.
21	In your view, to what extent do the following limit your teaching of physics?	a) Shortage of computer hardware. b) Shortage of computer software.	TIMSS 2008 School Questionnaire	1. TIMSS instruments have high reliability and validity. 2. TIMSS instruments have been used for similar studies in international surveys. 3. Literature suggests the appropriateness of the

Question on QPT			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
		c) Shortage of textbooks for students' use. d) Shortage of other instructional equipment for students' use. e) Shortage of equipment for your use in demonstrations and other exercises. f) Inadequate physical facilities. g) High student/teacher ratio. h) unavailability of computers with internet access (for on-line resources)		selected items to investigate the focus of the study.
School Climate				
22	In your school, to what extent is the learning of students hindered by the following phenomena?	a) Student truancy. b) Students arriving late for school. c) Students not attending compulsory school events (e.g., school assemblies) or excursions. d) Students lacking respect for teachers. e) Disruption of classes by students. f) Student use of alcohol or illegal drugs. g) Students intimidating or bullying other students. h) Students not being	PISA 2012 school questionnaire	1. PISA instruments have high reliability and validity. 2. PISA instruments have been used for similar studies in international surveys. 3. Literature suggests the appropriateness of the items to investigate the focus of the study.

Question on QPT				Source of Questionnaire item	Reason for inclusion/Modification
Question root			Question Stem		
			encouraged to achieve their full potential. i) Poor student-teacher relations. j) Teachers having to teach students of heterogeneous ability levels within the same class. k) Teachers' low expectations of students.		

Development of Research Instruments

I2: Questionnaire for Physics Students (QPS)
(Non-Demographic part)

<table>
<tr><th colspan="3">Question on QPS</th><th rowspan="2">Source of Questionnaire item</th><th rowspan="2">Reason for inclusion/Modification</th></tr>
<tr><th colspan="2">Question root</th><th>Question Stem</th></tr>
<tr><td></td><td colspan="4">About Physics enrolment</td></tr>
<tr><td rowspan="7">5</td><td rowspan="7">What do you think are the main school-related reasons for your choosing to study physics at the Senior Secondary School level?</td><td>a. The way physics contents in Basic science was taught
motivated me to choose physics</td><td rowspan="7">TIMSS 2008 Student questionnaire</td><td rowspan="7">1. TIMSS instruments have high reliability and validity.
2. TIMSS instruments have been used for similar studies in international surveys.
3. Literature suggests the appropriateness of the items to investigate the focus of the study.</td></tr>
<tr><td>b. Physics lessons are interesting and stimulating</td></tr>
<tr><td>c. My school has enough facilities for conducting experiments or investigations in physics.</td></tr>
<tr><td>d. My school has qualified physics teachers and that gives me the confidence to choose the subject.</td></tr>
<tr><td>d. The guidance counselor in my school said I should do physics because he/she thinks I can.</td></tr>
<tr><td>e. I enjoy my physics teacher. He shows great interest in the subject</td></tr>
<tr><td>Any other? (Please state)……………………………….</td></tr>
<tr><td></td><td colspan="4">About your Physics lessons</td></tr>
<tr><td rowspan="4">6</td><td rowspan="4">Please indicate your level of agreement to the following questions about your physics lessons</td><td>a) I am always excited to go for my physics classes.</td><td rowspan="4">UPMAP 2008 (Institute of Education, University of London)</td><td rowspan="4">1. The UPMAP instrument has an established reliability and validity.
2. The selected items from the original instrument are appropriate to elicit data for the study.
3.The instrument was used for a similar study investigating factors that influence students’ choice of physics</td></tr>
<tr><td>b) In my physics lessons, my teacher explains how a physics idea can be applied to a number of different situations.</td></tr>
<tr><td>c) In my physics lessons, I have the opportunity to discuss my ideas about physics.</td></tr>
<tr><td>d) My physics lessons are always interesting so I enjoy them</td></tr>
</table>

Question on QPS			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
		e) I find it easy to apply most physics concepts to everyday problems.		post-16 in the UK.
		f) I always learn new skills and ideas when studying Physics.		
		g) In my physics lessons, we are given the opportunity to do an experiment or demonstration to test our own ideas.		
		h) Students are allowed access to laboratory facilities for experiments and practical investigations.		
7	How often do you do these activities in your physics lessons?	a) We listen to the teacher present new material	TIMSS 2008	As for Q5 above
		b) We work problems on our own		
		c) we work on problems together with other students		
		d) We review what has been taught		
		e) We review homework		
		f) We have oral or written tests or quizzes		
8	How often do you use the following in your physics lessons?	a) Calculator	TIMSS 2008	As for Q5 above
		b) Computer		
		c) Other technology (DVD, Video,etc)		
9	How often do you do the following in your physics lessons?	a) We watch the teacher demonstrate an experiment or investigation	TIMSS 2008	As for Q5 above
		b) We conduct an experiment or investigation		
		c) We use laws and formulas of physics to solve problems		
		d) We give explanations about what we are studying		
		e) We relate what we are learning in physics to our daily lives		
		f) We memorize formulas and procedures of		

Question on QPS			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
		physics		
		g) We read our physics textbooks and other resource materials		
		h) We watch the teacher demonstrate physics on a computer		
		i) We use computer simulations on physics ourselves		
	About your Physics teacher			
10	Please indicate your level of agreement to the following questions about your physics teacher	a) My physics teacher has high expectations of what the students can learn.	UPMAP 2008/ PISA 2012	1. As for Q6 above 2. - PISA instruments have high reliability and validity. - PISA instruments have been used for similar studies in international surveys. - Literature suggests the appropriateness of the items to investigate the focus of the study.
		b) My physics teacher believes that all students can learn physics.		
		c) My physics teacher gives us homework.		
		d) My physics teacher marks and returns homework quickly.		
		e) My physics teacher is interested in what the students think.		
		f) My physics teacher ensures that students complete their homework.		
		g) My physics teacher treats all students fairly regardless of their abilities in physics.		
		h) My physics teacher is good at teaching physics.		
		i) Students get along well with my physics teacher.		
		j) My physics teacher is interested in students' well-being.		
		k) If I need extra help, I always get it from my Physics teacher.		
	Your School environment			
11	Please indicate your level of agreement to the	a) My school environment is friendly for learning	UPMAP 2008	As for Q6 above
		b) My physics classmates are cooperative and		

Question on QPS			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
	following questions about your physics teacher.	friendly c) Adults in my school seem to listen to students' concerns. f) At the close of school I always look forward to another school day h) I am comfortable talking to teachers about problems in this school.		
	Future study			
12	If you plan to continue your education, which of the following comes closest to the area you intend to study most?	a)SCIENCE (e.g., physics, chemistry, biological, earth science) b)HEALTH SCIENCES (e.g., dentistry, medicine, pharmacy, veterinary medicine) c)ENGINEERING (chemical engineering, civil engineering, electrical engineering, mechanical engineering) d)COMPUTER and INFORMATION SCIENCES (e.g., systems analyst) e)MATHEMATICS (e.g., calculus, statistics) f)ENVIRONMENTAL SCIENCES (e.g. Architecture, Survey, Estate Management) g)OTHER FIELD OF STUDY (Please mention …..) h) I DO NOT WISH TO CONTINUE MY EDUCATION 12b. Please explain your choice above in terms of your career aspiration. (*e.g. I plan to study ………….(one above) because I want a future career in ……………….)*	TIMSS 2008	As for Q5 above. To also understand the future career orientation of physics students.

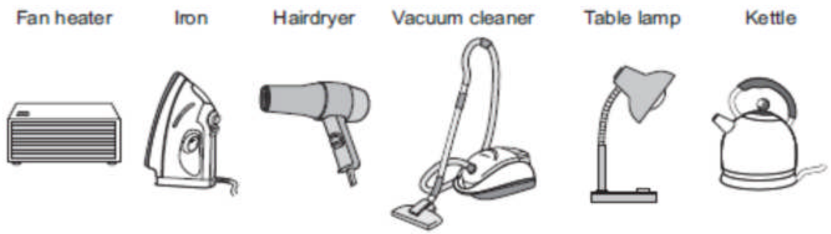
Development of Research Instruments

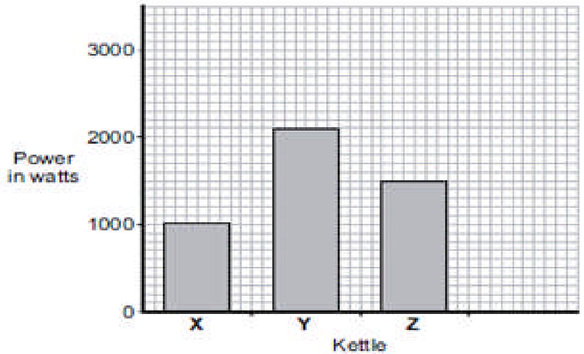
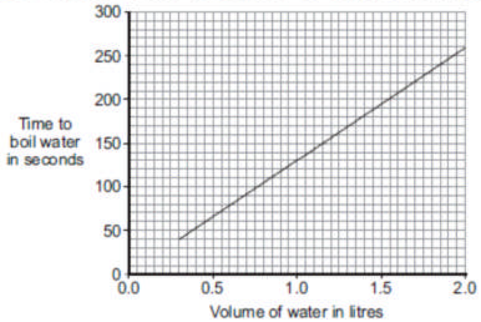
I3: Questionnaire for Non-Physics Students (QNPS)
(Non-Demographic part)

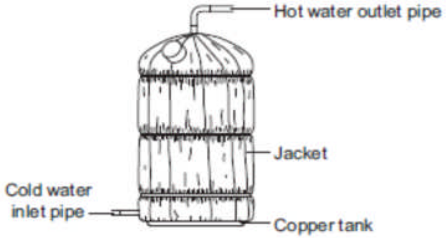
Question on QNPS			Source of Questionnaire item	Reason for inclusion/Modification
Question root		Question Stem		
5.	What do you think are the main school-related reasons for you NOT TO choose to study physics at the Senior Secondary School level?	a. The way physics contents in Basic science was taught made me NOT to choose physics b. Physics lessons are boring. c. I do not enjoy conducting experiments or investigations in physics. d. The school guidance counselor and or the physics teacher advised I should not do physics because he/she thought I couldn't. e. My school does not have qualified physics teachers. f. Physics is not relevant for my future career g. There is no physics laboratory in my school so I was afraid to choose the subject h. There are no laboratory facilities for practical work in physics in my school. i. My physics teacher did not show interest in the subject. j. Physics is taught by theory without practical work k. Any other? (Please state)……..	*TIMSS 2008 student questionnaire	* Although the original TIMSS items were for physics students, the questions were reversed and modified for non-physics students who were included in my study. Also, the questions were considered appropriate to as evident in literature to elicit information from non-physics on school related factors that influenced their not choosing physics in the SSS classes.

Development of Research Instruments

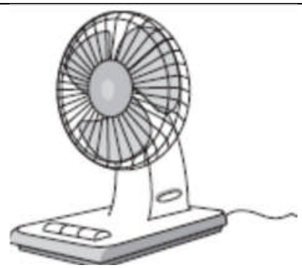
I4: Physics Achievement Test (PAT)

	PAT Questions	Source	Reason for inclusion
1	(a) State the equation linking the density of a substance with its mass and volume. (b) When oil leaks out of a damaged oil-tanker, it forms a very thin layer of oil, known as an oil slick, on the water. One such oil slick covers an approximately rectangular area measuring 2.5×10^4 m by 6.0×10^3 m. The oil slick is 3.0×10^{-6} m (0.0000030 m) thick. (i) Calculate the volume of the oil slick. (ii) The density of the oil is 900 kg / m3. Calculate the mass of oil in the slick.	IGCSE October/November 2012	1. The question is considered adequate to test physics achievement as content, covered under 'interaction of matter, space and time' has been taught in schools in Nigeria. 2. General reasons for adapting questions from IGCSE are explained in the relevant section in chapter 3.
2	The pictures show six different household appliances.  **(a)** Four of the appliances, including the fan heater, are designed to transform electrical energy into heat. Name the other three appliances designed to transform electrical energy into heat. **2 (b)** The bar chart shows the power of three kettles, X, Y, and Z.	AQA GCSE January 2013	1. This question was considered adequate to test for physics achievement as content was taught under 'conservation principles' in schools in Nigeria. 2. General reasons for adapting questions from AQA GCSE are explained in the relevant section in chapter 3.

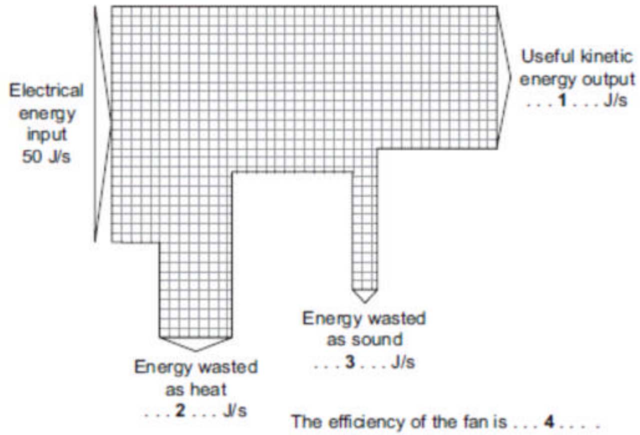
PAT Questions	Source	Reason for inclusion
 **(i)** In one week, each kettle is used for a total of 30 minutes. Which kettle costs the most to use? Put a tick (✓) next to your answer. X ☐ Y ☐ Z ☐ **(ii)** A new ‘express boil’ kettle boils water faster than any other kettle. Draw a fourth bar on the chart to show the possible power of an ‘express boil’ kettle. **2(c)** The g[illegible]tric kettle depends on the volum  A householder always fills the kettle to the top, even when only enough boiling water for one small cup of coffee or tea is wanted. Explain how the householder		

	PAT Questions	Source	Reason for inclusion
	is wasting money.		
3	The diagram shows a jacket fitted to a hot water tank.  Match words, A, B, C and D, with the numbers 1 – 4 in the sentences. A conduction B convection C insulation D radiation Heat will travel through the copper wall of the tank by ….. 1 … The jacket helps to keep the water warm because the fiberglass inside the jacket provides … 2 …. The hot water outlet is at the top of the tank because hot water will rise to the top by . 3 … Heat is lost from the surface of the tank by ….. 4 ……	AQA GCSE November 2012	1. This question was considered adequate to test for physics achievement as content was taught under 'conservation principles' in schools in Nigeria. 2. General reasons for adapting questions from AQA GCSE are explained in the relevant section in chapter 3.
4	The diagram shows an electric fan.	AQA GCSE November 2012	1. This question was considered adequate to test for physics achievement as content

<table>
<tr><th colspan="2">PAT Questions</th><th>Source</th><th>Reason for inclusion</th></tr>
<tr><td></td><td>



The Sankey diagram gives the energy transformations for the fan.

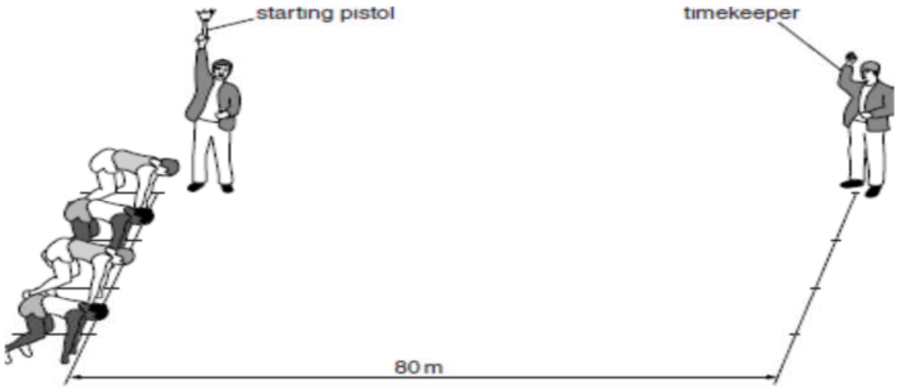


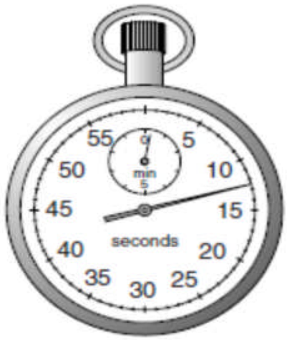
$$\text{efficiency} = \frac{\text{useful energy transfered by the device}}{\text{total energy supplied to the device}}$$

Match numbers, A, B, C, D, with the labels 1 – 4 on the Sankey diagram.

A 0.6
B 5
C 15
D 30

</td><td></td><td>was taught under ‘conservation principles’ and ‘Fields at rest and in motion’ in schools in Nigeria.
2. General reasons for adapting questions from AQA GCSE are explained in the relevant section in chapter 3.</td></tr>
</table>

	PAT Questions	Source	Reason for inclusion
5	Fig. 5.1 shows four runners at the start of an 80 m race on a school sports day.  Fig. 5.1 (not to scale) **(a)** Sound travels at 320 m / s. Calculate the time taken for the sound from the starting pistol to reach the timekeeper. **(b)** The timekeeper takes 0.20 s to react after hearing the sound and then starts the stopwatch. He makes no other experimental inaccuracies. **(i)** By how much will his time for the race be in error? time error = ... s **(ii)** Suggest how he can reduce this error, whilst still using the same stopwatch. **(c)** When he stops the stopwatch as the winner crosses the finishing line, the appearance of the stopwatch is as shown in Fig. 5.	IGCSE October/November 2012	1. The question is considered adequate to test physics achievement as content, covered under 'interaction of matter, space and time' has been taught in schools in Nigeria. 2. General reasons for adapting questions from IGCSE are explained in the relevant section in chapter 3.

PAT Questions		Source	Reason for inclusion
	 Fig. 5.2 How long did the winner actually take to run the race?		
6	Fig. 6.1 shows a cell.  Fig. 6.1 **(a)** What does the 1.5 V indicate about the cell? **(b)** Three cells identical to the cell in Fig. 8.1 make up a 4.5 V battery. The battery is connected in series with a 180 Ω resistor. Calculate the current in the circuit. current = ... **(c)** A second 180 Ω resistor is connected in parallel with the 180 Ω resistor from **(b)(i)** In the space below, draw the circuit diagram of the two resistors in parallel, connected to the battery. Use standard symbols. **(ii)** State the value of 1. the potential difference across the second 180 Ω resistor, ... 2. the current in the second 180 Ω resistor.	IGCSE October/November 2012	1. The question is considered adequate to test physics achievement as content, covered under 'Fields at rest and in motion' has been taught in schools in Nigeria. 2. General reasons for adapting questions from IGCSE are explained in the relevant section in chapter 3.

Appendix J

Department of Education,
University of York,
Heslington, York
YO10 5DD,
United Kingdom.
29th December, 2014.

The Chairman,
Rivers State Senior Secondary Schools Board,
Emekuku Street, D/Line,
Port Harcourt, Rivers State,
Nigeria.

Dear Sir,

REQUEST FOR ACCESS TO SENIOR SECONDARY SCHOOLS FOR MY RESEARCH

I am from Rivers State and a PhD research student at the University of York in the United Kingdom. I am interested in investigating school-based factors that may affect the enrolment and achievement of senior secondary school physics students in Rivers State, Nigeria.

I intend to get the view of a wide range of physics teachers and physics and non-physics students on the teaching and learning of physics at the secondary school level. It is hoped that their experiences over the years within the school will greatly contribute to the success of my research.

I would want to use schools in Opobo/Nkoro, Omuma, Okrika, Khana, Andoni and Ogba/Egbema/Ndoni LGA's.

For my research to be successful, I need to have:

- Access to physics SSCE results for the school for the last 5 years
- The observation of physics teaching-learning class sessions
- Administration of questionnaires to physics teachers and physics and non-physics students
- Administration of a Physics Assessment Test
- An interview session with physics teachers
- An interview session with a group of physics and non-physics students in SS 3

I therefore request for access to schools under your jurisdiction for the purpose of this research. The interview sessions would take less than one hour and may be arranged even after the school hours.

All information extracted from the school results, tests, interviews, observations and questionnaire responses shall be treated with **strict confidentiality and anonymity**. NO NAMES OF PERSONS OR SCHOOLS shall appear in the report of the research or in any publication arising as the information so gathered is for the sole purpose of the research. No person other than the researcher and his supervisors will have access to materials so obtained. I shall send you and all participating schools a brief summary of my findings at the end of my research and do hope that it will be found useful in improving the teaching and learning of physics in your schools.

Your kind approval will be most appreciated. For further details, I can be contacted via email:ta697@york.ac.uk or Tel: 08037029072, +4417767561913.

Yours Faithfully,

Telima Adolphus (Researcher)
Supervisors: Prof Judith Bennett (email:judith.bennett@york.ac.uk; Tel: +441904323471) and
Dr. Jeremy Airey (email:jeremy.airey@york.ac.uk; Tel: +441904323475)

Appendix J1

Department of Education
University of York
Heslington
York
YO10 5DD
United Kingdom.
Date: ……………2014.

The Principal
…………………………………………..
…………………………………………..
…………………………………………..

Dear Sir/Madam,

REQUEST FOR USE OF YOUR SCHOOL FOR MY RESEARCH

I am an indigene of Rivers State and a PhD research student at the University of York in the United Kingdom. I am interested in investigating school-based factors that may affect the enrolment and achievement of senior secondary school physics students in Rivers State, Nigeria.

I intend to get the view of a wide range of physics teachers and physics and non-physics students on the teaching and learning of physics at the secondary school level. It is hoped that their experiences over the years within the school will in no small measure contribute to the success of my research

The demands of my research include:

- Access to physics SSCE results for the school for the last 5 years
- The observation of physics teaching-learning class sessions
- Administration of questionnaires to physics teachers and physics and non-physics students
- Administration of the PAT
- An interview session with physics teachers
- An interview session with a group of physics and non-physics students in SS 3

I therefore request for access to use your school for the purpose of this research.

I would like to visit your school anytime most convenient to you within the official hours between Monday and Friday in the month of ………………………. The interview sessions would take less than one hour and may be arranged even after the school hours.

All information extracted from the school results, interviews, observations and questionnaire responses shall be treated with **strict confidentiality and anonymity**. NO NAME OF PERSONS OR SCHOOL shall appear in the report of the research as the information so gathered is for the sole purpose of the research. No other person other than the researcher will be accessible to materials so obtained. I shall send a brief summary of my findings at the end of my research and do hope that it will be found useful in improving the teaching and learning of physics in your school.

Attached is the letter of approval from the Senior Secondary Schools' Board.

Yours Faithfully,

Telima Adolphus

Appendix J2

Department of Education
University of York
Heslington
York
YO10 5DD
United Kingdom.
Date: ……………2014.

To: All physics teachers
……………………………………
……………………………………

Dear Sir/Madam,

REQUEST FOR USE OF YOUR SCHOOL FOR MY RESEARCH

I am an indigene of Rivers State and a PhD research student at the University of York in the United Kingdom. I am interested in investigating school-based factors that may affect the enrolment and achievement of senior secondary school physics students in Rivers State, Nigeria.

I intend to get the view of a wide range of physics teachers and physics and non-physics students on the teaching and learning of physics at the secondary school level. It is hoped that their experiences over the years within the school will in no small measure contribute to the success of my research

It is hoped that your experience gained over the years in the business of teaching will in no small measure contribute to the success of my research.

The demands of my research include:

- Access to physics SSCE results for the school for the last 5 years
- The observation of physics teaching-learning class sessions
- Administration of questionnaires to physics teachers and physics and non-physics students
- Administration of the PAT
- An interview session with physics teachers
- An interview session with a group of physics and non-physics students in SS 3

I have secured permission from your principal and do hope that you will assist me maximally in the conduct of this research.

I would like to visit your school anytime most convenient to you within the official hours between Monday and Friday in the month of ………………………. The interview sessions would take less than one hour and may be arranged even after the school hours.

The participants consent form is attached herewith for your consideration.

Your kind approval will be most appreciated.

Yours Faithfully,

Telima Adolphus

Appendix K

PORT HARCOURT
RIVERS STATE NIGERIA
Rivers of Possibilities

RIVERS STATE
SENIOR SECONDARY SCHOOLS BOARD
P. M. B. 5243, Port Harcourt.

Our Ref: Your Ref: Date: February 13, 2015

TO WHOM IT MAY CONCERN

The bearer, Mr Telima Adolphus, is conducting a research on Enrolment and achievement of Senior Secondary School Physics Students in Rivers State, Nigeria and has requested for your assistance.

Schools to be covered by his research work are located in Opobo/Nkoro, Omuma, Okrika, Khana, Andoni and Ogba Egbema/Ndoni LGA. His research priorities are:

- Access to Physics SSCE results for the past 5 years
- Observation of Physics teaching-learning class sessions
- Administration of questionnaires to Physics teachers, Physics and non-Physics Students
- Administration of a Physics Assessment Test
- Interview session with Physics teachers and
- Interview Session with a group of Physics and non-Physics Students in SS3.

Please, give him your full co-operation as he visits your School.

SENIOR SECONDARY SCHOOLS BOARD
PORT HARCOURT
13 FEB 2015
Odu, G.A
DPRS of The Director
Planning Research & Statistics
For: Chairman.

Appendix L

Participant Consent Form (Teachers/Students)

What will be involved in participation?

I understand that:

- The purpose of the proposed study is to investigate school-based factors that may affect the enrolment and achievement of senior secondary school physics students in Rivers State, Nigeria.
- I will be providing information through an interview and or questionnaire in which I will be asked questions about school my experiences, facilities, teaching and learning of physics in my school.
- Response to the questionnaire may take about 15 minutes (for students) and 25 minutes (for teachers) while the interview session will take about 45minutes to one hour.
- The interview will be audio recorded and the recording will later be transcribed.
- I may decline to answer any questions and that I may withdraw my agreement to participate at any time up to the completion of the interview or response to the questionnaire.
- I will have an opportunity to comment on the accuracy of the transcribed record once it has been produced.
- At that time when I decide to decline, I know that I may indicate whether or not the data collected up to that point can be used in the study, and that any information I do not want used will be destroyed immediately.
- Refreshment shall be provided for me for participating in this study.

How will my data be handled?

I understand that:

My participation is voluntary, and I may withdraw myself and my data at any time during the data collection by informing the researcher without any penalty being imposed on me.

- No other use will be made of the recordings without my written permission and that interviews will be recorded solely for the purpose of analysis.
- The data will be handled and stored in a manner in which ensures that only the researcher can identify me as their source.
- The data will only be used for academic and research purposes.

What should I do if I have questions or concerns?

I understand that:

- This project has been reviewed by and received ethics clearance through the ethics committee in the Department of Education at the University of York, United Kingdom.
- If I have any questions about this research, I should in the first instance contact the Researcher, Telima Adolphus (email: ta697@york.ac.uk) or his supervisors: Prof Judith Bennett (email: judith.bennett@york.ac.uk), Dr. Jeremy Airey (email: jeremy.airey@york.ac.uk) or the Chair, Education Ethics Committee, University of York, Dr. Emma Marsden (emma.marsden@york.ac.uk)

Do you agree to participate in the study? Yes ☐ No ☐

Name of participant _________________ Date _______ Signature_________________

Name of researcher _________________ Date _______ Signature_________________

Information for parents/guardians

Dear Parent/Guardian,

I am Mr Telima Adolphus, a PhD research student at the University of York in the United Kingdom. I am interested in investigating school-based factors that may affect the enrolment and achievement of senior secondary school physics students in Rivers State, Nigeria.

I intend to get the view of a wide range of physics teachers and physics and non-physics students on the teaching and learning of physics at the secondary school level. It is hoped that their experiences over the years within the school will greatly contribute to the success of my research which is aimed at improving the teaching and learning of Physics in our secondary schools.

This is a formal request for your consent to allow your child/ward participate in the study. The student questionnaire will take just about 10 - 15 minutes while the interview session will last about 45 minutes.

Thank you for your cooperation.

Telima Adolphus (Researcher)

(Please detach the consent form below and return through your child/ward)

Parents/Guardians consent Form

I have read and understood the information given to me about the study and give my permission for my child/ward, ………………………………………………………………………(Name) to take part.

I have been informed about the aims and procedures involved in this research. I reserve the right to withdraw my child at any stage during the research. I understand that the information gained will be confidential and that my child's name will be removed from any materials used in this research.

Name of parent/guardian _____________________________Date _______Signature__________

Name of researcher _________________________________Date _______Signature__________

For concerns about this research, you may contact the researcher, Telima Adolphus (email: ta697@york.ac.uk) or his supervisors: Prof Judith Bennett (email: judith.bennett@york.ac.uk), Dr. Jeremy Airey (email: jeremy.airey@york.ac.uk) or the Chair, Education Ethics Committee, University of York, Dr. Emma Marsden (emma.marsden@york.ac.uk)

Appendix M

Education Ethics Committee
Ethical Issues Audit Form

This questionnaire should be completed for each research study that you carry out as part of your degree. Once completed, please email this form to your supervisor. You should then discuss the form fully with your supervisor, who should approve the completed form. **You must not collect your data until you have had this form approved by your supervisor (and possibly others - your supervisor will guide you).**

Surname / Family Name:	Adolphus
First Name / Given Name:	Telima
Programme:	PhD in Education
Supervisor (of this research study):	Prof. Judith Bennett and Dr Jeremy Airey

Topic (or area) of the proposed research study:
Investigations into school-based factors affecting the enrolment and achievement of senior secondary school physics students in Rivers State, Nigeria.
Where the research will be conducted:
Rivers State, Nigeria
Methods that will be used to collect data:
Questionnaires, interviews, classroom observation and secondary data of school results.
If you will be using human participants, how will you recruit them?
All physics teachers in all 31 public schools in 3 local government areas of Rivers State, Nigeria, shall be purposively selected for the research. Also, by stratified random sampling technique, physics students in the senior secondary class 3 from the 31 schools shall be selected as participants. After the selection, letters will be written first to the relevant school management authorities for permission to use teachers and students from the schools. When permission is granted, letters will be written to principals, teachers and students for their consent to participate in the study. Those who consent will be recruited for the study.

Supervisors, please read *Ethical Approval Procedures: Students*. Note: If the study involves children, vulnerable participants, sensitive topics, or an intervention into normal educational practice, this form must also be approved by the programme leader (or Programme Director if the supervisor is also the Programme Leader); or the TAP member for Research Students. It may also require review by the full Ethics Committee (see below).

First approval: by the supervisor of the research study (after reviewing the form):

Please select one of the following options.

I believe that this study, as planned, meets normal ethical standards	x
I am unsure if this study, as planned, meets normal ethical standards	☐
I believe that this study, as planned, does not meet normal ethical standards and requires some modification	☐

Supervisor's Name (please type):	Jeremy Airey and Judith Bennett
Date:	09 June 2014

Supervisor - If the study involves children, vulnerable participants, sensitive topics, or an intervention into normal educational practice (see *Ethical Approval Procedures: Students*), please email this form for second approval to the Programme Leader (or Programme Director if the supervisor is also the Programme Leader); or the TAP member for Research Students. For this second approval, other documents may need to be sent in the same email e.g. the proposal (or a summary of it) and any informed consent and participant information sheets.

If the study has none of the above characteristics, the supervisor should email this completed form to the Programme Administrator.

Second approval: by the Programme Leader; or Programme Director; or TAP member for Research Students:

Please select one of the following options:

I believe that this study, as planned, meets normal ethical standards	☐
I am unsure if this study, as planned, meets normal ethical standards	☐
I believe that this study, as planned, does not meet normal ethical standards and requires some modification	☐

Name of Programme Leader; or Programme Director; or TAP member (please type):	
Date:	Click here to enter a date.

The supervisor should now email this completed form to the Programme Administrator, unless approval is required by the full Ethics Committee (see below).

Approval required by the full Education Ethics Committee?

Note to Programme Leader, Programme Director, or TAP member: If the study involves a) deception, or b) an intervention and procedures could cause concerns, or c) if the topic is sensitive or potentially distressing, review by the full Education Ethics Committee is required. Please forward to the Research Administrator (education-research-administrator@york.ac.uk).

FOR COMPLETION BY THE STUDENT

Data sources

1 If your research involves collecting secondary data only **go to SECTION 2**.

2 If your research involves collecting data from people (e.g. by observing, testing, or teaching them, or from interviews or questionnaires) **go to SECTION 1.**

SECTION 1: For studies involving people

3 Is the amount of time you are asking research participants to give reasonable? **YES**

4 Is any disruption to their normal routines at an acceptable level? **YES**

5 Are any of the questions to be asked, or areas to be probed, likely to cause anxiety or distress to research participants? **NO**

6 Are all the data collection methods used necessary? **YES**

7 Are the data collection methods appropriate to the context and participants? **YES**

8 Will the research involve deception? **NO**

9 Will the research involve sensitive or potentially distressing topics? (The latter might include abuse, bereavement, bullying, drugs, ethnicity, gender, personal relationships, political views, religion, sex, violence. If there is lack of certainty about whether a topic is sensitive, advice should be sought from the Ethics Committee.) **NO**

If YES, what steps will you take to ensure that the methods and procedures are appropriate, not burdensome, and are sensitive to ethical considerations?

10 Does your research involve collecting data from vulnerable or high risk groups? (The latter might include participants who are asylum seekers, unemployed, homeless, looked after children, victims or perpetrators of abuse, or those who have special educational needs. If there is a lack of certainty about whether participants are vulnerable or high risk, advice should be sought from the Ethics Committee. Please note, children with none of the above characteristics are not necessarily vulnerable, though approval for your project must be given by at least two members of staff; see above). **NO**

If YES, what steps will you take to ensure that the methods and procedures are appropriate, not burdensome, and are sensitive to ethical considerations?

11 Are the research participants under 16 years of age? **YES**
If NO, go to question 12.

If YES, and you intend to interact with the children, do you intend to ensure that another adult is present during all such interactions? **NO**

If NO, please explain, for example:
i) This would seriously compromise the validity of the research because [***provide reason***]

During the focus group interview for instance, the presence of a known adult may cause potential bias and influence interviewee's responses.

ii) I have/will have a full Disclosure and Barring Service check (formerly Criminal Records Bureau check). **NO**

iii) Other reasons:

I have taught as I teacher in primary and secondary schools in Nigeria for about 12 years and more so, a criminal Records Bureau check is not required for working with young people in Nigeria. A permission from School authorities, parents and the students will suffice.

Payment to participants

12 If research participants are to receive reimbursement of expenses, or any other incentives or benefits for taking part in your research, please give details, indicating what or how much money they will receive and, briefly, the basis on which this was decided:

Interview participants will be refreshed with snacks and soft drinks as the interview sessions are planned to hold during breaks or just after school.

If your study involves an INTERVENTION i.e. a change to normal practice made for the purposes of the research, go to question 13 (this does not include 'laboratory style' studies i.e. where ALL participation is voluntary):

If your study does not involve an intervention, go to question 20.

13 Is the extent of the change within the range of changes that teachers (or equivalent) would normally be able to make within their own discretion? Choose an item.

14 Will the change be fully discussed with those directly involved (teachers, senior school managers, pupils, parents – as appropriate)? Choose an item.

15 Are you confident that *all* treatments (including comparison groups in multiple intervention studies) will potentially provide some educational benefit that is compatible with current educational aims in that particular context? (Note: This is *not* asking you to justify a non-active control i.e. continued normal practice) Choose an item.
Please **briefly** describe this / these benefit(s):

16 If you intend to have two or more groups, are you offering the control / comparison group an opportunity to have the experimental / innovative treatment at some later point (this can include making the materials available to the school or learners)? Choose an item.

If NO, please explain:

17 If you intend to have two or more groups of participants receiving different treatment, do the informed consent forms give this information? Choose an item.

18 If you are randomly assigning participants to different treatments, have you considered the ethical implications of this? Choose an item.

19 If you are randomly assigning participants to different treatments (including non-active controls), will the institution and participants (or parents where participants are under 16) be informed of this in advance of agreeing to participate? Choose an item.

If NO, please explain:

General protocol for working in institutions

20 Do you intend to conduct yourself, and advise your team to conduct themselves, in a professional manner as a representative of the University of York, respectful of the rules, demands and systems within the institution you are visiting? **YES**

21 If you intend to carry out research with children under 16, have you read and understood the Education Ethics Committee's *Guidance on Working with Children Under 16*? **YES**

Informed consent

22 Have you prepared Informed Consent Form(s) which participants in the study will be asked to sign, and which are appropriate for different kinds of participants? **YES**

If YES, **please attach the informed consent form(s).**

If NO, please explain:

23 Please check the details on the informed consent form(s) match each one of your answers below. Does this informed consent form:

a) inform participants in advance about what their involvement in the research study will entail? **YES**

b) inform participants of the purpose of the research? **YES**

c) inform participants of what will happen to the data they provide (how this will be stored, who will have access to it, whether and how individuals' identities will be protected during this process)? **YES**

d) if there is a possibility that you may use some of the data publicly (e.g. in presentations or online), inform the participants how identifiable such data will be **and** give them the opportunity to decline such use of data? **YES**

e) give the names and contact details (e.g. email) of at least two people to whom queries, concerns or complaints should be directed? One of these people should be on the Education Ethics Committee and not involved with the research. **YES**

f) in studies involving interviews or focus groups, inform participants that they will be given an opportunity to comment on your *written record* of the event? **YES**

If NO, have you made this clear this on your consent form? Choose an item.

If NO, please explain why not:

g) inform participants how long the data is likely to be kept for? **YES**

h) inform participants if the data could be used for future analysis and/or other purposes? **YES**

i) inform participants they may withdraw from the study during data collection? **YES**

j) provide a date/timescale by which participants will be able to withdraw their data and tell the participants how to do this? (NB. If your data is going to be completely anonymised, any withdrawal of data needs to happen before this.) **YES**

**NA if your data will be anonymous at point of collection*

If your answer was NO to any of the above, please explain here, indicating which item(s) you are referring to (a-j):

24 Who will be asked to sign an Informed Consent Form? Please select all that apply:

CATEGORY	
Adult research participants	✓
Research participants under 16	✓
Teachers	✓
Parents	✓
Head/Senior leadership team member	☐
Other (please explain)	☐

25 In studies involving an **intervention** with under 16s, will you seek informed consent from parents?

If NO, please explain:

If YES, please delete to indicate whether this is 'opt-in' or 'opt-out'
If 'opt-out', please explain why 'opt-in' is not being offered:

SECTION 2

Data Storage, Analysis, Management and Protection

26 I am accessing data from a non-publicly available source (regardless of whether the data is identifiable) e.g. pupil data held by a school or local authority, learners' work. **YES**

If YES, I have obtained written permission, via an informed consent document, from a figure of authority who is responsible for holding the data. This informed consent a) acknowledges responsibility for releasing the data and b) confirms that releasing the data does not violate any informed consents or implicit agreements at the point the data was initially gathered. **YES**

27 I have read and understood the Education Ethics Committee's *Guidance on Data Storage and Protection* **YES**

28 I will keep any data appropriately secure (e.g. in a locked cabinet), maintaining confidentiality and anonymity (e.g. identifiers will be encoded and the code available to as few people as possible) where possible. **YES**

29 If your data can be traced to identifiable participants:
a) who will be able to access your data?

Myself(Telima), Judith and Jeremy (my Supervisors)

b) approximately how long will you need to keep it in this identifiable format?

3 years

30 If working in collaboration with other colleagues, students, or if under someone's supervision, please discuss and complete the following:

We have agreed:
a) [*Telima Adolphus*] will be responsible for keeping and storing the data
b) [*Telima, Judith and Jeremy*] will have access to the data
c) [*Telima, Judith and Jeremy*] will have the rights to publish using the data

Reporting your research

31 In any reports that you write about your research, will you do everything possible to ensure that the identity of any individual research participant, or the institution which they attend or work for, cannot be deduced by a reader? **YES**

If NO please explain:

Conflict of interests

32 If the Principal Investigator or any other key investigators or collaborators have any direct personal involvement in the organisation sponsoring or funding the research that may give rise to a possible conflict of interest, please give details:

Not Applicable

Potential ethical problems as your research progresses

33 If you see any potential problems arising during the course of the research, please give details here and describe how you plan to deal with them:

None is foreseen yet, but when any arise, referral will be made to my supervisors and the Departmental ethical committee if I think I cannot handle the problem.

Student's Name (please type):	Telima Adolphus
Date:	04 June 2014

Please email this form to your supervisor. They must approve it, and send it to the Programme Administrator by email.

NOTE ON IMPLEMENTING THE PROCEDURES APPROVED HERE:

If your plans change as you carry out the research study, you should discuss any changes you make with your supervisor. If the changes are significant, your supervisor may advise you to complete a new 'Ethical issues audit' form.

For Taught Masters students, on submitting your MA dissertation to the programme administrator, you will be asked to sign to indicate that your research did not deviate significantly from the procedures you have outlined above.

For Research Students (MA by Research, MPhil, PhD), once your data collection is over, you must write an email to your supervisor to confirm that your research did not deviate significantly from the procedures you have outlined above.

References

References

Abdullahi, A. (1982). *Science Teaching in Nigeria*. Ilorin: Atoto Press.

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. & Reiss, M. J. (2012). Practical work: It's effectiveness in primary and secondary schools in England. *Journal of Research in Science Teaching*, 49 (8), 1035-1055.

Abubakar, A. S. & Adebayo, F. O. (2014). Using computer based test method for the conduct of examination in Nigeria: Prospects, challenges and strategies. *Mediterranean Journal of Social Sciences.* 5(2), 47-55.

Adegoke, B. A. (2011). Effect of multimedia instruction on senior secondary school students' achievement in physics. *European Journal of Educational Studies*, 3(3), 537 - 550.

Adesoji, F.A & Olatunbosun, S.M (2008). Student, Teacher and School Environment factors as determinants of achievement in Senior Secondary School Chemistry in Oyo State, Nigeria. *The Journal of international Social Research*, 1(2), 13-34.

Adeyemi, J.K. & Ige, A.M.A. (2002). Examination malpractices in Nigerian educational system: Causes, effects and the way out. *Nigerian Journal of Clinical and Counseling Psychology*, 8(1), 57-76.

Adeyemi, T. (2005). The Influence of the Number of Science Laboratories on Students' Academic Performance in Senior Secondary Examinations in Ekiti State, Nigeria. *Research in Education*, 74(1), 91-98.

Adeyemi, T. O. (2008). Science laboratories and the quality of output from secondary schools in Ondo State, Nigeria. *Asian Journal of Information Management*, 2(1),23-30.

Adeyemi, T. O. & Olaleye, F. O. (2010). Information Communication and Technology (ICT) for the Effective Management of Secondary Schools for Sustainable Development in Ekiti State, Nigeria. *American-Eurasian Journal of Scientific Research*, 5(2), 106-113.

Adeyemo, S.A. (2010a). Teaching/ learning physics in Nigerian secondary school: The curriculum transformation, issues, problems and prospects. *International Journal of Educational Research and Technology*, 1(1), 99-111.

Adeyemo, S. A. (2010b). The impact of Information and Communication Technology (ICT) on teaching and learning of physics. *International Journal of Educational Research and Technology*, 1(2), 48-59.

Adeyinka, A. A. (1988). Major trends in curriculum development in Nigeria. *Ilorin Journal of Education*, 8, 9-19.

Adolphus, T. (2013). Effects of Collaborative and Demonstration Approaches on the Conceptual understanding of Electromagnetic Induction in Secondary schools in Port Harcourt:. *Unpublished M.Ed Research project of the University of Port Harcourt*.

Adolphus, T. & Torunarigha, Y. D. (2008). Comparative analysis of teacher qualification and product performance of distance and regular teacher education programme: Implication for qualitative teacher education in Nigeria. *International Journal of Educational Development*. II(I). pp 61-69.

Adomi, E. E. & Kpangban, E. (2010). Application of ICTs in Nigerian secondary schools. *Library Philosophy and Practice (e-journal)*, paper 345. Retrieved online on 03/03/2016 at http://digitalcommons.unl.edu/libphilprac/345.

Aduwa-Ogiegbaen, S. E. & Iyamu, E. O. S. (2005). Using Information and Communication Technology in secondary schools in Nigeria: Problems and prospects. *Educational Technology & Society*, 8(1), 104-112.

Aina, J. K. (2012). Challenges and prospects of primary science teaching in Nigeria. *Continental Journal of Educational Research*, 5(2), 32-37.

Aina, J. K. (2013). Instructional Materials and Improvisation in Physics Class: Implications for Teaching and Learning. *IOSR Journal of Research & Method in Education*, 2(5), 38 – 42.

Aina, J. K & Adedo, G.A. (2013). Correlation between continuous assessment (CA) and Students' performance in physics. *Journal of Education and Practice*. 4(6), 6-9.

Aina, J.K. & Akanbi, A.G. (2013). Perceived causes of students' low enrolment in science in secondary schools, Nigeria. *International Journal of Secondary Education*, 1(5), 18-22.

Aina, J.K. & Akintunde, Z. T. (2013). Analysis of Gender Performance in Physics in Colleges of Education, Nigeria. *Journal of Education and Practice*,4(6), 1-5.

Akanbi A.O. (2003). Trend in physics education in secondary schools in Kwara State. *Lafiagi Journal of science education*, 5(1& 2), 69- 75.

Akanwa, U.N. & Ovute, A.O. (2014). The effect of constructivist teaching model on SSS physics students' achievement and interest. *Journal of Research & Method in Education*. 4(1), 35-38.

Akinsolu, A.O.(2010). Teachers and students' academic performance in Nigerian secondary schools: Implications for planning: *Florida Journal of Educational Administration & Policy*. Vol.3 (2), 86-103.

Akiri, A. A. (2013). Effects of teachers' effectiveness on students' academic performance in public secondary schools, Delta State, Nigeria. *Journal of Educational and Social Research*, 3(3), 105-112.

Akpan, E.U.U. (1986). Factors affecting students' choice of science subjects in Nigerian secondary schools. *Research in Science & Technological Education*, 4(1), 99-109.

Aladejana, F. (2007). The implication of ICT and NKS for science teaching: whither Nigeria. *Complex Systems*, 17, 113-124.

Alamina, J.I. (2008). *Fundamental principles of science Teaching and learning*: Port Harcourt: Votex Publishers.

Alebiosu, K. A. (2000). Effects of two instructional methods on senior secondary school students' perceptions of the difficulty in learning some chemical concepts and their achievement gains. *Journal of Educational Foundations and Management*, 1 (1), 55–64.

Aliyu, U.A., Yashe, A. & Adeyeye, A.C. (2013). Effects of teachers' qualification on performance in further mathematics among secondary school students. *Mathematical Theory and Modeling*, 3(11), 140-146.

Amenyedzi, F. W. K., Lartey, M. N. & Dzomeku, B. M. (2011). The use of computers and internet as supplementary source of educational material: A case study of the senior high schools in the Tema Metropolis in Ghana. *Contemporary Educational Technology*, 2(2), 151-162.

American Physical Society (2010). National Task Force on Teacher Education in Physics: Report Synopsis. Retrieved online on 03/02/2016 at www.aps.org

Amunga, J. K., Amadalo, M. M., & Musera, G. (2011). Disparities in chemistry and biology achievement in secondary schools: Implications for vision 2030. *International Journal of Humanities and Social Science.* 1(18), 226-236.

Angell, C., Guttersrud, O., Henriksen, E.K. & Isnes, A. (2004). Physics: Frightful, But Fun Pupils' and Teachers' Views of Physics and Physics Teaching. *Science education*, 88(5), 683-706.

Anyanwu, J. C. & Erhijakpor, A.E.O. (2007). Education expenditures and school enrolment in Africa: Illustrations from Nigeria and other SANE countries. African Development Bank; Economic Research Working Paper, No. 92. Retrieved online on 17/03/2016 at http://www.afdb.org/

Anzene, S.J. (2014). Trends in examination malpractice in Nigerian educational system and its effects on the socio-economic and political development of Nigeria. *Asian Journal of Humanities and Social Sciences*, 2(3), 1-8.

Arokoyu, A.A. & Aderonmu, T.S.B. (2014). Quality of Science Teaching in Public Secondary Schools in Rivers State: The Journey So Far. *British Journal of Education, Society & Behavioural Science* 4(12), 1737-1749.

Atagabe, A. (2011). State of science education in the Upper East Region: An address delivered by the Acting Regional Director of Education at the 53rd Annual Conference, of the Ghana Association of Science Teachers (GAST) in Bolgatanga, September 1, 2011. Retrieved online at http://www.modernghana.com/news/348504/1/upper-east-records-poor-enrolment-of-students-in-s.html on June 27, 2014.

Atanda, A.I & Jaiyeoba, A.O (2011). Effects of School-Based Quality Factors on Secondary School Students' Achievement in English Language in South-Western and North-Central Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS)* 2 (2): 93-99.

Atkinson, D. (2012). Parental influence: the deciding factor in student careers. Retrieved online 24/ 06/2014 at http://www.fenews.co.uk/fe-news/parental-influence-the-deciding-factor-in-student-careers

Australian Academy of Science (2012). *Physics Decadal Plan 2012 – 2021: Building on Excellence in Physics, Underpinning Australia's Future*. Retrieved on 08/08/2014 at http://www.utas.edu.au/__data/assets/pdf_file/0005/333428/physics_decadal_plan_2012_2021.pdf

Australian Curriculum, Assessment and Reporting Authority (2014). Australian curriculum:

Science retrieved 9/6/2014 at http://www.australiancurriculum.edu.au.

Australian Government (n.d). Australian Education System retrieved on 9/6/2014 at http://www.studyinaustralia.gov.au//uk/australian-education/education-system

Bachman, R. & Schutt, R. K. (2014). *The Practice of Research in Criminology and Criminal Justice*. 5th edition, Delaware: SAGE publications.

Bamidele, L. (2004). Students' poor performance in physics: A bane to our nation's technological development. *Nigerian Journal of Science Education and Practice*, 2(1),174

Bao, L., Cai, T., Koenig, K., Fang, K., Han, J., Wang, J., … Wu, N. (2009). Learning and Scientific Reasoning. *Science*, 323, 586-587.

Barge, J. D. (2013). *Teacher assessment of performance standard 3: Instructional strategies.* Georgia Department of Education. Retrieved online at www.cobbk12.org on 24/09/2015.

Barmby, P. & Defty, N. (2006). Secondary school pupils' perception of physics. *Research in Science & Technological Education*, 24(2), 199-215.

Bar-Yam, M., Rhoades, K., Sweeney, L.B., Kaput, J. & Bar-Yam, Y. (2002). Changes in the Teaching and Learning Process in a Complex Education System. *Complex Systems Perspectives on Education and the Educational System.* Retrieved online at http://www.necsi.edu on 24/09/2015.

Bayraktar, S. (2001). A meta-analysis of the effectiveness of computer-assisted instruction in science education. *Journal of Research on Technology in Education*, 34(2), 173-188.

Bell, J. (2010). *Doing your research project*: New York: McGraw-Hill International.

Bello, T. O. (2011). Effect of Group Instructional Strategy on Students' Performance in Selected Physics Concepts. *The African Symposium*. 11(1), 71-79.

Bello, T. O. (2012). Effect of Availability and Utilization of Physics Laboratory Equipment on Students' Academic Achievement in Senior Secondary School Physics. *World Journal of Education*, 2(5), 1-7.

Bennett, J., Hampden-Thompson & Lubben, F (2011). *Schools that make a difference to post-compulsory uptake of physical science*: Final project report to the Astra Zeneca Science Teaching Trust. York: University of York, Department of Education.

Bennett, J., Lubben, F. & Hampden-Thompson (2013). Schools that make a difference to post-compulsory uptake of physical science subjects: some comparative case studies in England. *International Journal of science Education*, 35(4), 663-689.

Berghel, H., Daly, C. & Lavelle, D. (1984). *Computer Literacy: The effects of Teaching Method on Student Performance by Gender*. Proceedings of EDCompCon '84, 9 – 14. Retrieved online on 20/07/2015 at http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=5584

Bettinger, E. P. & Long, B. T. (2005). Do faculty serve as role models? The impact of instructor gender on female students. *The American Economic Review*,95(2), 152-157.

Biau, D.J., Kerneis, S. & Porcher, R. (20080. Statistics in Brief: The Importance of Sample size in the Planning and Interpretation of Medical Research. *Clinical Orthopaedics and Related research*, 466(9), 2282-2288.

Black, T. R., Atwaru-Okello, D., Kiwanuka, J., Serwadda, D., Birabi, O., Malinga, F., Biumigishu, A., & Rodd, A. (1998). Science education in Uganda: progress and possibilities, *International Journal of Science Education*, 20 (2), 239-252.

Blickenstaff, J. C. (2005). Women in science careers: leaky pipeline or gender filter? *Gender and Education*, 17(4), 369-386.

Blosser, P. E. (1990). The role of the laboratory in science teaching. Research Matters – to the science teacher, Reston, VA: National Association for Research in Science Teaching. Retrieved online on 06/02/2016 at www.narst.org

Boit, M., Njoki, A., & Chang'ach, J. K. (2012). The influence of examinations on the stated curriculum goals. *American International Journal of Contemporary Research.* 2(2), 179-182.

Bonwell, C. & Eison, J. (1991). *Active Learning: Creating Excitement in the Classroom.* AEHE-ERIC Higher Education Report No. 1. Washington, D.C.: Jossey-Bass.

Boote, D. N. & Beile, P. (2005). Scholars before researchers: On the centrality of the dissertation literature review in research preparation. *Educational Researcher*, 34(6), 3-15.

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.

Breakwell, G. M. & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science*, 1, 183-197.

Briggs, D. C. (2009). "Preparation for College Admission Exams. 2009 NACAC Discussion Paper." National Association for College Admission Counseling, USA. Retrieved on line on 04/02/2016 at www.nber.org

Brok, P. D., Brekelmans, M. & Wubbels, T. (2004). Interpersonal teacher behavior and student outcomes. *School Effectiveness and School Improvement*, 15(3-4), 407-442).

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review* 31 (1), 21–32.

Bryman, A. (2012). *Social Research Methods*, (4th Ed.). Oxford: Oxford University Press.

Buabeng, I., Ossei-Anito, T. A. & Ampiah, J. G. (2014). An Investigation into Physics Teaching in Senior High Schools. *World Journal of Education*, 4(5), 40 – 50.

Buddin, R & Zamarro, G (2009). Teacher Qualifications and Student Achievement in Urban Elementary Schools. Santa Monica, CA: RAND Corporation, Retrieved at http://www.rand.org/pubs/reprints/RP1410 on 31/05/2015.

Bukunola, B, J., & Idowu, O. D. (2012). Effectiveness of cooperative learning strategies on Nigerian junior secondary students' academic achievement in basic science. *British Journal of Education, Society & Behavioural Science*, 2(3), 307-325.

Celik, P., Onder, F. & Silay, I. (2011). The effects of problem-based learning on the students' success in physics course. *Procedia – Social and Behavioral Sciences*, (28), 656-660.

Central Intelligence Agency (CIA) (2015). *The World Factbook*: Retrieved online at https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html on July 22, 2015.

Centre for Science Education (n.d). Developing practical work in Ghana: the Ghana Science Resource Centres. Retrieved online on 29/02/2016 at https://www.shu.ac.uk/research/cse/news/developing-practical-work-ghana-ghana-science-resource-centres on 29/02/2015.

Cepni, S., Tas, E. & Kose. S. (2006). The effects of computer-assisted material on students' cognitive levels, misconceptions and attitudes towards science. *Computers & Education*, 46, 192-205.

Chang, H. & Lederman, N. G. (1994). The effect of levels of cooperation within physical science laboratory groups on physical science achievement. *Journal of Research in Science Teaching*, 31 (2), 167-181.

Chang, K., Chen, Y., Lin, H. & Sung, Y.(2008). Effects of learning support in simulation-based physics learning. *Computers & Education*, 51, 1486-1498.

Christian, M. (2014). Learning Strategies, Age, Gender and School-location as Predictors of Students' Achievement in Chemistry in Rivers State, Nigeria. *Research on Humanities and Social Sciences*, 4(21), 121-127.

Clotfelter, C. T., Ladd, H. F. & Vigdor, J. L. (2007). Teacher credentials and student achievement in high school: A cross-subject analysis with student fixed effects. NBER Working Paper 13617. Retrieved online from http://www.nber.org/papers/w13617 on 06/05/2016.

Coe, R., Aloisi, C., Higgins, S., & Major, L. E. (2014). What makes great teaching? Review of the underpinning research. Retrieved on 31/03/2015 at file:///C:/Users/Public/Documents/Intternational%20journals%20for%20review/What-makes-great-teaching-FINAL-4.11.14.pdf

Cohen, J.(2014). School Climate Policy and Practice Trends: A Paradox. *Teachers College Record*, Retrieved on 23/12/2015 from http://www.tcrecord.org

Cohen, L., Manion, L., & Morrison, K. (2011). *Research Methods in Education*:7th Edition. London: Routledge.

Coleman, J.S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. L. (1966). *Equality of educational opportunity*. Washington, D.C.: National Center for Educational Statistics.

Cooper, P. & Mcintyre, D. (1996). *Effective teaching and learning: teachers' and students' perspectives.* Buckingham: Open University Press.

Cox, J. (2015, August 10). *What Exactly is the Role of a Teacher?* Retrieved December 21, 2015, from http://k6educators.about.com

Creswell, J.W (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. 4th Boston: Pearson Education, Inc.

Daluba, N. E. (2013). Effect of demonstration method of teaching on students' achievement in Agricultural Science. *World Journal of Education*, 3(6), 1-7.

Darling-Hammond, L. (2000). Teacher quality and student achievement. *Education policy analysis archives*, 8(1), 1-44.

Darling-Hammond, L. (2012). *Creating a comprehensive system for evaluating and supporting effective teaching*. Stanford, CA. Stanford Center for Opportunity Policy in Education.

Daso, P. O. (2013). Teacher variables and senior secondary students' achievement in Mathematics in Rivers State, Nigeria. *European Scientific Journal*, 9(10), 271-289.

Dayal, D. (2007). *Modern Methods of teaching Physics:* New Delhi: APH publishing.

Dekkers, J., & Laeter, J. (2001). Enrolment trends in school science education in Australia. *International Journal of Science Education*, 23(5), 487-500.

De Jong, T & Van Joolingen, W.R (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research*, 68(2), 179-202.

Department of Basic Education, Republic of South Africa (2011). *National Curriculum Statement (NCS): Curriculum and assessment policy statement grades 7-9 (Natural sciences).* Retrieved online on 06/12/2014 at www.education.gov.za

Department for Education (2013). *The national curriculum in England: Framework document*. Retrieved at www.gov.uk/dfe/nationalcurriculum on 26/05/2014.

Dick, T. P. & Rallis, S. F. (1991). Factors and influences on high school students' career choices. *Journal for Research in Mathematics Education*, 22 (4), 281-292.

DiPerna, J. C., Volpe, R. J., & Elliott, S. N. (2002). A model of academic enablers and elementary reading/language arts achievement. *School of Psychology Review*, 31, 293-312.

Dorans, N. (2008). *The practice of comparing scores on different test*. ETS Report No. 6. Retrieved from http://www.ets.org on 04/02/2016.

Drever, E. (2003). *Using semi-structured interviews in small-scale research: A teacher's guide.* Glasgow: SCRE Centre, University of Glasgow.

Duze, C.O. & Ogbah, R. (2013). The school climate: Challenges facing principals in secondary schools in Delta State of Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies*.4(1), 53-63.

Ebenezer, J. V. & Zoller, U. (1993). Grade 10 students' perceptions of and attitudes toward science teaching and school science. *Journal of Research in Science Teaching*, 30(2), 175–186.

Edomwonyi-Otu, L. & Avaa, A. (2011). The challenge of effective teaching of chemistry: A case study. *Leonardo Electronic Journal of Practices and Technologies*, 10(18), 1-8.

Ejidike, I. P., & Oyelana, A. A. (2015). Factors influencing effective teaching of chemistry:A case study of some selected high schools in Buffalo City metropolitan municipality, Eastern cape Province, South Africa. *International Journal of Educational Sciences.* 8(3), 605-617.

Ejiogu, U., Ihugba, O. A. & Nwosu, C. (2013). Causal Relationship between Nigeria Government Budget allocation to the Education Sector and Economic Growth. *Discourse Journal of Educational Research*. 1(8), 54-64.

Ememe, P.I., Aitokhuehi, O.O., Jegede, S. & Ojo-Ajibare, J.O. (2013). Enhancing teaching quality through continuing professional education. *European Journal of Educational Studies*, 5(2), 277-291.

Erinosho, S.Y. (2013). How Do Students Perceive the Difficulty of Physics in Secondary School? An Exploratory Study in Nigeria. *International Journal for Cross-Disciplinary Subjects in Education(IJCDSE)*.3(3), 1510 – 1515.

Esquembre, F. (2002), Computers in physics education. *Computer Physics Communication* 147, 13-18.

Ezeweani, U. L., & Atomatofa, R. O. (2012). Choosing a career in science: The Nigerian student perception. *International Journal of Research Studies in Educational Technology.*1(2), 78-81.

Fafunwa, A.B. (1974). *History of Education in Nigeria.* London: Allen & Unwin

Faremi, Y.A. (2014). Assessment of teaching strategies adopted for effective implementation of science subjects and trade modules curriculum in Nigerian technical colleges. *Journal of Educational and Social Research,* 4(6), 391-396.

Federal Ministry of Education, FME (2009). *National physics curriculum for senior secondary schools:* Abuja: Nigerian Educational Research and Development Council.

Federal Republic of Nigeria (FRN) (1977). *National Policy on Education,* 1st edition, Lagos: NERDC press.

Federal Republic of Nigeria (2004). *National policy on Education.* 4th edition, Yaba, Lagos: NERDC press.

Federal Republic of Nigeria (2008). *The new senior secondary school curriculum structure*. Lagos, NERDC press.

Federal Republic of Nigeria (FRN) (2013). *National Policy on Education,* 6th edition: Lagos: NERDC press.

Federal Republic of Nigeria (FRN) (2016). *National budget.* Retrieved online on 03/02/2016 at www.budgetoffice.gov.ng

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. London: SAGE publishers, 4th Edition.

Fischer, R. (2009). Rural-Urban migration: A necessity to survive. Munich, Retrieved online on 04/03/2016 at www.grin.com/en/e-book

Francis, L. J., & Greer, J. E. (1999). Measuring attitude towards science among secondary school students: the affective domain. *Research in Science & Technological Education,* 17(2), 219-226.

Freedman, R. A. (1996). Challenges in Teaching and Learning Introductory Physics. In B. Cabrera, H. Gutfreund & V. Kresin, (Eds.), *From High Temperature Superconductivity to Microminiature* (313-322). New York: Plenum Press.

Friedman, B. D. & Allen, K.N. (2011). Systems theory. In Brandell, J.R (ed). *Theory & Practice in Clinical Social Work,* Second Edition, Wayne state university, USA. SAGE Publications.

Fuller, B. (1986). Raising School Quality in Developing Countries: What Investments Boost Learning? *World Bank Discussion Papers 2*. Washington DC: The World Bank.

Gaigher, E., Rogan, J.M. & Braun, M.W.H. (2006). The effect of a structured problem solving strategy on performance in physics in disadvantaged South African schools. *African Journal of Research in SMT Education,* 10(2), 15 – 26.

Gallagher, H. A. (2004). Vaughn elementary's innovative teacher evaluation system: Are teacher evaluation scores related to growth in student achievement? *Peabody Journal of Education*, 79(4), 79-107.

Gamoran, A., & Long, D. A. (2006). Equality of Educational Opportunity: A 40-year retrospective (*WCER Working Paper No. 2006-9*). Madison: University of Wisconsin–Madison, Wisconsin Center for Education Research. Retrieved May, 29, 2014 from http://www.wcer.wisc.edu/publications/workingPapers/papers.php

Getahun W. (2002). School based factors contributing to differences in students' achievement at high and low passing rate scorers of Government Secondary Schools of Addis Ababa at National Examination. *Unpublished M.A. thesis, Addis Ababa University, Ethiopia.*

Gbamanja, S.P.T. (1999). *Modern methods in science Education in Africa.* Port Harcourt: paragraphics.

Gill, T. & Bell, J.F. (2013).What Factors Determine the Uptake of A-level Physics?*International Journal of Science education*, 35(5), 753 – 772.

Glewwe, P. W., Hanushek, E. A., Humpage, S. D., & Ravina, R. (2011). School resources and educational outcomes in developing countries: A review of the literature from 1990 to 2010 (No. w17554). *National Bureau of Economic Research*.

Glewwe, P. & Jacoby, H. (1994). Student Achievement and Schooling Choice in Low-Income Countries: Evidence from Ghana. *The Journal of Human Resources*, 29(3), 843-864.

Gordon, I. & Monastiriotis, V. (2006). Education, location, education: a spatial analysis of English secondary school public examination results. *Research papers in Environmental and Spatial Analysis*, No. 116, 1-32. Retrieved online on 22/01/2016 at www.lse.ac.uk

Greaney, V. & Kellaghan, T. (2008). *Assessing National Achievement Levels in Education*. Washington,DC: The World Bank. Volume 1.

Greenberg, M. T., Weissberg, R. P., O'Brien, M. U., Zins, J. E., Fredericks, L. & Elias, M. J. (2003). Enhancing school-based prevention and youth development through coordinated social, emotional, and academic learning. *American Psychologist*, 58(6/7), 466-474.

Greenwald, R., Hedges, L. V., & Laine, R. D. (1996). The effect of school resources on student achievement. *Review of Educational Research*, 66, 361-396.

Greenwald, R., Laine, R.D., & Hedges, L.V. (1996). The school funding controversy: Reality bites. *Educational Leadership*, 53, 78-79.

Guion, L.A. (2002). Triangulation: Establishing the validity of Qualitative Studies. Publication number, FCS6014, Department of Family, Youth and Community Sciences, Florida Cooperative Extension Service, Institute of Food and agricultural Sciences, University of Florida. Retrieved at www.rayman-bacchus.net/ on 11/09/2015.

Hackling, M.W., Goodrum, D., Rennie, L. (2001). The State of science in Australian Secondary Schools. *Australian Science Teachers' Journal*, 47(4), 6-17.

Hanuscin, D. L. (2007). The use of specialized laboratory facilities for science in elementary schools: A call for research. *Journal of Elementary Science Education*, 19(2), 59-64.

Hanushek, E. A. (1986). The economics of schooling: Production and efficiency in public schools. *Journal of economic literature*, 1141-1177.

Hanushek, E. A. (1994a). An exchange: Part II: Money might matter somewhere: A response to Hedges, Laine, & Greenwald. *Educational Researcher*, 5-8.

Hanushek, E. A. (1994b). *Making schools work: Improving performance and controlling costs*. Brookings Institution Press

Hanushek, E. A. (1996). School resources and student performance. *Does money matter*, 43-73.

Hanushek, E. A. (1997). Assessing the effects of school resources on student performance: An update. *Educational evaluation and policy analysis*, *19*(2), 141-164.

Hanushek, E. A. (2006a). School resources. *Handbook of the Economics of Education*, *2*, 865-908.

Hanushek, E. A. (2006). Does Educational Tracking Affect Performance and Inequality? Differences-in-Differences Evidence Across Countries. *The Economic Journal*, *116*(510), C63-C76.

Hanushek, E.A. (2011). The economic value of higher teacher quality. *Economics of Education Review*, 30(3), 466-479.

Hanushek, E. A & Rivkin, S.G. (2006). "Teacher Quality." In Hanushek, E.A. & Welch, F. (Eds): *Handbook of the Economics of Education*, pp1051–1078. Amsterdam: North Holland.

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(1), 55-69.

Harwell, M., D'Amico, L., Stein, M. K. & Gatti, G. (2000, April). *The effects of teachers' professional development on student achievement in community school district #2*. Being a paper presented at the annual meeting of the American Educational Research Association New Orleans, LA.

Hedges, L. V., Laine, R. D., & Greenwald, R. (1994a). Does money matter? A meta-analysis of studies of the effects of differential school inputs on student outcomes. *Educational Researcher*, 23(3), 5-14.

Hedges, L. V., Laine, R. D., & Greenwald, R. (1994b). Money does matter somewhere: A reply to Hanushek. Educational Researcher, 23(4), 9-10.

Hendley, D., Parkinson, J., Stables, A. & Tanner, H. (1995). Gender differences in pupil attitudes to the national curriculum foundation subjects of english, mathematics, science and technology in Key Stage 3 in South Wales. *Educational Studies*, 21(1), 85–97.

Heyneman, S. & Loxley, W. (1983). The effect of primary school quality on academic achievement across twenty-nine high- and low-income countries. *American Journal of Sociology*, 88, 1162 -1194.

Hofstein, A. & Lunetta, V.N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational Research*, 52(2), 201-217.

Hofstein, A. & Lunetta, V.N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, 88(1), 28-54.

Hofstein, A. & Mamlok-Naaman, R. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice,* 8(2), 105-107.

Hofstein, A., Shore, R. & Kipnis, M. (2004). Providing high school chemistry students with opportunities to develop learning skills in an inquiry-type laboratory: a case study. International Journal of Science Education, 26(1), 447-62.

Holtzhausen, S. (2001). *Triangulation as a powerful tool to strengthen the qualitative research design: The research-based learning career preparation programme (RBLCPPP) as a case study*. Paper presented at the Higher Education Conference, Lancaster University, July 16–18.

Homan, R. (2001). The principle of assumed consent: the ethics of gatekeeping. *Journal of Philosophy of Education*, 35(3), 329-343.

Howe, A.C. & Berenson, S.B. (2003). *High achieving girls in mathematics. What's wrong with working hard?* Paper presented at the The 27th International Conference of the International Group for the Psychology of Mathematics Education, PME 27, Honolulu, HI.

Hussain, A., Azeem, M. & Shakoor, A. (2011). Physics teaching methods: Scientific inquiry Vs Traditional lecture. *Journal of Humanities and Social Science*, 1(19), 269-276.

Hussain, S., Ahmed, S., Mubeen,S., & Tariq, S.(2011). The Effectiveness of Teaching Physics through Project Method on Academic Achievement of Students at Secondary Level -A Case Study. *Journal of Education and Practice*, 2(8), 28-34.

Ilie, S., Jerrim, J. & Vignoles, A. (2016). Teacher attitudes and character in English schools: Evidence from TALIS. University of Cambridge, Faculty of Education. Retrieved online on 13/05/2016 at www.summit-bestinclass.com

Institute of Physics, IOP (2011). *It's different for girls: How can senior leaders in schools support the take-up of A-level physics by girls*? Retrieved on 06/11/2013 at www.iop.org/girlsinphysics

Institute of Physics, IOP (2012). *It's different for girls: The influence of schools.* Retrieved on 06/11/2013 at www.iop.org/girlsinphysics

Jaiyeoba, A.O. & Atanda, A.I. (2011). School quality factors and secondary school students'achievement in mathematics in south-western and north-central Nigeria. *The African Symposium*, 11(1), 91-100.

Jegede, P.O. & Owolabi, J. A. (1998). Computer education in Nigerian secondary schools: Gaps between policy and practice. *Meridian*, 6(2), 1-11. Retrieved online on 03/03/2016 at www.ncsu.edu/meridian

Jimoyiannis, A. & Komis, V. (2001). Computer simulations in physics teaching and learning: a case study on students' understanding of trajectory motion. *Computers & Education*, 36, 183-204.

Jo, M., Nelson, J.E. & Kiecker, P. (1997). A model for controlling social desirability bias by direct and indirect questioning. *Marketing Letters*, 8(4), 429-437.

Johnson, R.B., Onwuegbuzie, A.J. & Tuner, L.A. (2007). Toward a definition of mixed methods research . *Journal of Mixed Methods Research*. 1(2), 112-133.

Joint Council for General Qualifications (2015). *GCSE Examination results.* Retrieved online at http://www.jcq.org.uk on 25/08/2015.

Jordan, R. C., Ruibal-Villasenor, M., Hmelo-Silver, C. E. & Etkina, E. (2011). Laboratory materials: Affordances or Constrains? *Journal of Research in Science Teaching*, 48(9), 1010-1025.

Karakuyu, Y. (2010). The effect of concept mapping on attitude and achievement in a physics course. *International Journal of the physical sciences*, 5(6), 724-737.

Kasirye, I. (2009). Determinants of Learning Achievement in Uganda. Retrieved 30/05/2014 at http://www.csae.ox.ac.uk/conferences/2009-EdiA/papers/325-Kasirye.pdf.

Kelly, A. (1988). Option Choice for Girls and Boys. *Research in Science & Technological Education.* 6(1), 5 – 23.

Kelly, A. (2012). Measuring 'equity' and 'equitability' in school effectiveness research. *British Educational Research Journal*, 38(6), 977-1002.

Kelly, A. (2015). Measuring equity in educational effectiveness research: the properties and Possibilities of quantitative indicators. *International Journal of Research & Method in Education*, 38(2), 115-136.

Kelly, D., Xie, H., Nord, C.W., Jenkins, F., Chan, J.Y., and Kastberg, D. (2013). *Performance of U.S. 15-Year-Old Students in Mathematics, Science, and Reading Literacy in an International Context: First Look at PISA 2012 (NCES 2014-024)*. U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved 30/01/2016 from http://nces.ed.gov/pubsearch

Kimberlin, C. L. & Winterstein, A.G. (2008). Validity and reliability of measurement instruments used in research. *American Journal of Health-System Pharmacists*, 65, 2272-2284.

Kitzinger, J. (1994). The methodology of focus groups: the importance of interaction between research participants. *Sociology of Health & Illness*, 16(1), 103-121.

Knapp, M.S. (2003). Professional development as a policy pathway. *Review of Research in Education*. 27, 109-157.

Koksal, E.A. & Berberoglu, G. (2014). The effect of guided-inquiry instruction on 6th grade Turkish students' achievement, science process skills, and attitudes toward science. *International Journal of Science Education*, 36(1), 66-78.

Kolb, D.A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Kothari, C.R. (2004). *Research Methodology: Methods and Techniques* (2nd Revised Edition). New Delhi: New Age International publishers.

Krueger, A. B. (2003). Economic considerations and class size. *The Economic Journal,* 113(485), F34-F63.

Kunz, G.M., Nugent, G.C., Pedersen, J.E., DeChenne, S.E. & Houston, J. (2013). *Meeting Rural Science Teachers' Needs: Professional Development with on-going technology-delivered instructional coaching*. R^{2}ED Working Paper No. 2013-2018. Retrieved online on 21/12/2015 at http://r2ed.unl.edu

Lawson, A. E., Banks, D. L. & Logvin, M. (2007). Self-efficacy, reasoning ability and achievement in college biology. *Journal of Research in Science Teaching*, 44(5), 706-724.

Lelkes, Y., Krosnick, J. A., Marx, D. M., Judd, C. M., & Park, B. (2012). Complete anonymity compromises the accuracy of selfreports. *Journal of Experimental Social Psychology*, 48(6), 1291–1299. doi:10.1016/j.jesp.2012.07.002

Lips, D., Watkins, S., & Fleming, J. (2008). "Does spending more on education improve academic achievement?" *The Heritage Foundation*, Washington, D.C. September 8. Retrieved online on 15/10/2014 at www.heritage.org/research/reports/2008/09

Loukas, A. (2007). What is school climate? *Leadership Compass*, 5, 1–3.

Lunetta V,N., Hofstein A. & Clough M., (2007). Learning and teaching in the school science laboratory: an analysis of research, theory, and practice, In N, Lederman & S. Abel (Eds,), Handbook of research on science education. (393-441), Mahwah, NJ: Lawrence Erlbaum.

Lupton, R. (2004). Schools in Disadvantaged Areas: Recognising Context and Raising Quality.Centre for Analysing of Social Exclusion, CASE paper 76. Retrieved online on 03/02/2016 at http://sticerd.lse.ac.uk/dps/case/cp/CASEpaper76.pdf

Lyons, T. (2006). The Puzzle of Falling Enrolments in Physics and Chemistry Courses: Putting Some Pieces Together. *Research in Science Education*, 36,285-311.

Lyons, T. & Quinn, F. (2010). Choosing Science: Understanding the declines in senior high school science enrolments. National Centre of Science, ICT and Mathematics Education for Rural and Regional Australia, viewed 29 July 2014, http://apo.org.au/node/20912

Macneil, A.J., Prater, D.L. & Busch, S. (2009). The effects of school culture and climate on student achievement. *International Journal of Leadership in Education*, 12(1), 73-84.

Magno, M.C. (2007). Science education in developing countries in Asia: Issues and concerns for planners and implementers. In Nagao, M., Rogan, J.M & Magno, M.C. (eds). *Mathematics and science education in developing countries: Issues, experiences and cooperation prospects*. Diliman, Quezon City: University of Philippines Press.

Maoga, F.O. & Sureiman, O. (2011). Factors affecting the enrolment of students in geography in public secondary schools in Kenya. *Journal of Technology and Education in Nigeria*, 16(2), 1-9.

Marshall, M.L. (2004). *Examining school climate: defining factors and educational influences*. Retrieved 22/12/2015 from Georgia State University Center for School Safety, School Climate and Classroom Management at http://schoolsafety.education.gsu.edu/

Mathison, S. (1988). Why triangulate? *Educational Researcher*, 77(2), 13-17.

Mbugua, Z. K., Kibet, K., Muthaa, G. M., & Nkonke, G. R.(2012). Factors Contributing To Students' Poor Performance in Mathematics at Kenya Certificate of Secondary Education in Kenya: A Case of Baringo County, Kenya. *American International Journal of Contemporary Research*, 2(6), 87 -91.

McBer, H. (2000). *Research into teacher effectiveness: A model of teacher effectiveness*. Research Report No 216, DfEE. Retrieved online on 15/01/2016 at www.dera.ioe.ac.uk

McCaffrey, D. F., Lockwood, J. R., Koreetz, D., Louis, T. A., & Hamilton, L. (2004). Models for value-added modeling of teacher effects. *Journal of Educational and Behavioral Statistics*, 29(1), 67–101.

McCrory, P. (2013). In defence of the classroom science demonstration. *School Science Review*, 95(350), 81-87.

McDonald, J.H (2014). *Handbook of Biological Statistics*. Baltimore, Maryland: Sparky House Publishing.

McGreal, T.L. (1980). Helping teachers set goals. *Educational Leadership*, 37, 414- 419.

McGrew, K. (2008). Beyond IQ: A Model of Academic Competence and Motivation (MACM). Retrieved on 16/01/2014 from http://www.iapsych.com/acmcewok/ModelsofSchoolLearning.TheImportanceofLe.html

Mehmood, T. & Rehman, Z. (2011). Effective use of teaching methodologies at secondary level in Pakistan. *Journal of American Science*, 7(2), 313-320.

Melone, J., Cavanagh, R., Webster, B., Dekkers, J., Toomey, R., O'Donovan, R., & Elliot, R. (1997). Choosing or avoiding mathematics at the upper-secondary school level: some significant factors. MERGA 20, 331-336.

Meremikwu, A., & Enukoha, O. (2010). Instructional aids, school variables and pupil's Mathematics achievement in primary schools in Cross River State, Nigeria. In Joubert, M. & Andrews, P. (Eds), *Proceedings of the British Congress for Mathematics Education*, 30(1), 278-283, April.

Metzler, J. & Woessmann, L. (2010). *The impact of teacher subject knowledge on student achievement: evidence from within-teacher within-student variation*. Bonn:The Institute for the Study of Labor (IZA) Discussion Paper, 4999, June.

Milenković, Z. M. (2011). Application of Mann-Whitney U test in research of professional training of primary school teachers. *Metodicki Obzori [Methodological Horizons]*, 6(1), 73–79.

Mincu, M. (2013). Teacher Quality and School improvement: What is the role of research? *Research and Teacher Education: the BERA-RSA Inquiry, London: BERA*.

Modebelu, M.N. & Nwakpadolu, G.M. (2013). Effective Teaching and Learning of Agricultural Science for Food Security and National Sustainability. *Journal of Educational and Social Research*, 3(4), 161-170.

Mortimore, P., & Sammons, P. (1987). New evidence on effective elementary schools. *Educational Leadership*, 45 (1), 4-8.

Mujtaba, T & Reiss, M.J. (2012). Factors Affecting whether Students in England Choose to Study Physics once the Subject is Optional. Retrieved online on 11/07/2014 at https://www.ioe.ac.uk/Research_paper_%28Strand_1%29_-_NARST_2012.pdf

Mujtaba, T & Reiss, M.J. (2013). What Sort of Girl Wants to Study Physics After the Age of 16? Findings from a Large-scale UK Survey. *International Journal of Science Education*, 35(17). 2979-2998.

Mukaka, M.M. (2012). Statistics corner: A guide to appropriate use of correlation coefficient in medical science. *Malawi Medical Journal*, 24(3), 69-71.

Mullis, I.V.S., Martin, M.O., Robitaille, D.F. & Foy, P. (2009). *TIMSS Advanced 2008 International Report: Findings from IEA's Study of Achievement in Advanced Mathematics and Physics in the Final Year of Secondary Schoo*l, Chestnut Hill, MA: TIMSS & PIRLS International Study Center.

Mundalamo, F. J. (2006). The Influence of Foundation Physics on the Performance of Students in Physics I at several South African Universities. *An unpublished PhD Thesis submitted to the University of South Africa.*

Murphy, P. & Whitelegg, E. (2006). Girls in the Physics Classroom: A review of the research on the participation of girls in physics. Institute of Physics Report. Retrieved online on 16/05/2016 at http://www.iop.org.

Musasia, A.M., Abacha, O.A. & Biyoyo, M.E. (2012). Effect of Practical Work in Physics on Girls' Performance, Attitude change and Skills acquisition in the form two-form three Secondary Schools' transition in Kenya. International Journal of Humanities and Social Science, 2(23), 151 – 166.

Nascimento, P.A.M. (2008). School Resources and student achievement: Worldwide findings and methodological issues. *Educate – Special issue*, 19-30. Retrieved on 27/03/2015 at http://www.educatejournal.org.

National Centre for Education Statistics (NCES) (2013). *Trends in International Mathematics and Science study*. Retrieved at http://nces.ed.gov/timss on 30/01/2016.

National Centre for Education Statistics (2014). Education Expenditures by countries. Retrieved at http://nces.ed.gov/programs/coe/indicator_cmd.asp on 26/05/14

National Center for Learning Disabilities (2010). Teacher Effectiveness and Professional Development. Retrieved at www.ncld.org on 19/11/2015.

National Research Council. (2006*). America's Lab Report: Investigations in High School Science.* Committee on High School Science Laboratories: Role and Vision, Singer, S.R., Hilton, M.L. & Schweingruber, H.A. (Eds). Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Research Council (2009). *Learning Science in Informal Environments: People, Places and Pursuits*. Bell, P., Lewenstein, B., Shouse, A.W. & Feder, M.A. (Eds). Board in Science Education: Centre for Education, Washington DC: The National Academies Press.

National School Climate Council (NSCC). (2007). *The School climate challenge: Narrowing the gap between school climate research and school climate policy, practice guidelines and teacher education policy*. Retrieved on 23/12/2015 at www.schoolclimate.org

National Science Teachers Association (1999). NSTA position statement: The use of computers in science education. Retrieved June 30, 2015 from http://www.nsta.org/about/positions/computers.aspx

National Science Teachers Association (2007). NSTA position statement: The Integral Role of

Laboratory Investigations in Science Instruction. Retrieved 13/02/2016 from http://www.nsta.org/about/positions/laboratory.aspx

Nganji, J., Kwemain, R. & Taku, C. (2010), Clossing the digital gap in Cameroonian secondary schools through the CIAC project. *International Journal of Education and Development Using Information and Communication Technology*, 6(2), 106-114.

Njoku, Z. C. & Ezinwa, U.S. (2014). Comparative effects of peer teaching and lecture method on students' achievement and interest in some difficult concepts in chemistry. *Journal of Science Teachers Association of Nigeria (JSTAN)*,49(1), 60-73.

Nwana, S. (2012). Challenges in the application of e-learning by secondary school teachers in Anambra State, Nigeria. *African Journal of Teacher Education*, 2(1), 1-9.

Nwankwo, O.C. (2010). *Practical Guide to Research Writing.* Port Harcourt, Golden publishers Limited.

Nye, B., Konstantopoulos, S., & Hedges, L. V. (2004). How large are teacher effects? *Educational evaluation and policy analysis*, *26*(3), 237-257.

Obomanu, B.J. & Adaramola, M.O. (2011). Factors Related to Under Achievement in Science, Technology and Mathematics Education (STME) in Secondary Schools in Rivers State, Nigeria. *World Journal of Education*, 1(1), 102-109.

Odubunmi, O. & Balogun, T. A. (1991). The effect of laboratory and lecture teaching methods on cognitive achievement in integrated science. *Journal of Research in Science Teaching*, 28(3), 213–224. doi: 10.1002/tea.3660280303.

OECD (2015). *How resources, policies and practices are related to education outcomes*. Retrieved online on 17/03/2016 at www.oecd.org/pisa/keyfindings/Vol4Ch1.pdf

Ofqual (2015a). *Comparability of Different GCSE and A Level Subjects in England:An Introduction: ISC Working Paper 1*. Coventry, The office of Qualifications and Examinations Regulation.

Ogunleye, A. O. (1999). *Science Education in Nigeria: Historical development, curriculum reforms and research.* Lagos: Sunshine International publications (Nig) limited.

Ogunmade, T. O. (2005). *The status and quality of secondary science teaching and learning in Lagos State, Nigeria*. Unpublished PhD thesis, Edith Cowan University, Australia. Retrieved from http://ro.ecu.edu.au/theses/86.

Ojebiyi, O.A. & Sunday, F. L. (2014). An historical survey of the development of science and technology education in Nigeria. *Academic Journal of Interdisciplinary Studies,*3(6), 285-294.

Okeke, F.N.(2011). Physics Education: Training and Challenges. *Paper presented at the 34th International Conference of the Nigerian Institute of Physics (NIP)* held at Ile – Ife, October 11 – 15, 2011.

Olagunju, A.M. & Abiona, O.F. (2008). Production and utilizationof resources in biology education: A case study of South West Nigerian secondary schools. *International Journal of Africa & African American Studies*, 7(2), 49-56.

Oladejo, M.A., Olosunde, G.R., Ojebisi, A.O. & Isola, O.M. (2011). Instructional materials and students' academic achievement in physics: Some policy implications. *European Journal of Humanities and Social Sciences*, 2(1), 113-126.

Oludipe, B. & Oludipe, D. I. (2010). Effect of Constructivist-Based Teaching Strategy on Academic Performance of Students in Integrated Science at the Junior Secondary School Level. *Educational Research Reviews*, 5(7), 347-353.

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.

Omosewo, E. O. (1995). Science laboratory management patterns in selected secondary schools of Moro local government area of Kwara State. *Journal of Science Teaching and Learning*. 1(1&2), 63-71.

Omosewo, E.O. (2003). Factors influencing Female Students' choice of Physics in Selected Secondary Schools in Ilorin Metropolis. *Journal of Studies in Education*, 1(5), 131 – 140.

Oni, J. O. (2009). Management of primary education in Nigeria: Trends, constraints and solutions. *The Social Sciences* 4(3), 286-290.

Onipede, H. (2003).National development hinges on quality education. *The Comet*, 2 January, 21.

Onuka, A.O.U. & Durowoju, E.O. (2013). Stakeholders' role in curbing examination malpractice in Nigeria. *International Journal of Economy, Management and Social Sciences*, 2(6),342-348.

Onwioduokit, F.A. (2001). Science Education and Nation building: Curriculum implications. *The Nigerian Journal of Curriculum and instruction*. 10(1), 65 – 68.

Organisation for Economic Co-operation and Development (OECD) (2007). *Glossary of statistical terms.* OECD, Retrieved online on 22/01/2016 at https://stats.oecd.org

Oriahi, C. I., Uhumuavbi, P. O., & Aguele, L. I. (2010). Choice of science and technology subjects among secondary school students. *Journal of Social Science,* 22(3), 191-198.

Ormerod, M. B. (1975). Subject preference and choice in co-educational and single-sex secondary schools. *British Journal of Educational Psychology.* 45(3), 257-267.

Osborne, J., Driver, R., & Simon, S. (1998). Attitudes to science: issues and concerns. *School Science Review*, 79 (288), 27–33.

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.

Oseni, M. (2012). Adequacy of Budgetary Allocation to Educational Institutions in Nigeria. *Pakistan Journal of Business and Economic Review* , 3(1), 143-157.

Osokoya, M.M. & Akuche, U.E. (2012). Effects of school location on students' learning outcomes in practical physics. *Ife Psychologia*, 20(1), 241-251.

Osuafor, A. & Okoli, J. (2013). Challenges encountered by non-science teachers in teaching basic science and technology in the Nigerian Universal Basic Education (UBE) curriculum. *African Journal of Teacher Education,*3(3), 1-8.

Osuolale, O. J. (2014). Problems of teaching and learning science in junior secondary schools in Nasarawa state, Nigeria. *Journal of Education and Practice*, 5(34), 109-118.

Owoeye, J. S. & Olatunde, Y. P. (2011). School Location and Academic Achievement of Secondary School in Ekiti State, Nigeria. *Asian Social Science*, 7(5), 170-175.

Owoeye, J. S. & Yara, P. O. (2011). School facilities and academic achievement of secondary school agricultural science in Ekiti State, Nigeria. *Asian Social Science,* 7(7), 64-74.

Owolabi, O.T. & Adedayo, J.O. (2012). Effect of teacher's qualification on the performance of senior secondary school physics students: Implication for technology in Nigeria. *English Language Teaching*, 5(6), 72-77.

Pautasso, M. (2013). Ten simple rules for writing a literature review. *PloS Computational Biology*, 9(7), 1-4.

Pan, D., Rudo, Z. H., Schneider, C. L. & Smith-Hansen, L. (2003). Examination of Resource Allocation in education: Connecting Spending to Student Performance. *Southwest Educational Development Laboratory Research Report*. Texas: SEDL. Retrieved on May30,2014 from http://www.sedl.org/pubs/policyresearch/policydocs/Examination.pdf

Patrick, A. O. (2009). Evaluation of teaching in secondary schools in Delta State 2 – teaching of the sciences. *International Journal of Educational Sciences,* 1(2), 119-129.

Perera, J. & Velummayilum, P. (2008). Women's career choice and gender roles: a South Asian experience. *The Clinical Teacher,* 5(3), 186 – 190.

Powney, J. & Watts, M. (1987). *Interviewing in Educational Research*. London: Routledge & Kegan Paul.

Purkey, S. C., & Smith, M. S. (1983). Effective schools: A review. *The Elementary School Journal*, 83(4), 426-452.

Quarcoo-Nelson, R., Buabeng, I. & Osafo, D. K. (2012). Impact of audio-visual aids on senior high school students' achievement in physics. *Eurasian Journal of Physics and Chemistry Education.* 4(1), 46-54.

Questions for Governors (2014). *What proportion of students choose to continue each of the sciences (physics, chemistry and biology) and maths at A level?* Retrieved online on 08/12/2014 at http://www.questionsforgovernors.co.uk/choices

Raine, D. & Collette, J. (2003). Problem-based learning in Astrophysics. *European Journal of Physics*, (24), S41-S46.

Ramsden, P. (2003). *Learning to lead in higher education.* London: Taylor & Francis.

Rennie, L.J., Goodrum, D. & Hackling, M. (2001). Science Teaching and Learning in Australian Schools: Results of a National Study. *Research in Science Education,* 31: 455-498.

Reid, N. & Skryabina, E. A. (2002). Attitudes towards Physics. *Research in Science & Technological Education*, 20(1), 67-81.

Reid, N. & Skryabina, E. A. (2003). Gender and physics. *International Journal of Science Education*, 25(4), 509-536.

Republic of South Africa (2013). *2013 National Senior Certificate Examination Technical Report.* Pretoria: Department of Basic Education.

Revzina, L (2008). Investigating social-desirability bias in self-reporting on motivational attitudes by adult students. *Doctoral Dissertation presented to the Faculty of the School of Education, Learning and Instruction Department, University of San Francisco.*

Reynold, A. J. & Walberg, H. J. (1992). A process model of mathematics achievement and attitude. *Journal of Research in Mathematics Education.* 23(4), 306-328.

Reynolds, D., Sammons, P., De Fraine, B., Damme, J. V., Townsend, T., Teddlie, C., & Stringfield, S. (2014). Educational effectiveness research (EER): a state-of-the-art review. *International Journal of Research, Policy and Practice.* 25(2), 197-230.

Rice, J. K. (2010). The impact of teacher experience: Examining the evidence and policy implications (Brief No. 11, August). Washington, DC: National Center for Analysis of Longitudinal Data in Education Research. Retrieved online on 13/05/2016 at www.urban.org.

Rich, Y. (1993). Educational goals of teachers in heterogeneous and homogeneous classes in elementary and junior high school. *Teaching & Teacher Education*, 9(1), 81-90.

Richards, J.C. & Farrell, T.S.C. (2005). *Professional development for language teachers: Strategies for teacher learning.* Cambridge: Cambridge University Press.

Rivkin, S.G., Hanushek, E.A. & Kain, J.F (2005). Teachers, Schools and Academic Achievement. *Econometrica*, 73(2), 417-458.

RMC Research Corporation (2010). *Science Classroom Observation Protocol – Washington State's Vision of Effective Science Learning Experiences for Students*. Retrieved on 19/12/2014 at http://science-ed.pnnl.gov/resources/admin_community/pdf/scienceclassroomobservationguide.pdf

RMC Research Corporation (2013). *TEAMS – References list and resources for: identifying measures for evaluating changes in teacher practice, teacher and student attitudes and beliefs, and sustainability*. Retrieved on 25/05/2015 at http://teams.mspnet.org/media/data/TEAMS_NSF_ReferencesList_9_20_13.docx?media_000000008160.docx

Rockstroh, A.H. (2013). *Teacher Characteristics on Student Achievement: An Examination of High Schools in Ohio*. Retrieved on 03/05/2014 from http://www.martin.uky.edu/centers_research/Capstones_2013/Rockstroh.pdf

Rosen, L. D. & Weil, M. M. (1995). Computer availability, computer experience and technophobia among public school teachers. *Computers in Human Behavior*, 11(1), 9-31.

Rumsey, D.J. (2011). *Statistics For Dummies*, 2nd Edition, New Jersey: John Wiley & Sons.

Rutten, N., van Joolingen, W.R. & van der Veen, J.T. (2012). The learning effects of computer simulations in science education. *Computers & Education*, 58, 136-153.

Savasci, H. S & Tomul, E. (2013). The Relationship between educational Resources of Schools and Academic Achievement. *International Education Studies*, 6(4), 114-123.

Schroeder, C.M., Scott, T.P., Tolson, H., Huang.T. & Lee, Y. (2007). A mata-analysis of national research: effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching*, 44(10), 1436-1460.

Science Learning Network (2014). *Summary of science GCSE results 2014*. Retrieved online on 09/12/2014 at https://www.sciencelearningcentres.org.uk/news/summary-science-gcse-results-2014/

Science Teachers Association of Nigeria, STAN. (n.d). *Aims of the Association*. Retrieved online on 15/03/2016 at http://www.stanonline.org/aims.php

Selcuk, G.S. & Caliskan, S. (2010). A small-scale study comparing the impacts of problem-based learning and traditional methods on student satisfaction in the introductory physics course. *Procedia Social and Behavioral Sciences*, (2), 809 – 813.

Semela, T. (2010). Who is joining physics and why? Factors influencing the choice of physics among Ethiopian university students. *International Journal of Environmental & Science Education*. 5(3), 319 – 340.

Sim, J. (1998). Collecting and analyzing qualitative data: issues raised by the focus group. *Journal of Advanced Nursing*, 28(2), 345-352.

Simpson, M., & Tuson, J. (2003). *Using observation in small-scale research: A beginner's guide.* Glasgow: SCRE Centre, University of Glasgow.

Smetana, L. K. & Bell, R. L. (2012). Computer simulations to support science instruction and learning: A critical review of the literature. *International Journal of Science Education*, 34(9), 1337-1370.

Smithers, A. & Robinson, P. (2009). *Physics Participation and Policies: Lessons from Abroad* Buckingham: Carmichael Press.

South African Institute of Race Relations (SAIRR) (2013). *Only 20% of maths, physics Matriculants exceed 50% pass mark.* Retrieved on 06/12/2014 at http://www.sabc.co.za/news/a/55ce55004e5c358c8491b7f251b4e4e2/Only-20-of-maths,-physics-matriculants-exceed-50-pass-mark:-SAIRR-20132901

South African Schools Act 84 of 1996. Retrieved online on 06/12/2014 at www.gov.za

South Australia Education Act (1972). *Version 1.7.2012* retrieved online 9/6/2014 at http://www.legislation.sa.gov.au/LZ/C/A/EDUCATION%20ACT%201972.aspx

Sparkes, R. A. (1995). No problem here! The supply of physics teachers in Scotland. *The Curriculum Journal*, 6, 101 - 113.

Stables, A. (1990). Differences between pupils from mixed and single-sex schools in their enjoyment of school subjects and in their attitude to science and to school. *Educational Review*, 42 (3), 221-230.

Steinkamp, M. W., & Maehr, M. L. (1983). Affect, Ability, and Science Achievement: A Quantitative Synthesis of correlational research. *Review of Educational Research*, 53 (3), 369-396.

Stephen. U. S. (2011). The status of material resources for effective teaching of physics in secondary schools in Akwa Ibom State of Nigeria. *African Research Review*, 5(4), 242-249.

Stichweh, R. (2011) "Systems Theory", In: Bertrand Badie *et al*., (eds.),*International Encyclopedia of Political Science.* Sage New York.

Stokking, K. M. (2000). Predicting the choice of physics in secondary education. *International Journal of Science Education*, 22(12), 1261 – 1283.

Sundberg, M. D., Dini, M. L. & Li, E. (1994). Decreasing course content improves student comprehension of science and attitudes toward science in freshman biology. *Journal of Research in Science Teaching*, 31(6), 679–693.

Taale, K.D. (2011). Improving physics problem solving skills of students of Somanya Senior High Secondary Technical School in the Yilo Krobo District of Eastern Region of Ghana. *Journal of Education and Practice*, 2(6), 8-20.

Tabachnick, B. G. & Fidell, L. S. (2007). *Using Multivariate Statistics*. 5th Edition, Boston: Pearson Education Inc.

Tambawal, M. U. (2013). Examination malpractices, causes, effects and solutions. *A paper presented at the stake holders forum on raising integrity in the conduct of examinations in the Nigerian educational system.* February, 7.

Tanner, K.D. (2013). Structure Matters: Twenty-One Teaching Strategies to Promote Student Engagement and Cultivate Classroom Equity. *CBE Life Sciences Education*, (*12*)322-331.

Tebabal, A. & Kahssay, G. (2011). The effects of student-centered approach in improving students' graphical interpretation skills and conceptual understanding of kinematical motion. *Lat. Am. J. Phys. Edu.*, 5(2), 374-381.

Tekbiyik, A., Konur, K. B., & Pirasa, N. (2008, May). *Effects of computer assisted instruction on students' attitudes towards science courses in Turkey: A meta-analysis*. Paper presented at the 8th International Educational Technology Conference (IETC 2008). May 6-9, Anadolu university, Eskisehir, Turkey. Retrieved on 30 June, 2015 from http://files.eric.ed.gov/fulltext/ED504052.pdf

Thapa, A., Cohen, J., Guffey, S., & Higgins-D'Alessandro, A. (2013). A review of school climate research. *Review of Educational Research*, 83(3), 357-385.

The Sutton Trust (2011). Improving the impact of teachers on pupil achievement in the UK – interim findings. Retrieved on 31 March, 2015 from file:///C:/Users/Public/Documents/Intternational% 20journals %20for%20review/2teachers-impact-report-final.pdf

Thomas, O.O., & Israel, O.O. (2013). Assessing the relative effectiveness of three teaching methods in the measurement of students' performance in physics. *International Journal of Materials, Methods and Technologies*, 1(8), 116-125.

Tobin K.G., (1990). Research on science laboratory activities: in pursuit of better questions and answers to improve learning. *School Science and Mathematics*, 90, 403-418.

Tobias, S. & Birrer, F. A. J. (1999). Who will study physics, and why? *European Journal of Physics*, 20, 365 – 372.

Trundle, K. C. & Bell, R.L. (2010). The use of a computer simulation to promote conceptual change:A quasi-experimental study. *Computers & Education*, 54, 1078-1088.

Uline, C. & Tschannen-Moran, M. (2008). The walls speak: the interplay of quality facilities, school climate and student achievement. Journal of Educational Administration, 46(1), 55-73.

UNICEF (2009). *Child Friendly Schools Evaluation: Country report for Nigeria*. New York: UNICEF. Retrieved online on 07/04/2016 at http://www.air.org/sites/default/files/

Uside, O. N., Barchok, K.H. & Abura, O.G. (2013). Effect of discovery method on secondary school students' achievement in physics in Kenya. *Asian Journal of Social Sciences & humanities*, 2(3), 351-358.

Varma, S. (2014, August 19). 75% of schools lack descent science labs: Survey. *The Times of India*. Retrieved from http://timesofindia.indiatimes.com on 26/02/2016.

Veselinovska, S.S., Gudeva, L.K. & Djokic, M.M. (2011). The effect of teaching methods on cognitive achievement in biology studying. *Procedia Social and Behavioral Sciences*, 15, 2521-2527.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K. & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research*, 34(3), 229-243.

Von Bertalanffy, L. (1968). *General Systems Theory*. New York: Braziller.

Vorsino, W. S. (1992). *Improving the effectiveness of science laboratory instruction for elementary students through the use of a process approach for change*. Ed. D. Practicum, Nova University. (EDRS No. ED 357976).

WAEC cancels 2014 results of Candidates (2015, May 07). *Vanguard*. Retrieved from http://www.vanguardngr.com/2015/05/waec-cancels-2014-results-of-candidates/ on August 17, 2015.

Walberg, H. J. (1984). Improving the productivity of America's schools. *Educational Leadership*, 19 -27.

Walberg, H. J., Haertel, G. D., Pascarella, E., Junker, L.K., & Boulanger, D. (1981). Probing a model of Educational Productivity in Science with National assessment Samples of Early Adolescents. *American Educational Research Association*, 18(2), 233 -249.

Walonick, D.S. (1993). General Systems Theory retrieved 27/02/2014 at http://www.statpac.org/walonick/systems-theory.htm

Wambugu, P. W., & Changeiywo, J. M. (2008). Effects of mastery learning approach on secondary school students' physics achievement. *Eurasia Journal of Mathematics, Science & Technology Education.* 4(3), 293-302.

Wasanga, C. M. (1997). *The attitude towards science among primary and secondary school students in Kenya.* Nairobi: Academy of science publishers.

Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad*. Dallas, TX. National Staff Development Council.

Weiner, J. (2007). *Measurement: Reliability and validity measures*. Mimeo, Bloomberg School of Public Health, Johns Hopkins University. Retrieved online @ http://ocw.jhsph.edu/ on 11/12/2015.

White, S. & Tesfaye, C.L. (2010). High School Physics Courses & Enrollments: Results from the 2008-2009 Nationwide Survey of High School Physics Teachers. Downloaded online on 29/07/2014 at http://www.aip.org/statistics/reports/high-school-physics-courses-enrollments

White, S. & Tesfaye, C. L. (2011). *Under-Represented Minorities in High School Physics – Results from the 2008 -09 Nationwide survey of High School Physics Teachers*. Retrieved on line on 29/07/2014 at http://www.aip.org/statistics/reports/under-represented-minorities-high-school-physics

White, S. & Tesfaye, C. L. (2014). Nearly 1.4 Million High School Physics Students – Enrollments in AP and Second-year courses up 26% even though number of graduates down in 2012-2013. *The Physics Teacher*, 52, 276 – 277. http://dx.doi.org/10.1119/1.4872405

Wilkinson, S. (2004). Focus group research, In Silverman, D. (Ed). *Qualitative Research: Theory, Methods and Practice.* London: Sage Publications.

Williams, C., Stanisstreet, M., Spall, K., Boyes, E.& Dickson, D. (2003). Why aren't secondary students interested in physics? *Physics Education*, 38(4), 324 – 329.

Wilson, V. (2014). Research Methods: Triangulation. *Evidence Based Library and Information Practice, 9*(1), 74-75. Retrieved from http://socialiststudies.com/index.php/

Wise, K.C. (1996). Strategies for teaching science: What works? *The Clearing House: A Journal of Educational Strategies, Issues and Ideas,*69(6), 337-338.

Wise, K.C. & Okey, J.R. (1983). A meta-analysis of the effects of various science teaching strategies on achievement. *Journal of Research in Science Teaching*, 20(5), 419-435.

Woessmann, L. (2003). Schooling Resources, Educational Institutions and Student Performance: the International Evidence. *Oxford Bulletin of Economics and Statistics*. 68(2), 117-170.

Woolnough, B. (1994). *Effective science teaching*. Buckingham: Open University Press.

Woolnough, B. E., Guo, Y., Leite, M. S., Almeida, M. J., Ryu, T., Wang, Z., & Young, D. (1997). Factors affecting student choice of career in science and engineering: parallel studies in Australia, Canada, China, England, Japan and Portugal. *Research in Science & Technological Education*, 15(1), 105-121.

Workineh, G. (2002). School based factors contributing to differences in students' achievement at high and low passing rate scorers of Government Secondary Schools of Addis Ababa at National Examination. *Unpublished M.A. thesis, Addis Ababa University, Ethiopia.*

Wright, S. P., Horn, S. P., & Sanders, W. L. (1997). Teacher and classroom context effects on student achievement: Implications for teacher evaluation. *Journal of Personnel Evaluation in Education.* 11, 57-67.

Wynarczyk, P. & Hale, S. (2009). *Improving take up of science and Technology subjects in schools and colleges: A synthesis review.* Report prepared for the Economic and Social Research Council (ESRC) "Science in Society" Team and the Department for Children, Schools and Families (DCSF). Retrieved online on 03/02/2016 at www.esrc.ac.uk

Xu, J. (2009). School Location, Student Achievement, and Homework Management Reported by Middle School Students. *The School Community Journal*, 19(2), 27-44.

Yoon, K. S., Duncan, T., Lee, S. W.Y., Scarloss, B., & Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects student achievement* (Issues & Answers Report, REL 2007–No. 033). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest. Retrieved from http://ies.ed.gov/ncee/edlabs on 21/15/2015.

Yu, G. (2007). Research evidence of school effectiveness in sub-saharan Africa. *EdQual working paper No.7*. University of Bristol, UK.

Yusuf, M.A. & Adigun, J.T. (2010). The Influence of School Sex, Location and Type on Students' Academic Performance. *Int J Edu Sci*, 2(2), 81-85.

Zhu, Z. (2008). *A Comparison Study of Students' Reasons for Taking Physics between Two Australian High Schools and Two Chinese High Schools*. Paper presented at the Australian Association for Research in Education held at Brisbane

Zuzovsky, R. (2005). *Teachers' qualifications and their impact on student achievement: Findings from TIMSS 2003 data for Israel*. Retrieved 01/10/2015 from http://www.ierinstitute.org/fileadmin/Documents/IERI_Monograph/IERI_Monograph_Volume_02_Chapter_02.pdf