

Modeling the Relationship between Physics Teacher Characteristics, Teaching Behaviour and Students' Achievement in Physics

Titilayo Adeoye Ajadi

Department of Science and Technology Education, University of Ibadan, Nigeria

Abstract

This paper assessed the relationships between teacher characteristics and teaching behaviour and the concomitant effects of the relationships on senior secondary school students' achievement in physics. The hypothesis tested was: that professionally trained teachers at university and who demonstrate appropriate teaching skills, would encourage students to learn better and do well in physics. Thirty-two physics teachers and 1163 physics students were randomly selected from thirty senior secondary schools (SSS) in Ogun and Oyo States, Nigeria. Two instruments were used to collect data: Teacher-students Interaction Observation Schedule (Cronbach alpha = 0.79) and Physics Achievement Test (KR-20=0.86). The result of Pearson Product Moment Correlation Coefficient among teacher qualification ($r=.76$; $p<.05$), teaching experience ($r=.78$; $p<.05$) have significant relation; 69% have direct causal effect while 31% of the variables have indirect effect on students' achievement in Physics. Adjusted Goodness of Fit Index (AGFI), normed fit index (NFI), and comparative Fit Index (CFI) are 1.00 (perfect fit - good model fit). Results showed that there was a significant relationship between teacher factors, and teaching skills on students' achievement in Physics. However, it was recommended that highly qualified and experienced teacher should be employed to teach physics in senior secondary schools.

Keywords: Teacher qualification, Teaching experience, Lesson preparation, Introduction, Lesson presentation, Communication, Students' achievement in physics

Introduction

Physics is a nature of science that is based on experiments, measurements and mathematical analysis with the purpose of finding quantitative physical laws for everything within and outside the environment. Physics is the study of matter and natural events, based on empirical observations and quantitative measurements. Many technical or basic tools and equipment surrounding us work according to the laws of physics. It is a subject that requires the processes of science to understand the theoretical concepts and their applications in solving everyday life problems. Also, the importance of physics to the society is evident in man's reliance on technology. In other words, the indices of development of any country are Physics-based technologies. This is evident in the level of students' enrolment and performance in physics in school based and external examinations.

In Nigerian secondary schools, students study physics as a subject for three years, which is senior secondary school (SSS) as stipulated in the National Policy on Education (Federal Republic of Nigeria – FRN, (2013). Teachers at secondary school level are required to engage students in practical words involving conducting experiments, with the aims of developing their scientific knowledge and experimental skills, and at the same time arousing, sustaining interest and cultivating their attitude

positively to physics and physics related phenomena.

Though physics quest for technological advancement of developing nations such as Nigeria, enrolment and achievement at external examinations conducted by the West African Examinations Council (WAEC) and National Examinations Council (NECO) fall below expectation. The level of performance of students in physics in these examinations is of much concern to government, educationists and researchers in the field of physics education (Adegoke, 2010; Adeoye, 2006). Although, the performance of physics students in WAEC examinations (May/June) from 2007 to 2014 improved in some years (51% in 2010, 64% in 2011, 69% in 2012 and 60% in 2014), the improvement is not sufficient to conclude that students have mastered physics. The pass percentage was average throughout this period, but poor performance was observed between 2007, 2008, 2009 and 2013 with 43%, 48%, 48% and 47% respectively.

Some studies have found that teacher-students relationship has positive impact on students' learning outcomes in school subjects. For example, Bradley, Pauley and Pauley (2006) found that positive teacher-student classroom interactions improve students' affective and cognitive development, increase motivation for learning and minimized negative students' behaviour in the classroom. Positive teacher-students relationships are characterized by situations in which the teacher manages classroom

activities by giving directions to teaching and learning activities, by stimulating students' participation in the teaching and learning activities, by asking questions and allowing them to ask questions, contribute ideas, and by arousing students' interest in the subject.

Teaching involves the use of classroom practises. Many studies used quantitative method of multiple correlations to study link between students' academic achievement and teacher classroom practices, as well as other aspects of teaching, such as the professional development teachers receive in support of their classroom practices and teacher characteristics. Goe (2007) defines teachers' classroom practices as including practices both in and out of the classroom such as, planning, lesson preparation, introduction of the lesson, classroom communication, lesson presentation, organisation of the lesson, evaluation, classroom management, and interactions with students. Thus, there is a need to determine whether classroom practices (preparation, introduction, presentation, and communication) would have an impact on students' academic achievement in physics. Teacher need to plan his or her lesson before teaching to maximises instructional time/period. Many teachers fail in delivering their lesson properly because they fail to plan carefully and properly. Teacher should ensure that he/she knows the objectives of teaching a particular topic. It should also be stated and communicated to the students. The teacher must plan his/her lesson to follow a logical pattern, such that one idea leads to the other. The initial planning involves thinking or imagines through the lesson, the attention span of the students, their ability, their learning styles and the difficulty level of the topic and simplifies the difficult concepts. The teacher is able to make some modifications to achieve the objective.

Everything that a teacher does in the classroom is communication in one way or the other. If communication is not effective, the teacher's ideas, directions and thoughts are either lost or misunderstood. When commencing a class, a good communication skill is required. Classroom communication process involves three basic elements: the communicator, the message and the receiver. The teacher who is the communicator is often referred to as the source (Adjai, 2001; Onwuegbu, 2000). The teacher needs to arouse and sustain the students' interest. One way of getting students' interest is through attention getter through a statement, a story or a question. **The teacher could**

come up with a topic for discussion and encourage students to discuss openly, either in groups or the whole class could be involved in the discussion, and individual students are encouraged to make their contributions. Therefore, communication means the transfer or the transmission or exchange of ideas, knowledge, beliefs, attitudes or emotion from one person or group of persons to another. This process is a continuous one as feedback gives rise to new activities. Teachers are sensitive to the reactions of students when teaching in the classroom. Communication is an essential instrument for teaching; it causes a change in behaviour or reaction (Adjai, 2001). The teaching skills can only be practised by the qualified and experienced teachers in the classroom.

Teaching experience has long been thought to affect teaching skills, with more experienced teachers associated with greater teaching effectiveness. Okigbo and Okeke (2004) stress that teachers must be knowledgeable and experienced in the discipline they profess to teach. Experienced physics teachers perceive fewer classroom problems because they are better informed about the system than the beginning teachers who are new in the system and might not have known much about the students and classroom setting. Thus, the experienced teachers are better at maintaining discipline in the classroom than beginning teachers. Oladokun (2010) reports that students taught by experienced teachers performed significantly higher than those taught by non-experienced teachers in science process skill acquisition. Goldhaber and Brewer (2000) also discovered that teacher's experience positively relates to high school students' achievement in Physics.

Teachers' qualification exposure can go a long way to bring about students' high academic achievement. Asikha (2010) found that there is a perfect relationship between teachers' qualification and students' achievement in science. Betts, Zau, & Rice, (2003) found that there is a significant positive relationship between physics teachers' qualification and students' achievement in physics. Teacher post-secondary degree and students' performance found a positive relationship between those variables with higher level of performance among students whose teachers held a Bachelor's or Master's degree in physics than among students whose teachers were out of field.

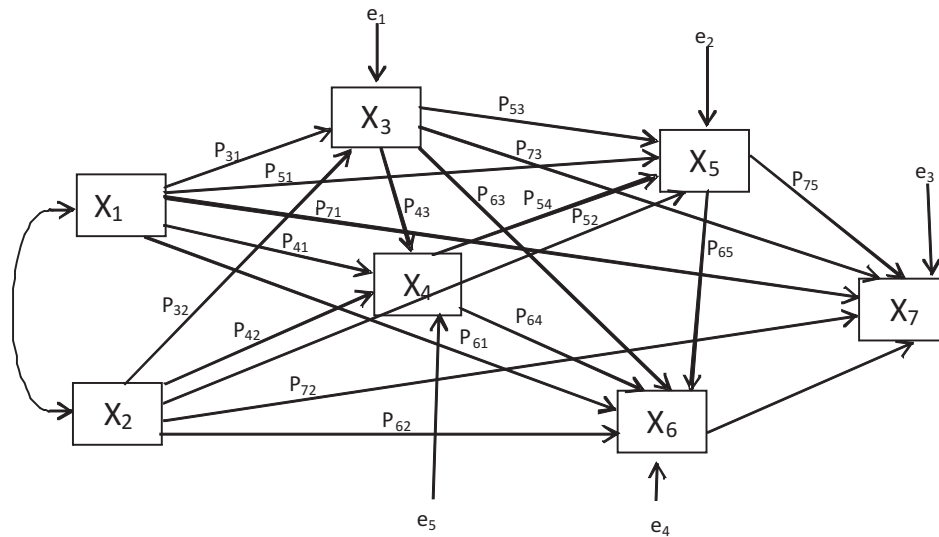


Figure1. Recursive Path Model of Students' Achievement in Physics Factors
Key: X₁ = Teacher Qualification; X₂ = Teaching Experience; X₃ = Lesson Preparation; X₄ = Lesson Introduction; X₅ = Lesson Presentation; X₆ = Communication; X₇ = Students Achievement in Physics.

Research Questions

The study sought answers to the following three research questions.

1. What is the pattern of correlation among variables of teacher factors (teacher qualification, and teaching experience), teaching skills (preparation, introduction, presentation, and communication), and students' achievement in physics?
2. What are the fit indices of the model? What are the fit indices of the hypothesized model for teacher factors (teacher qualification, and teaching experience), teaching skills (preparation, introduction, presentation, and communication), and students' achievement in physics?
3. Is the model which describes the causal effects among the teacher characteristics (qualification and teaching experience), teaching skills (preparation, introduction, presentation, and communication) and students' achievement in physics consistent with the observed mode?
4. What are the estimated direct, indirect, and total effects among the variables?

Methodology

Research Design

The study adopted correlation design and path analysis to assess the tenability of the hypothesized model.

Target Population

The target population for this study comprised all senior secondary school (SSII Physics students and their physics teachers) in the Southwest, Nigeria.

Participants

Thirty-two senior secondary school Physics teachers and 1163 senior secondary school (SSS) Physics students in Ogun and Oyo States, Nigeria, participated in the study. 32 SSS school students (aged 16-18⁺), sixty-two per cent were boys and 38% were girls were sampled and the Physics teachers in each sampled school was surveyed. The age of the sampled Physics teachers ranged between 30 and 52 years (57%) were men, while (43%) women. Their teaching experiences were seven years and above at the SSS level.

Instrumentation

Two instruments were used to generate data for this study. They are: Teacher-Students Interaction Observation Schedule (TSIOS), and Physics Achievement Test (PAT).

TSIOS developed by Abanihe(2008) was adapted. Section A consisted of 10 items on teacher gender, teacher qualification, class observed, time lesson

started and time lesson stopped. Section B consisted 40 items on seven different dimensions of the teaching-learning process: preparation, introduction, presentation, communication, development, organisation and evaluation. Four of these lesson preparation, introduction, presentation and communication were used in this study. Each section consisted of five to six items. TSIOS measured teacher qualification as NCE = 1; HND = 2, B.Sc. (Physics + Education) = 3; Master Degree in Physics = 4; PhD (Physics + Education) = 5. Section B of TSIOS was scored as Poor = 1, Fair = 2, Good = 3; Very Good = 4 and Excellent = 5 for each of the three sections. However, the researcher revalidated using Cronbach alpha; it yielded a value of 0.79

PAT was developed by researcher, this instrument had earlier been used by Ajadi 2017 as well as Adegoke and Ajadi (2016) to test students' intellectual achievement in seven selected topics in senior secondary school physics (motion, linear momentum, work, energy, power, heat and temperature). An initial draft of 80 items with four-point response format was used. The test items were constructed based on the first three domains of cognition (knowledge, comprehension, and application) using a table of specification. The content validity of the items was ensured given them

to teachers and expert in physics. *PAT* was subjected to item analysis and the item difficulty and discrimination indices were established using the 2-parameter model of Item Response Theory. On the basis of Test Information Function, items with difficulty parameters ranged from -1.34 and +1.86. The discrimination indices of the items ranged from 0.26 and 0.49. The final *PAT* comprised 40 items and reliability coefficient of 0.86 was obtained.

Procedure for Data Collection

Thirty-two physics teachers were observed for 10 lessons during the normal teaching periods in each school. This was to avoid disruptions to scheduled school programmes. Two research assistants used were attained to each classroom for the observation and coding of teacher activities as spelt out in TSIOS. Each lesson was coded for 45 minutes. The inter-rater reliability of the coding ascertained using Scot's Pi ranged from = 0.81 to 0.86.

Data Analysis

Data were analysed using SPSS Pearson Product Moment Correlation and AMOS 23. This helped in estimating linear relationship and path parameters as well as the total effects (direct and indirect) of independent variables.

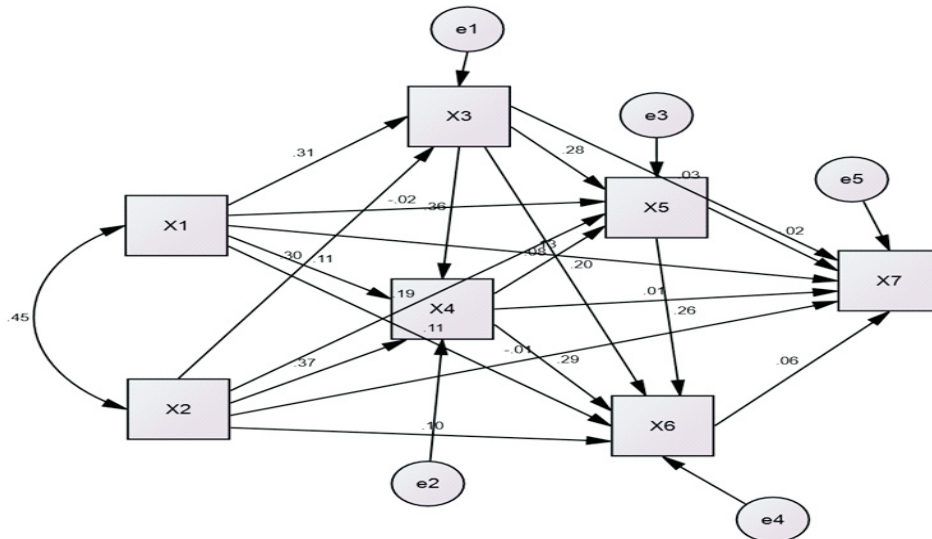


Figure. 2: Structural Model of the antecedents, mediators and the criterion variables
Key: X₁ = Teacher Qualification; X₂ = Teaching Experience; X₃ = Lesson Preparation; X₄ = Lesson Introduction; X₅ = Lesson Presentation; X₆ = Communication; X₇ = Students Achievement in Physics.

RESEARCH QUESTION 1: What is the pattern of correlation among variables of teacher factors (teacher qualification, and teaching experience), teaching skills (preparation, introduction, presentation, and communication), and students' achievement in physics?

A matrix of Pearson product-moment correlation coefficients, presented in Table 1 among the teaching experience, skills (preparation, introduction, presentation, and communication) and achievement in physics (criterion) scores was calculated.

Table 1: Correlation Matrix and Descriptive Statistics of the Variables

Variables	N	Mean	Std. Dev.	QLF	EXP	PRE	INT	PRS	COM	PAT
Qualification (QLF)	1163	2.55	1.166	1.00						
Experience (EXP)	1163	2.78	1.255	.66*	1.00					
Preparation (PRE)	1163	13.42	1.641	.43*	.39*	1.00				
Introduction (INT)	1163	14.17	1.856	.18*	.55*	.41*	1.00			
Presentation (PRS)	1163	10.14	1.361	-.03	.21*	.23*	.06*	1.00		
Communication (COM)	1163	17.09	2.267	.22*	.18*	.28*	.35*	.43*	1.00	
Physics Achievement (PAT)	1163	33.07	3.395	.39*	-.04	.06*	.02	-.06*	.08*	1.00

* Reported correlation is significant at, $p < .05$

Table 1 show that the relationship between students' achievement in physics and each of the predictors was low, except for teacher qualification (.39; $p < .05$). For example, the correlation coefficient between communication (.08); preparation and presentation (.06), and introduction (.02; $p < .05$). However, the table shows very good relationships between teacher qualification and teaching experience; teaching experience and lesson introduction; teacher qualification and lesson preparation. The table also shows a fair relationship between teaching experience and teacher skill-lesson communication. The relationships between skills in lesson preparation and lesson introduction, and presentation and communication were also good. These relationships explain that teacher characteristics such as qualification and experience are related to teacher teaching skills. For example the higher the qualification of the teacher (read physics with education) the better he or she is in lesson preparation and lesson communication. In the same vein, the more experienced the physics teacher is the better the teacher is in lesson preparation and lesson introduction.

RESEARCH QUESTION 2: What are the fit indices of the hypothesised model for teacher factors (teacher qualification, and teaching experience), teaching skills (preparation, introduction, presentation, and communication) and students' achievement in physics?

Table 2: Annotated Fit Summary for the 'Just' – identified Model

Fit Summary		
Chi-Square		.00
Chi-Square DF	0	
AGFI		1.00
NFI		1.00
CFI		1.00
RMSEA	.32	
RMR		.00

The chi-square is .00 ($df = 0, p = .00$). Overall, the model provides good fit. The sample size is large that the p-value of the chi-square test should be taken to be accurate. This same conclusion can be drawn by looking at other fit indices in the table. In Table 2, several fit indices are computed for the model. For example, the model fit chi-square is 0 and the corresponding degrees of freedom is also 0. This indicates that the model is 'just' identified. The Adjusted Goodness of Fit Index (AGFI) is 1.00; the Normed Fit Index (NFI) is 1.00, and the Comparative Fit Index (CFI) is 1.00. All these are perfect fits which reflects good model fit. The Root Mean Square Error (RMR) is .00, which indicates a very good fit. However, the root-mean-square error of

approximation (RMSEA) is .32 which is too large to be an acceptable model for the data. All values of these indices fall within the suggested guidelines as indicative of overall satisfactory model fit (Steiger& Lind, 1980; Browne & Cudeck, 1993, and Hu & Bentler, 1999). The structural equation model and the standardized estimates of the path coefficients of the effects of teacher qualification, teacher teaching experience, preparation, introduction, presentation, and communication on students' achievement in physics.

Model Testing

The hypothesised path model of figure 2 was fitted to covariance matrix constructed from the correlations of Table 1 with AMOS 23. This testing the hypothetical structural equation model was to examine the overall fit of the data.

RESEARCH QUESTION 3: Is the model which describes the causal effects among the teacher characteristics (teacher qualification and teaching experience), teaching skills (preparation, introduction, presentation, and communication) and students' achievement in physics consistent with the observed mode?

Table 3: Significant Paths of the Hypothesized Model

Paths	Path Coefficient	Significance	Decision
P ₃₁	.43*	S	Retain
P ₄₁	.18*	S	Retain
P ₅₁	-.03*	NS	Delete
P ₆₁	.22*	S	Retain
P ₇₁	.39*	S	Retain
P ₃₂	.39*	S	Retain
P ₄₂	.55*	S	Retain
P ₅₂	.21*	S	Retain
P ₆₂	.18*	S	Retain
P ₇₂	-.04	NS	Delete
P ₄₃	.41*	S	Retain
P ₅₃	.23*	S	Retain
P ₆₃	.28*	S	Retain
P ₇₃	.06*	S	Delete
P ₅₄	.06*	S	Retain
P ₆₄	.36*	S	Retain
P ₇₄	.02	NS	Delete
P ₆₅	.43*	S	Retain
P ₇₅	-.06*	S	Retain
P ₇₆	.08*	S	Delete

Key: S = Significant Path, NS = Non-Significant, (*) = Significant Correlation Coefficient.

Table 3 above represents the significant and non-significant paths for 20 paths that show the causal relationship among the variables (predictor and criterion). The 17 significant paths were retained and 3 non-significant causal relationships was trimmed off to arrive at meaningful causal model to explain teacher qualification, teaching experience, preparation, introduction, presentation, and communication, and students' achievement in physics. The new criteria for the significant path as recommended by Backlock as cited in Kerlinger and Pedhazor (1973); Kerlinger (2000); Kline (2005); Adegoke (2011), and Ajadi (2017) was that both path coefficient and zero order correlation must be significant at $p < 0.05$.

RESEARCH QUESTION 4: If the model is consistent, what are the estimated direct, indirect, and total effects among the variables?

Direct Effects

Once the model achieves an overall satisfactory fit, the second step in the model testing is the examination of statistical significance of each of the hypothesised direct and indirect effects.

Table 4: Direct, Indirect, and Total Effect of Teacher Factors, Skills, and Physics Achievement Model

Path	Direct Effect	Indirect Effect	Total Effect
To Preparation			
Teacher Qualification (QLF)	.43	.00	.43
Teaching Experience (EXP)	.39	.00	.39
To Lesson Introduction			
Teacher Qualification (QLF)	.18	.18	.36
Teaching Experience (EXP)	.55	.16	.71
Preparation (PRE)	.41	.00	.41
To Presentation			
Teacher Qualification (QLF)	-.03	.12	.09
Teaching Experience (EXP)	.21	.13	.34
Preparation (PRE)	.23	.02	.25
Introduction (INT)	.06	.00	.06
To Communication			
Teacher Qualification (QLF)	.22	.28	.50
Teaching Experience (EXP)	.18	.51	.69
Preparation (PRE)	.28	.25	.53
Introduction (INT)	.35	.02	.37
Presentation(PRS)	.43	.00	.43
To Physics Achievement			
Teacher Qualification (QLF)	.39	.07	.46
Teaching Experience (EXP)	-.04	.07	.03
Preparation (PRE)	.06	.04	.10
Introduction (INT)	.02	.03	.05
Presentation(PRS)	-.06	.04	-.02
Communication (COM)	.08	.00	.08
TOTAL	4.34	1.92	6.26

Table 5: Proportion of Direct and Indirect Effect of Independent Variables on Student Achievement in Physics

Effect	Frequency	Percentage
Direct	4.34	69%
Indirect	1.92	31%
Total	6.26	100%

Table 5 shows the result that 69% of the causal effects among teacher qualification, teaching experience, lesson preparation, lesson introduction, lesson presentation, communication, and students' achievement in physics are direct while 31% of the causal relationship among the variables in the model is indirect. This result is in line with recommendation that, it is better for variables in the model to be

directly influenced the criterion variable than for the effects to be indirect (Kerlinger and Lee, 2000).

Indirect Effects

Indirect effects are estimated statistically as the product of direct effects, which comprise them (Kline, 2005). They are also interpreted just as path coefficients. For example, the standardised indirect effect of Teacher Qualification on Physics Achievement is estimated as the product of the standardised coefficients for the paths as follows: (QLF to PRE)(PRE to PAT) + (QLF to PRE)(PRE to PRS)(PRS to PAT) + (QLF to PRE)(PRE to INT)(INT to PAT) + (QLF to PRE)(PRE to INT)(INT to PRS)(PRS to COM)(COM to PAT) + (QLF to

INT)(INT to COM)(COM to PAT) + (QLF to INT)(INT to PAT) + (QLF to INT)(INT to PRS)(PRS to PAT) + (QLF to COM)(COM to PAT). In numerical terms this equals $(0.0258) + (0.0989) + (0.003526) + (0.0003638832) + (0.00504) + (0.0036) + (-0.000648) + (0.0176) = 0.154175883$ (Approximately 0.15). Similarly, indirect effect of teaching experience on physics achievement is approximately 0.05. Others were calculated using the same method. However note that the path from Teacher Qualification (TQ) to Teaching Experience (TE) was **not** analysed because they were the exogenous variables in the model.

Discussion

The findings of this study show that although there were significant relationships among teacher qualification and preparation, teaching experience and introduction and skills in lesson presentation, introduction and communication. This may be as a result of students' level of performance in the physics test which was just at average level. These corroborate Allen's (2008) finding that teacher qualification and teaching experience are most influential factors in the classroom activities. According to Mayer, Mullens and Moore (2000), the most important factor in improving students' achievement is having a well-qualified teacher in the field in which they are trained, and have more than a few years of classroom experience. Also, Adeyemi (2008) found that students taught by more experienced teachers tend to achieve at higher level than their colleagues taught by inexperienced teachers. This is because experienced teachers have mastered the content of the subject matter and have acquired classroom skills to deal with different types of classroom problems. Adeyemi further explained that experienced teachers are able to concentrate more on the most appropriate ways to teach particular topics to students of different learning abilities and psychological orientations. These findings agree with Akinsolu (2010) found out that teachers who have spent more time studying and teaching are more effective overall and they develop higher thinking skills for meeting the needs of diverse students and, hence, increasing their performance and often do better than their peers who lacked qualified and experienced teachers.

Conclusion

It can be concluded from the results of this study that teachers with good teaching skills (preparation, introduction, presentation, and communication)

positively affect students' academic achievement in secondary schools.

Recommendation

Based on the findings of the study, the following recommendations were made:

- Teachers with higher qualification(s), that is experts in physics education at higher level, should teach Physics in the secondary schools.
- All physics teachers in secondary schools should possess quality teaching skills to improve students' academic achievement.
- Practicing physics teachers with NCE, HND, and/or B. Sc. should undergo in-service training such as seminars, Post Graduate Diploma Course in Education (PGDE) for effective teaching and learning in the classroom.
- Government should encourage the science teachers, especially of physics, through incentives and worthwhile science allowance.

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