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Structural Modeling of Teacher Characteristics, Skills in Teaching, and Students' Achievement in Secondary School Physics

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Abstract

In this paper, the author examined the relationships between teacher characteristics and teacher teaching skills and the concomitant effects of the relationships on senior secondary school students' achievement in Physics. It was hypothesized that teachers who were well qualified (that is read physics/mathematics and education in universities) and has considerable years of teaching experience would demonstrate appropriate teaching skills as measured by good lesson preparation, lesson presentation and evaluation of the objectives of the lesson. It was further hypothesized that demonstration of such appropriate teaching skills would encourage students to learn better and do well in Physics. To test these hypotheses, twenty senior secondary school Physics teachers and 863 senior secondary school Physics students were randomly selected from twenty-four senior secondary Schools (SSS) in Ogun and Oyo States, Nigeria. The study lasted for four weeks. Each teacher was observed for 10 lessons and rated using Teacher-students Interaction Observation Schedule. At the end of the fourth week Physics Achievement Test was administered to the students. Results showed that there was a significant and positive relationship between teacher characteristics and teachers' skill in lesson preparation, presentation and evaluation. Experienced and qualified teachers demonstrated appropriate teaching skills. It was found out that experience and qualified teachers had adequate skills to prepare for physics teaching in schools. It was found that teacher characteristics had influence on students' achievement in Physics. However, the mediating effect of teacher teaching skills had non-significant effect on students'

achievement in Physics. The results suggest that only qualified people should be employed to teach Physics in senior secondary schools.

Keywords: Teacher Characteristics, Lesson Preparation, Lesson Presentation, Evaluation of Lesson Objectives, Physics Education, Students' Achievement in Physics

Introduction

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. The level of scientific and technological advancement of nations led to their classification as being developed, developing or underdeveloped. Nations such as The United States of America, Britain, Japan and Germany are classified as developed on the basis of the fact that they are technologically advanced. On the other hand, many African including Nigeria are classified as developing because their technology is still at the rudimentary state. This is evident in the level of students' enrolment and performance in Physics in school based and external examinations.

Available evidence from public examining bodies such as the West African Examination Council (WAEC), the National Examination Council (NECO) shows that in the last five years (2009 - 2015), on the average, less than 60% of candidates who registered for Physics passed at the distinction and credit levels. Researchers in Physics Education in Nigeria (e.g. Adegoke, Adegoke, 2003; Olukoya, 2011) found out that one of the major factors responsible for students' not doing very well in Physics is the use of inappropriate and ineffective teaching methods. In addition, studies have shown that teacher-students interactions in the classroom have impact on students' attitude to physics and consequently achievement in physics. These observations have been corroborated by researchers from other climes. For example, Gok and Silay (2008) in their study conducted in United Kingdom found out that conventional or traditional method of teaching (notably lecture) has negative effects on students' attitude to Physics.

Some studies have found that positive teacher-students relationship has positive impact on students' learning outcomes in school based 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' behavior. 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 topics.

Teaching involves the use of many skills. These are skills in preparation for the lesson, and presentation of the lesson. In addition, the teacher needs the skill to properly evaluate, at the end and during the course of the lesson, the extent to which the students have mastered the contents of the lesson. In teaching preparation, the teacher has to consider the capabilities of the students, the time limit for the lesson, the entry behavior of the students, and the appropriateness of the methods of instruction he or she wishes to adopt. In lesson preparation, the teachers must be skillful in arranging the content of the lesson note preparation and materials to be learnt must be presented in a logical manner. Also the teacher must skillfully look for instructional/learning aids for the lesson to be real and interesting for the students

and reduce the level of abstractness that students usually attach to the learning of topics in Physics.

Presentation of the lesson starts from introduction. Introduction has to do with the different activities needed for initiating and introducing the students to the new lesson so as to arouse their interest. This could be by oral questioning, short story or events that similar to the experiences in the new lesson. The teacher needs skills in linking students' past experiences with the new topic. Teachers should be skillful in presentation of the contents of the lesson. This is because the materials to be learnt should be presented in a systematic way. The learners learn more when they are led from known to unknown or from simple to complex. That is the teacher must present the lesson so as to create a situation in which what the students learn in one step forms the basis of what they will learn in subsequent steps.

Evaluation of cognitive learning involves measuring students' knowledge and understanding in a subject by means of oral or written tests. Through this the teacher will be able to determine the extent to which students have mastered the contents of the lesson taught. According to McFarland (2003), through evaluation of the lesson objectives, teachers are able to give a value or quantify the progress which the students have made in his or her learning. A skillful teacher, during evaluation period should ask questions that cut across the six levels of behavioural objectives of Benjamin Bloom. That is questions should be spread across knowledge, compression, application, analysis, synthesis and evaluation levels. That is questions should test both the lower and higher level of cognition.

Previous studies (such as Berliner, 2005; Goldhaber and Brewer, 2000) have shown that teacher characteristics such as qualification and teaching experience are related to students' learning outcomes. For example, Goldhaber and Brewer (2000) reported a positive relationship between Physics knowledge and higher levels of performance among students whose teachers held bachelor's degree in Physics than among those whose teachers did not hold degree in Physics.

Teaching experience has long been thought to affect teaching skills, with more experienced teachers associated with greater teaching effectiveness (Adeyemi, 2008; Oladokun, 2010; Allen, 2010). For example in his study, Adeyemi (2008) reported that students taught by more experienced teachers achieve at a higher level because their teachers have mastered the content and have acquired classroom skills to deal with different types of classroom problems. Allen (2010) supporting Adeyemi' (2008) findings reported that inexperienced teachers typically express concern about lacking effective means of organizing the classroom and handling disruptive behaviours of students. Oladokun (2010) reported that students taught by experienced teachers performed significantly better than those taught by non-experienced teachers in science process skill acquisition. Goldhaber and Brewer (2000) also found that teacher experience positively related to higher school students achievement in Physics. Akinsolu (2010) posited that teachers who have spent more time studying and teaching are more effective overall and they develop higher order thinking skills for meeting the needs of diverse students, and hence, increasing their performance.

Although some studies have found out that years of teaching experience and qualification tend to affect students' achievement, the pattern of the affect has not been thoroughly researched. How do teaching experience and qualification affect teacher's presentation of the contents of the lesson? Do experienced teachers present the content of the content of the lesson better than the less experienced teachers? How does qualification affect teachers' evaluation skill? How do teacher teaching experience and qualification affect teacher-students classroom interaction and ultimately influence students' achievement in Physics. These are the issues examined in this study. To achieve this, a path analytic model of teacher characteristics, classroom behavior and students' achievement in secondary school physics in Nigeria was proposed (See Figure 1). The ultimate was to show how teacher characteristics, teacher skills in teaching are linked to affect students' achievement in Physics.

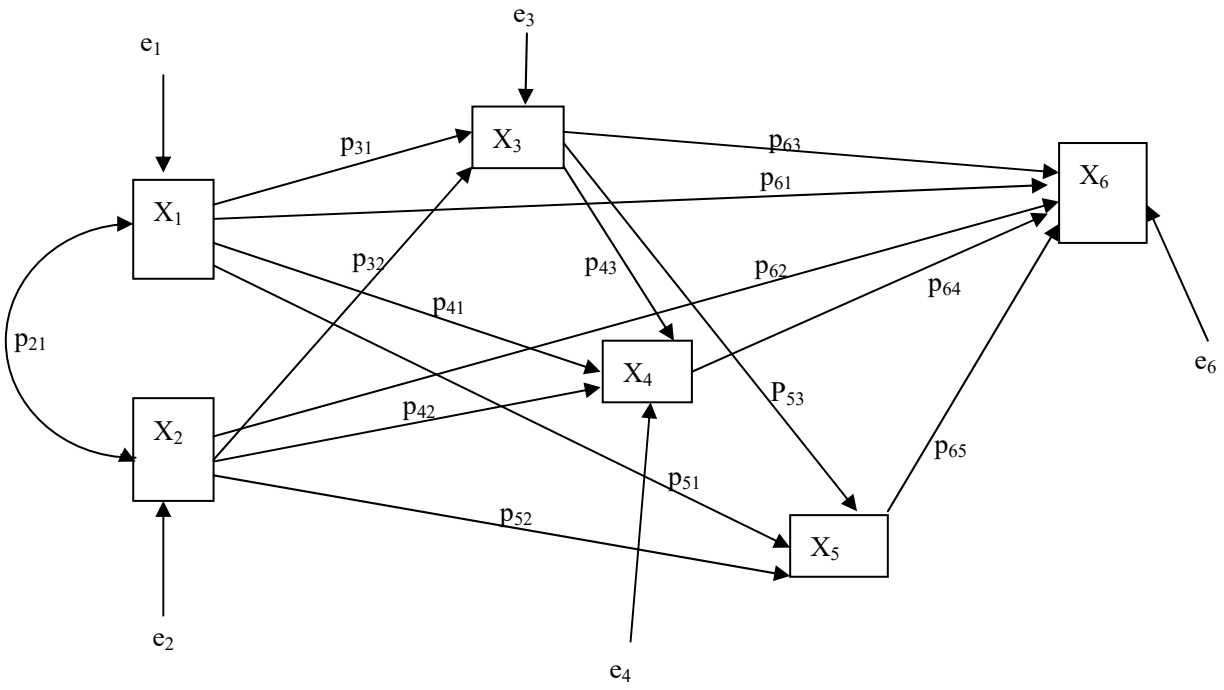

Figure 1. Recursive Path Model of Students' Achievement in Physics Factors

Key: X_1 = Teacher Qualification; X_2 = Teacher Teaching Experience; X_3 = Skills in Lesson Preparation; X_4 = Presentation of Lesson; X_5 = Teacher Evaluation Skills; X_6 = Students Achievement in Physics; p_{xy} = Path Coefficient; e_i = Error

Research Questions

To guide this study, three research questions were answered. These were:

1. What is the magnitude and direction of the correlation among variables of teacher characteristics, classroom behavior, and students' achievement in Physics?

2. Does the model which describes the causal effects among the teacher characteristics (qualification and teaching experience), teacher classroom behavior and students' achievement in Physics consistent with the observed model?

3. If the model is consistent, what are the estimated direct, indirect, and total causal effects among the variables?

A major significance of the study is that it points out the extent to which teacher qualification and teaching experience can influence teacher skill in lesson preparation, presentation and evaluation and consequently enhanced students' achievement in Physics. The study shows the need for the teacher recruiting establishments, such as the Teaching Service Commission and State Ministry/Department of Education that only academically qualified personnel should be employed for the teaching of physics in secondary schools.

Methodology

Research Design

The study adopted correlation design. Correlations among the variables were used to assess theoretical propositions about cause and effect without manipulating any of the variables. In addition, path analysis was used to assess the tenability of the hypothesized model.

Participants

Twenty-four senior secondary school Physics teachers and 863 senior secondary school Physics students selected from twenty senior secondary Schools (SSS) in Ogun and Oyo States, Nigeria, participated in the study. All public SSS schools and the Physics Teachers in all the schools in the two states were the target population. However by using both simple and stratified random sampling technique, 24 SSS Schools were sampled and the Physics Teachers in each sampled school was surveyed. The ages of the sampled Physics Teachers ranged between 26 and 51 years (standard deviation = 4.76 years) Fifty-seven percent of them were women, while 43% were men. They have all taught Physics for at least five years at the SSS level. The ages of the students ranged between 15 and 18 years (standard deviation = 1.08years). Sixty two percent were boys and 38% were girls.

Materials

Two instruments were used. These were: Teacher-students Interaction Observation Schedule (TsIOS) and Physics Achievement Test (PAT).

TsIOS: It was constructed by Abanihe in 2008. It is one of the instruments being used at the Institute of Education, University of Ibadan, to teach Postgraduate students classroom observation Course. It comprised of two sections A and B. Section A contains 10 items. These include: Teacher Gender, Teacher Qualification, Class Observed, Time Lesson Started and Time when Lesson Stopped. Section B contains 40 items on six different dimensions of teaching-learning process ranging from preparation, introduction-presentation, communication, development, organization and evaluation (See Appendix 1). The instrument was validated by the constructor and reliability coefficient of 0.88 was reported. However, I

revalidated and I obtained a reliability value of 0.83 (Cronbach Alpha Method). For the purpose of this study, only the sections on lesson preparation, presentation and evaluation were used.

PAT: This was developed by the second author. It was developed to test students' intellectual achievement in seven selected topics in senior secondary school Physics (Motion, Linear Momentum, Work, Energy, Power, Heat and Temperature). The initial draft of 80 test items was subjected to item analysis. The response format of A, B, C, and D was used. The item difficulty and discrimination indices were determined using the 2-parameter model of Item Response Theory. On the basis of Test Information Function, items with difficult values ranging from -1.34 and 1.86 were picked. The discrimination indices of the items ranged from 0.26 and 0.49. The final PAT comprised 60 items. The content validity of the items was determined by using test blueprint on the first three levels of Bloom's Taxonomy of Educational Objectives of Knowledge, Comprehension and Application.

Procedures

For the study, 20 research assistants were used. These were postgraduate students in the Institute of Education, University of Ibadan. All the research assistants were quite familiar with the use of the teacher-students observation schedule. Two research assistants were assigned to a school and the average score of the two research assistant was taken as the teacher's score. Each Physics teacher was observed for 10 lessons. This is because for each week there were three periods (two double periods and a single period with each period lasting 40 minutes) for Physics on the official school time table. Although the observations lasted four weeks in each school, the double period of the last week was used administering of Physics Achievement Test to the students.

The administration of the Physics test lasted 60 minutes in each school.

The Analysed Model

The model in this study incorporates three types of constructs: (a) antecedents variables, which include teacher characteristics (Qualification and Teaching Experience) that are not influenced by other variables in the model; (b) mediator variables, which include teachers' skill in lesson preparation, presentation of the content of the lesson, evaluation skill; and (c) criterion variable – students' achievement in Physics as being predicted by the other variables

The main assumption guiding the development of the model was based on a parsimonious attempt to build a concise and coherent model. Certain assumptions were set during the process of model development: (a) antecedents variables are positively related to both mediator variables and criterion variable (b) the students' achievement in Physics, as the criterion measure was considered to be under the influence of the antecedent variables either directly or when mediated through the mediator variables.

Results

Initially, a matrix of Pearson product-moment correlation coefficients, presented in Table 1 among the teacher characteristics (teacher qualification and experience), classroom behavior

(teachers' skill in lesson preparation, presentation of lesson, and evaluation) and achievement in Physics (criterion) scores was calculated. Means and standard deviations were also estimated.

Table 1. Correlation Matrix and Descriptive Statistics of the Variables (N =830)

Variables	1	2	3	4	5	6
1. Qualification	-					
2. Experience	0.47*	-				
3. Preparation	0.52*	0.42*	-			
4. Presentation	0.22*	0.46*	0.46*	-		
5. Evaluation	0.11*	0.08*	0.39*	0.21*	-	
6. Physics Ach.	0.29*	0.16*	0.14*	0.04	0.07*	-
Mean	2.78	2.86	13.50	10.11	19.07	32.69
SD	1.20	1.22	1.84	1.56	3.26	3.66

Note* Reported correlation is significant at, $p < 0.05$

Table 1 show that the bivariate relationship between students' achievement in physics and each of the predictors was low, except for teacher qualification (0.29). Although, the relationships were statistically significant (at $p < 0.05$), except for presentation of lesson, they were low. For example, the correlation coefficient between Physics achievement and evaluation is 0.07. However, the table shows very good relationships between teacher qualification and teaching experience; teacher qualification and lesson preparation; teacher qualification and physics achievement. The table also shows a fair relationship between teaching experience and teacher skills in preparation and presentation of lesson. The relationship between skill in lesson presentation and lesson presentation was 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 presentation. In the same vein, the more experienced the physics teacher is the better the teacher is in lesson preparation and lesson presentation.

Model Testing

The hypothesized path model of Figure 1 was fitted to covariance matrix constructed from the correlations and standard deviations of Table 1 with LISREL 9.2 (2015 Student Edition Jöreskog & Sörbom). Testing the hypothesized model was a two-step process. The first step was to examine the overall fit of the hypothetical structural equation model of the data. This is an omnibus test that in practical terms asks whether or not the specification of the paths, as conceptually supported, provides an acceptable model of the theoretical process underlying the variables.

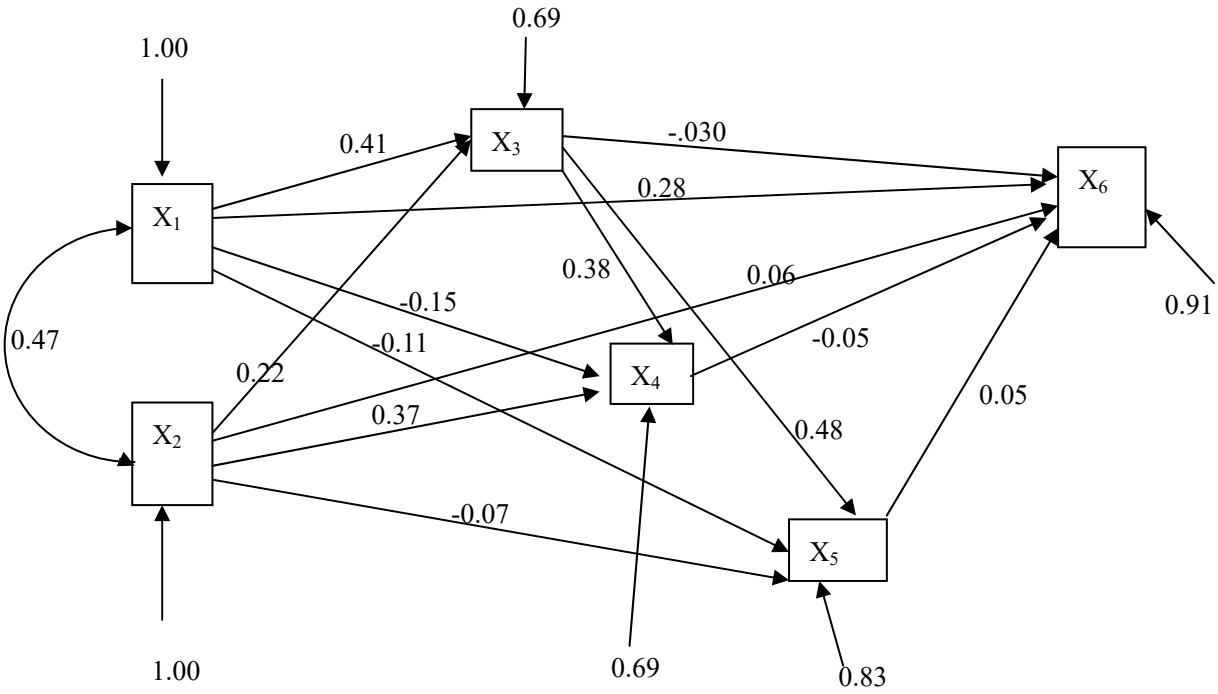

Figure 2. Structural Model of the antecedents, mediators and the criterion variables

The overall fit of the model was satisfactory χ^2 (1, N = 830) = 2.92, p = 0.09, which indicates non-significant differences between the sample variance-covariance matrix and population variance-covariance matrix implied by the model. Other fit indices were also examined including Root-Mean-Square Error of Approximation (RMSEA) = 0.05 (LO_{90} = 0.00 and HI_{90} = 0.11), Adjusted Goodness of Fit Index (AGFI) = 0.98, Comparative Fit Index (CFI) = 0.99, and Parsimony Goodness of Fit Index (PGFI) = 0.05. All values of these indices fall within the suggested guidelines as indicative of overall satisfactory model fit (Hu & Bentler, 1999). The structural equation model and the standardized estimates of the path coefficients of the effects of teacher qualification, teacher teaching experience, lesson preparation, lesson presentation and evaluation on students' achievement in Physics is presented in Figure 2

Direct Effects

Once the model achieves an overall satisfactory fit, the second step in the model testing is to examine the statistical significance of each of the hypothesized direct and indirect effects. With the regard to the direct effects, the test statistic is the z- value which must be greater than ±1.96 before the hypothesis that the estimate equals 0.00 can be rejected. The coefficients of the hypothesized direct paths are as presented in Table 3.

Table 3. Direct and Indirect Path Coefficients of the Physics Achievement Model

Paths	Direct Effect (ß)	Indirect Effect	Total Effects	R^2
To Lesson Preparation				0.31
Teacher Qualification (TQ)	0.41*	0.00	0.41	0.31
Teaching Experience (TE)	0.22*	0.00	0.22	0.17
To Lesson Presentation	-0.15*	0.16	0.01	0.09
Teacher Qualification (TQ)	0.37*	0.08	0.45	
Teaching Experience (TE)	0.38*	0.00	0.38	
Lesson Preparation (LP)	-0.11*	0.01	-0.10	
To Evaluation	-0.07*	-0.02	-0.09	
Teacher Qualification (TQ)	0.48*	0.00	0.48	
Teaching Experience (TE)	0.28*	0.00	0.28	
Lesson Preparation (LP)	0.06*	-0.01	0.05	
To Physics Achievement	-0.03	0.01	-0.02	
Teacher Qualification (TQ)	-0.05	0.00	-0.05	
Teaching Experience (TE)	0.05	0.00	0.00	
Lesson Preparation (LP)				
Lesson Presentation (LS)				
Evaluation (EV)				

Note* Path coefficient is significant at $p < 0.05$

Indirect Effects

In path analysis, indirect effects, according to Kline (2005), are estimated statistically as the product of direct effects, which comprise them. They are also interpreted just as path coefficients. For example, the standardized indirect effect of Teacher Qualification on Physics Achievement is estimated as the product of the standardized coefficients for the paths (TQ to LP) (LP to PA) + (TQ to LS)(LS to PA) + (TQ to EV)(EV to PA) + (TQ to LP)(LP to EV)(EV to PA). In numerical terms this equals (0.41)(-0.03) + (-0.15)(-0.05) + (-0.11)(0.05) + (0.41)(0.48)(0.05) = -0.002 (Approximately 0.00). 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

An essential goal of this study was to develop a causal model that could explain the hypothesis that the effect of teacher qualification and experience on students' achievement in physics could be mediated by teacher skill in lesson preparation, presentation and skills in evaluation of lesson objectives. The findings of this study show that although there were significant relationships among teacher qualification, teaching experience skill in lesson preparation and evaluation, the mediating effects of teacher skill in lesson preparation, presentation and evaluation on students' achievement in Physics were not strong. This may

be as a result of students' level of performance in the Physics test which was just at average level.

The most influential factors in this study were teacher qualification and teaching experience. This finding is consistent with other research findings such as Mayer Mullens and Moore (2000), Adeyemi (2008) and Allen (2010). According to Mayer, Mullens and Moore (2000), the most important factor in improving students' achievement is having a well-qualified teacher in every classroom. Mayer Mullens and Moore (2000) said that good teaching is enhanced when teachers teach in the field in which they are trained; and have more than a few years of experience. In their study, Rowan, Correnti and Miller (2002) reported positive relationship between students' achievement in Physics and teachers with a major in Physics

Teaching experience and mastery of subject matter are crucial as reported by Adeyemi (2008). According to Adeyemi, 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. Allen (2010) supporting these findings reported that inexperienced teachers typically express concern about lacking effective means of organizing the classroom and handling significant disruptive behavior of students. The overwhelming evidence currently available in the literature (such as Oladokun, 2010; Goldhaber & Brewer, 2000; Akinsolu, 2010) suggests that inexperienced teachers are less effective than the more senior teachers. For example, Oladokun reported that student taught by experienced teachers performed significantly better than those taught by less experienced teachers in science process skill acquisition. 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. The findings of this study are in line with the findings of past researchers.

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Appendix 1. University of Ibadan Institute Of Education Teacher – Students Interaction Observation Scale

Section A

1. Name of School……
   …….
2. School Type: Public……Private…….
3. Teacher Gender: Male…… Female…….
4. Highest Teacher Qualification:
   NCE…..B.Ed…….B.SC……B.SC/PGDE…….M.Ed……..M.SC
5. Years of Teaching Experience……. As at 1st October, 2015
6. Subject Taught…..Topic Taught…….
7. Time Started……Time Stopped……..

Section B: Behaviour Categories (Rate according to Degree of occurrence)

s/no	Behaviour	Ratings					
A	**Preparation**	**0**	**1**	**2**	**3**	**4**	**5**
1.	Adequately-prepared lesson note available						
2.	Relevant teaching-learning materials available						
3.	Teaching-learning materials provided adequately used						
4.	Prepared Lesson note agrees with the scheme of work for the term						
B	**Introduction**						
5.	Lesson starts on scheduled time						
6.	Topic clearly written on the board						
7.	Communicates the focus of the lesson						
8.	Starts less from known to unknown						
9.	Assess students' entry behavior						
C	**Content Mastery**						
10.	Demonstrates adequate knowledge of content						
11.	Relates course content to real life situations						
12.	Relates course content to other fields						
13.	Exhibits keen interest in the subject matter						
D	**Communication - Presentation**						
14.	Speaks fluent English Language						
15.	Communicates subject content in clear terms						

16.	Presents content in a step by step manner						
17.	Signals important points in the lesson						
E	**Development of Lesson**						
18.	Extent of use of Lecture method						
19.	Use the entire class time to teach						
20.	Explains the content of the lesson clearly						
21.	Encourages students to express their ideas						
22.	Extent of use of other methods of teaching						
23.	Summarises important points on the chalkboard						
F	**Questioning**						
24	Frequency of use of questions by the teacher						
25.	Distribution of questions among students						
26.	Frequency of use of recall questions						
27.	Frequency of higher level questions						
28.	Provides cues to stimulate students responses						
29.	Provides corrective feedback						
30.	Allows students to ask questions						
G.	**Classroom Organisation**						
31.	Praises students' performance						
32.	Maintains peaceful classroom environment						
33.	Treats every student with respect						
34.	Criticises students' utterances						
35.	Creates an orderly conduct of students						
H	**Evaluation**						
36.	Asks questions to measure the extent to which students understood the lesson						
37.	Quantity of evaluation questions is adequate						
38.	Quality of evaluation questions is adequate						
39.	Quality of home assignments given to students is adequate						
40.	Provides feedback						