Pupil Attainment in Secondary School Physics: The Case of Nigeria, Including Implications for Teachers and Teacher Educators

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Abstract

Despite the relevance of physics to many science and technological based careers, students' attainment in the subject has been of concern in many countries including Nigeria. The study examined physics attainment among secondary school pupils and found that physics attainment is low in Nigeria and that teacher quality and resource availability and utilization are some factors that affect student attainment. To enhance students' physics attainment, the study recommended that the content and curriculum of ITE programs be enhanced for the training and development of agency amongst teachers and the need for teachers to update their subject knowledge through regular participation in continuing professional development activities.

Keywords: Post-Compulsory Initial Teacher Education; Attainment; Secondary Physics; Resources.

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Introduction

The main aim of this study was to investigate the effect of school-based factors on physics attainment in secondary schools and to examine the implications for practice and Initial Teacher Education (ITE) providers. Attainment and its measures is therefore a key concern in this study. Some literature on students' attainment in physics and science in general has therefore been reviewed with a view of having a better understanding of attainment issues on a global perspective.

There is good evidence in literature that suggests that physics is perceived as a difficult subject (Angell, Guttersrud, Henriksen & Isnes, 2004; Murphy & Whitelegg, 2006; Author[1]& Omeodu, 2016) by many students and that most students who choose to continue with physics after the post-compulsory years of schooling into A-levels and universities are the 'most-able' of their peers (Woolnough, 1994). In fact, Osborne, Driver & Simon (1998) argued that 'physics and chemistry are taken by students who do well and are not taken as incidental or additional subjects' (p 30). It is however of concern, especially in Nigeria and in many other countries that a good percentage of those who consider themselves as 'able' and so enrol for the subject (physics), do not record impressive outcomes (Author[1]& Omeodu, 2016; Osborne *et al.*, 1998).

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. Table 1 (secondary data) 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 (FME, 2009; Obomanu & Adaramola, 2011).

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). 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 implication of the above statement is that the curriculum developers in Nigeria have acknowledged the fact that the teaching and learning of physics have associated problems that have hindered 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 *et al.*, 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.

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.

Method and methodology

The study utilised mixed methods. The choice of this approach is to have an in-depth understanding of main factors that affect pupil attainment in physics. It is hoped that this would enable the researcher to suggest ways of improving teachers' pedagogical practices and possible curriculum review of ITE programmes to ensure the effective development of teacher agency. The collection of data in varied forms is also 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 were 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. Interviews with physics teachers and focus group discussions involving both physics and non-physics students were also carried out for an in-depth investigation of the subject matter. Questionnaires, interviews, classroom observations, Physics Attainment Test (PAT) and secondary data were used as methods of data collection for the study.

Sample and sampling procedures

Purposive sampling was utilized to select 8 schools in the high and low performing local government areas in Rivers State, Nigeria. To capture the three school types, another criterion that was considered in the selection of local authorities was the running of a boy, girl and mixed schools, to explore the possibility of interesting outcomes of gender and physics attainment. All 14 physics teachers in the 8 schools opted-in to participate in the study. For student participants, only those whose parents consented to their participation were recruited for the study. In all, 14 physics teachers, 248 physics students and 116 non-physics students participated in the study.

The questionnaires

Two questionnaires were developed for use in the study. They are the Questionnaire for Physics Teachers (QPT) and the Questionnaire for Physics Students (QPS). The questionnaires are intended to elicit information from respondents that would generate data for statistical analysis. The *Questionnaire for Physics Teachers (QPT)* – a 22-item instrument posed 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 (Hanushek, 1997; Williams *et al.*, 2003). The *Questionnaire for Physics Students (QPS)* is a 12-item instrument that sought to generate information about the school, students' choice of physics, students' experiences in physics classrooms, their perception about their physics teacher and their school climate.

Interview and focus group schedules

The Interview Schedule for Teachers (ISfT) and the Interview Schedule for Students (ISfS) were developed and used for the study. The ISfT has 9 questions and was planned to last between 45-60 minutes, while the ISfS is composed of 8 questions, planned for a duration of about 25-45 minutes and 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 thought-out questions developed by the researcher from an extensive search of the literature on possible school-based factors that could influence students' enrolment in physics.

Classroom observation

It was 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 formed 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 (2010) 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.

The Physics Attainment Test (PAT)

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.

Validity and reliability of instruments

All the research instruments were validated by experts in the field of science education and physics classroom teachers in UK and Nigeria. The instruments were adjudged to be suitable as to elicit relevant information for the study. To test for the reliability of the instrument, the test-re-test method was utilised. The correlation coefficients obtained for the instruments were $r = 0.891$ for the QPS, $r = 0.819$ 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 for the study.

Results

The SSCE attainment record for the period 2004 to 2013 for Nigeria is shown in Table 1 and shows the poor attainment of physics students in Nigeria. The erratic nature of the performances with dips and peaks that are not consistent poses a great challenge in describing the physics attainment of students in Nigeria. Between 2004 and 2013, Physics had four years (2006, 2010, 2011 and 2012) when more than 50% of students enrolled in SSCE passed with credit level or higher grades.

Table 1: SSCE attainment in Physics in Nigeria (2004-2013)

Year	Total SSCE Enrolment	Total Physics Enrolment	% Credit pass
2004	1051246	333783	47.8
2005	1091763	355633	40.8
2006	1184223	221494	56.9
2007	1275330	424147	42.9
2008	1369142	464199	47.1
2009	1373009	475001	46.2
2010	1351557	481830	50.2
2011	1540250	572143	62.6
2012	1695878	637712	67.2
2013	1689188	647358	46.0

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

The SSCE attainment record for the same period (2004-2014) for Rivers State is presented in Table 2. The graph showing the trend is shown as Figure 1.

Table 2: SSCE attainment in Physics in Rivers State (2004-2013)

Year	Total SSCE Enrolment	Total Physics Enrolment	% Credit pass
2004	66358	26964	47.5
2005	72229	30000	55.1
2006	76594	32587	70.0
2007	87004	37338	58.5
2008	99271	42145	65.9
2009	81618	35518	48.9
2010	43757	20456	47.3
2011	61429	28203	72.1
2012	60654	27712	81.5
2013	65688	30448	58.6

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

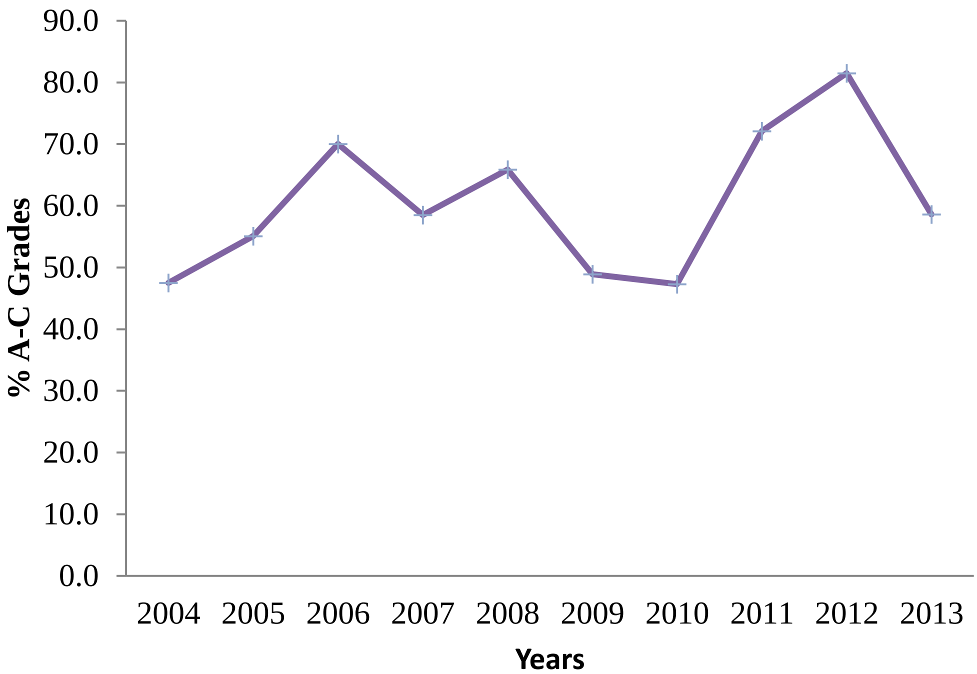


Figure 1: Attainment trend of physics, Rivers 2004-2013

As observed, there appears not to be any predictable trend in the physics attainment of students for the period of 10 years in Rivers State as is the case with the National results. There are periods of increase and decrease in attainment. For instance, the attainment appreciated between 2004 and 2006 and started undulating from 2007 to 2010 when it rose significantly up to 2012 before dipping low in 2013.

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. The PAT was introduced into the study to validate the SSCE results of the schools in physics. 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'. SC is a specialist science college in the state. The SSCE and PAT results are examined in the sections that follow.

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 3 below. A general look at the table shows a difficulty in establishing trend of performance as observed both in the state and 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 Table 5. 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 4. The converted SSCE scores are then compared with the attainment scores in the PAT shown in Table 6. 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 examined under the 'discussion' section.

Table 3: SSCE attainment 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 4: 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: Mean Zone 1 SSCE attainment scores in percentages

Zone1 \ Years	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 6: Comparison of Zone 1 SSCE and PAT scores in percentages

Zone1 \ Exam Type	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**

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 7. 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 Table 8. The converted SSCE scores are compared with the PAT attainment scores and shown in Table 9. 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.

Table 7: SSCE attainment in physics for 2010-2014 of participating schools in Zone 2

Zone2 \ Years	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 8: 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 9: 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**

SSCE and PAT results of the Science College

SSCE result for all five years was obtained from the school and presented in Table 10.

Table 10: SSCE attainment 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

Also in SC, 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 11 while the school means for the SSCE and PAT are shown in Table 12.

Table 11: Mean 'SC' 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 12: Mean 'SC' 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. A summary of the SSCE and PAT comparison of participating schools is shown in Table 13 and Figure 2.

Table 13: SSCE and PAT Performance by school

Zones	**Schools**	Mean SSCE %	Mean PAT %	Difference (%)
Zone 1	A1	54.2	15.5	38.7
	B1	31.6	20.3	11.3
	C1	45.2	13.5	31.7
	D1	47.9	11.6	36.3
Zone 2	A2	52.9	25.3	27.6
	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	

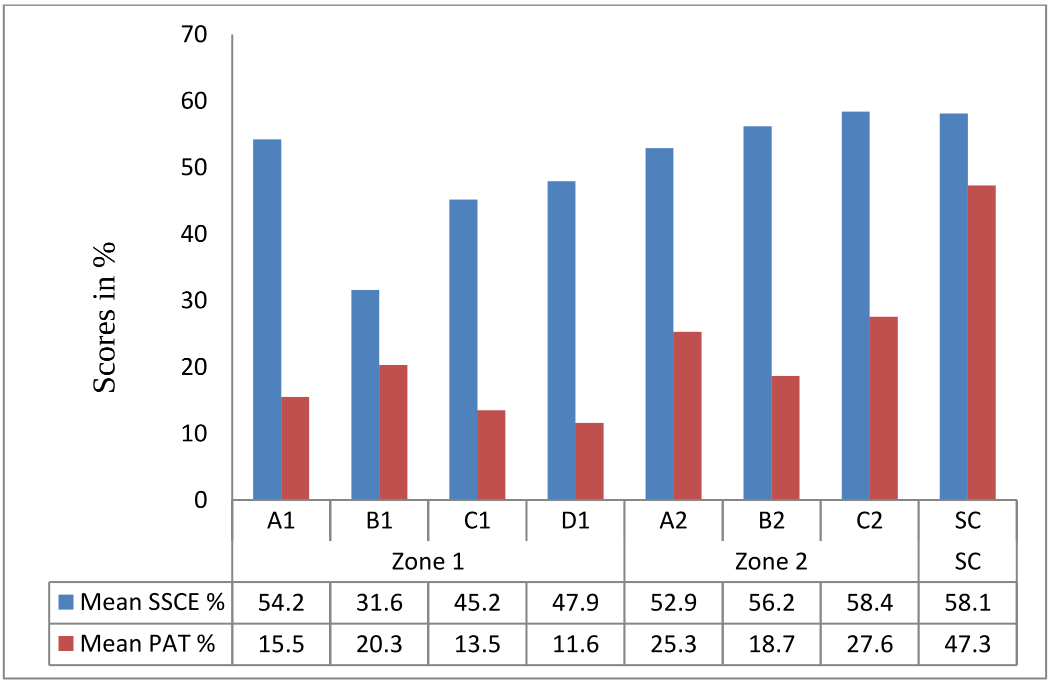


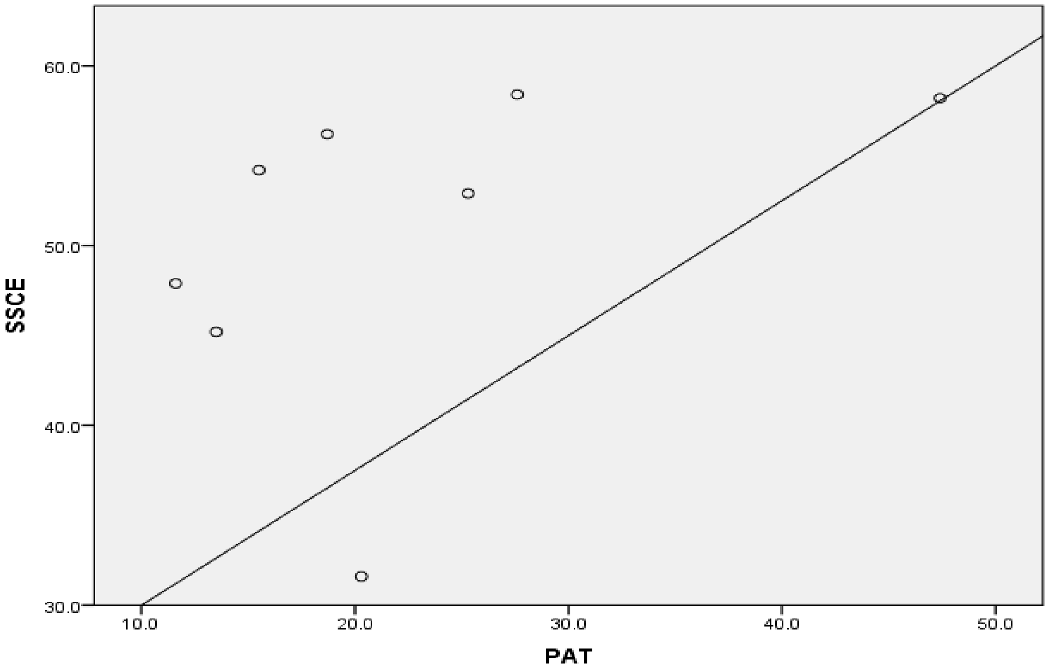
Fig. 2: Comparison of SSCE and PAT achievements

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 14.

Table 14: Pearson correlation of SSCE and PAT Performance of schools

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

The result shows that there is no significant (r = 0.428, p = 0.29, > 0.05) between the SSCE and PAT scores. A scatter plot of SSCE versus PAT was also done for all 8 schools and shown in Figure 3. 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.



Some quantitative data fr

Fig. 3: Scatter plot of SSCE and PAT scores

The opinion of teachers was sought for general factors that could limit the effective teaching and learning of physics in schools and by implication, contribute to low attainment in exams. The response of teacher is presented in Table 15 and reveals 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.

Students' opinion on how they learn physics was sought. Their responses as shown in Table16 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 15: 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

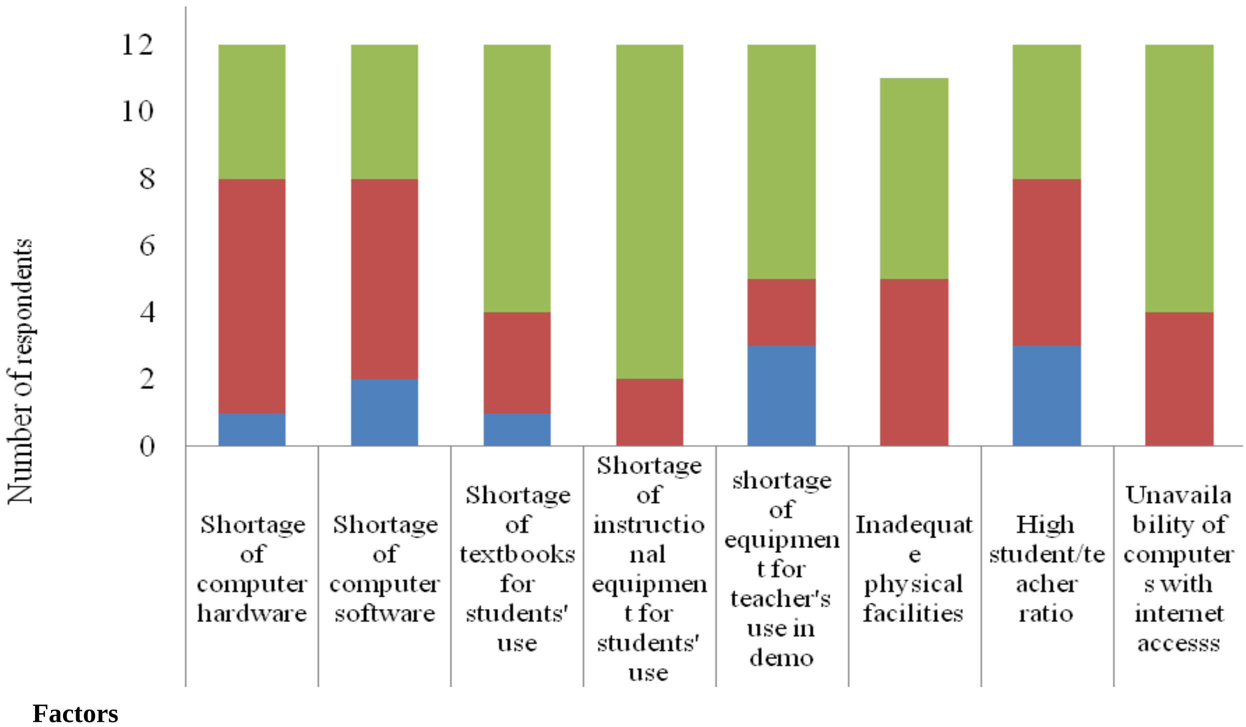


Fig.4: Teachers' opinion on limiting factors to effective physics teaching

Table 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

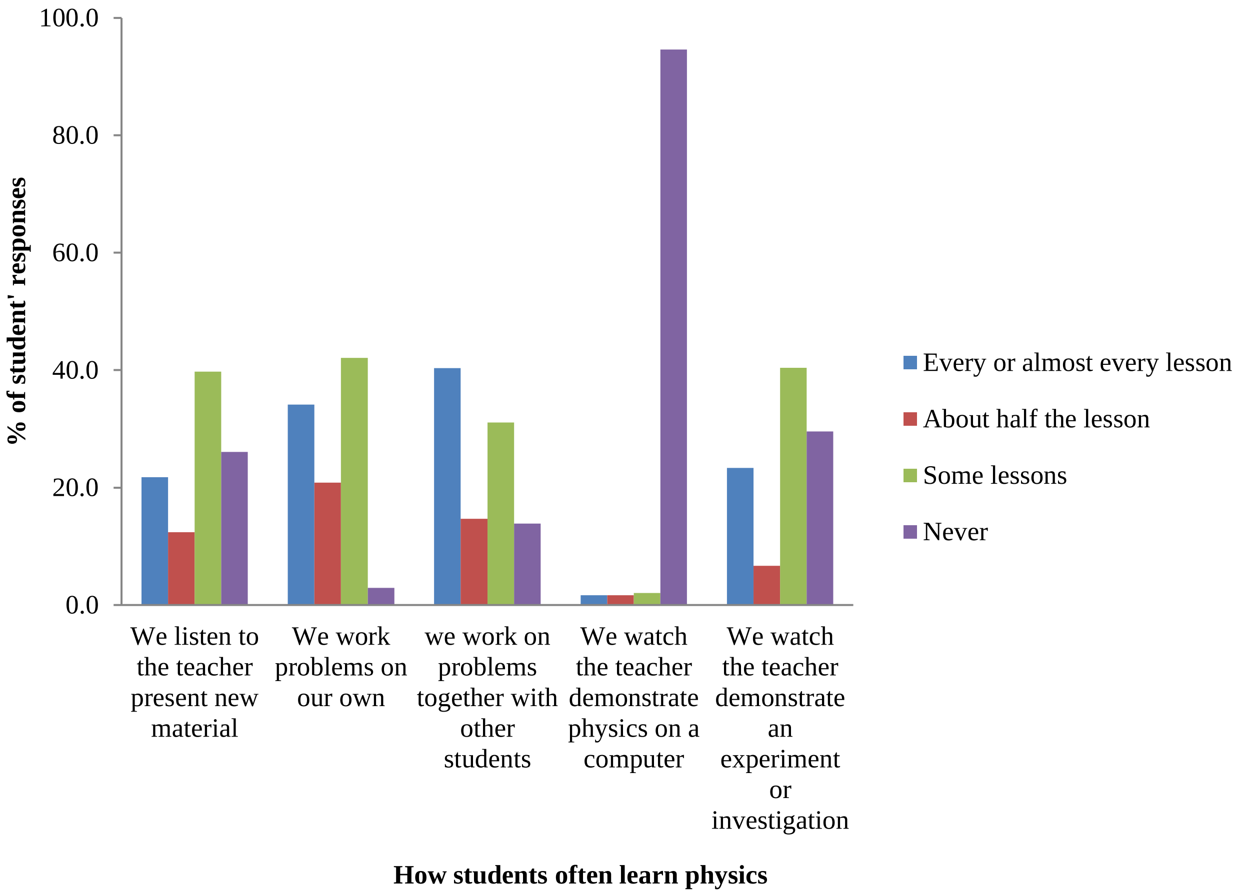


Figure 5: How students say they learn physics in classroom

Classroom observation of physics lessons

Classroom observation of physics lessons was made in 7 out of the 8 schools used in the study. The Science Classroom Observation Worksheet (SCOW) 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 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 formed 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.

Table 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)

Discussion of findings

The findings of this study suggest that there has not been a consistent pattern in the attainment of students enrolled for physics in Nigeria and that the average attainment level of students enrolled for senior secondary school certificate examinations in Rivers State was higher than the National. On attainment, the result of students in the Physics Attainment Test, PAT shows a very poor performance. These findings are discussed hereunder.

Physics attainment

The summary of students' percentage A-C grade attainment in physics at the senior secondary certificate examinations for Nigeria and Rivers State from 2004 to 2013 is shown in Tables 1 and 2. A look at these tables and Figure 1 shows that there is no consistent trend or pattern in physics attainment in Nigeria. 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 not only in physics, but generally 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, as in many other countries as highlighted in the introduction, 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. In Nigeria for instance, 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 and attainment in the STEM subjects including physics in recent times (Ofqual, 2015) 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 and 2, showing the National and Rivers State students' SSCE attainment in physics for the period 2004-2013 is that the average percentage A-C grade attainments in Rivers State is higher than the national average. 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 physics may not be as bad as has been reported in the literature, if judged from records of SSCE performance where the state average is seen to be higher than the national. The finding of this study based on the SSCE records of students' physics attainment in Rivers State is therefore opposed to the earlier position of Obomanu & Adaramola (2011) who had reported 'under attainment' 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. 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; Christian, 2014). Poor attainment in particularly physics has also been reported in Ghana (Buabeng *et al.,* 2014), South Africa (Gaigher, Rogan & Braum, 2006; SAIRR, 2013) and the United States of America (Bao *et al*., 2009; American Physical Society, 2010).

A concern about this position of a 'fair' and not 'poor attainment' of science students in Rivers State, particularly in physics is the issue of the reliability and credibility of the conduct of the WAEC examination.

A comparison of the SSCE and PAT scores as summarised on Table 13 shows a wide variation in school attainment in physics. As 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 13) 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 (Tambawal, 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 (see fig.3). In other schools, a wide margin is observed between the SSCE and PAT mean performances. Table 13 and Fig. 2 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%.

As discussed, 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 calls 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.

Again, the scores as shown in Table 13 (for the PAT attainments) reveal that the attainment level of students in physics is low in Nigeria. As was explained earlier, 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). 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 is some research evidence in the literature that suggests 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.

Factors affecting physics attainment

On possible factors that could hinder effective physics teaching and learning and by implication, students' understanding, findings from the study suggests that 'shortage of equipment for teachers' use in demo' was a limiting factor to the effective teaching and learning of physics (Table 15 and Figure 4). On how they commonly learn physics, 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 16). 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 Table 17). 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 and also, may have contributed to the poor attainment of students in the subject. The finding of the present study from the classroom observations is consistent with those of Buabeng *et al.,* (2014), 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 that do not facilitate student understanding. 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. 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. This view is consistent 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).

Conclusions and recommendations

This study has critically examined pupils’ attainment in secondary school physics in Nigeria and possible factors that may have affected effective teaching and learning. The study has provided some insight into the attainment, teaching and learning of physics in Nigerian schools. The finding of this research, that physics teachers adopt more teacher-centred approaches and that the approach that teachers adopt affects students’ 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 develop the required motivation to perform well in the subject. 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. Also, that ITE providers ensure that the curricula and experiences Trainee teachers engage in are appropriate in terms of skills and knowledge to develop the required agency for their trainees in practice.

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. Also, ITE providers would need to enrich their curriculum to produce teachers with agency with good mastery of the subject and curriculum knowledge. 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.

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 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.

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