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INFLUENCE OF TEACHER VARIABLE ON PHYSICS STUDENTS' ACHIEVEMENT: A CASE OF STRUCTURAL EQUATION MODELLING

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ABSTRACT

Persistent poor performance of students in physics internal and external examinations prompted this study on the influence of teacher variable on physics students' achievement using structural equation modelling. A correlational research design with a sample a sample of 630 respondents was adopted for the study. Data were collected using Teacher Variable Questionnaire (TVQ) and students variable proforma. An internal consistency reliability index of the items of the TVQ was estimated to be 0.948 using Cronbach Alpha. Data were analysed using path analytic and multiple regression approaches. Findings of the study revealed a significant recursive causal model for the explanation of the physics students' achievement based on the selected variables. It was recommended among others that school authorities should encourage professional development of teachers through the organization of in-service training programs for teachers.

KEYWORDS: Modelling, Influence, Path Analysis, Teacher Variable, Achievement & Physics

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Original Article

INTRODUCTION

Physics is the study of matter and natural events based on empirical observations and quantitative measurements (Ojediran, Oludipe & Ehindero, 2014). According to Ojediran, Oludipe, and Ehindero (2014:1), "teachers at secondary school level are required to engage students in practical works involving conducting experiments, with the aim 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". The above quotation is in line with secondary school physics curriculum. The objectives of studying physics include, among others, "to provide basic literacy in physics for functional living in the society and to acquire essential scientific skills and attitudes as a preparation for the technological application of physics" (Federal Republic of Nigeria, 2013: 15). Thus, physics concepts and principles are indispensable for national development in technology.

Despite these laudable objectives of physics in secondary schools, students' achievement in West African Senior School Certificate physics has been poor from 2005 to 2014 (Ojediran, Oludipe, & Ehindero, 2014). This fact was further buttressed by the trend in the students' achievement in West African Senior School Certificate physics from 2005-2014 as shown in Table 1.

Year	No	%Credit	% Fail
2005	15970	5047(31.60%)	68.40%
2006	15947	6705(39.57%)	60.43%
2007	17308	4865(28.10%)	71.90%
2008	18239	5761(31.58%)	68.42%
2009	18546	4877(26.30%)	73.70%
2010	19440	5886(30.28%)	69.72%
2011	18770	5327(28.38%)	71.62%
2012	20182	7832(38.81%)	61.19%
2013	19860	7205(36.28%)	63.72%
2014	21680	6781(31.28%)	68.72%

Source: West African Examination's Council, 2014.

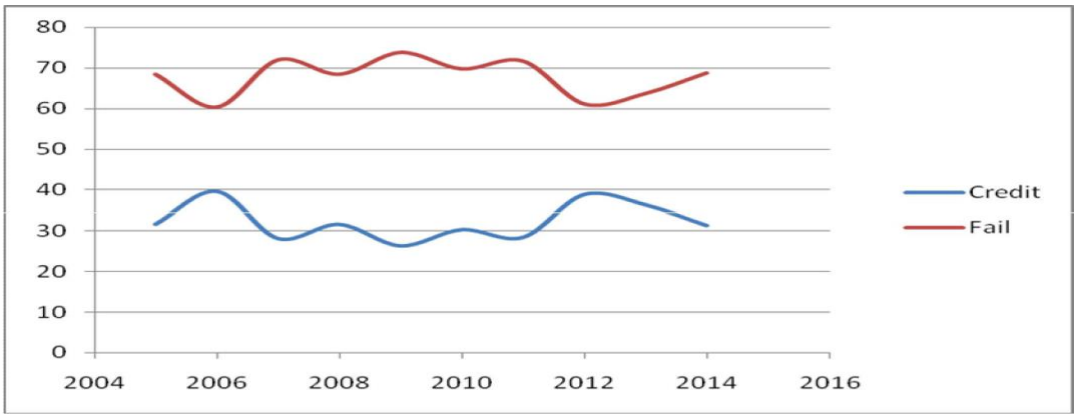

Figure 1: Graph of Students' Performance in Physics from 2005-2014

Table 1 shows that the percentage of failure in the WASSCE from 2005-2014 was higher than the percentage of credit pass. However, figure 1 shows that there has been an increase and decrease over the years as indicated in the percentage of credit pass and failure in physics. Most currently, several studies have noted the decline in the achievement of learners in science subjects including Basic science (Ugwuanyi et al., 2019a; Ugwuanyi et al., 2019b; Ugwuanyi & Okeke, 2020; Agboeze et al., 2020; Ugwuanyi, Okeke & Njeze, 2020; Ugwuanyi, Okeke, & Ageda, 2020; Onah et al., 2020; Njoku et al., 2020; Benson et al., 2020; Inyama, Nwagbo & Ugwuanyi, 2020). This depicts an ugly trend in the students' achievement in secondary school physics. This situation cannot necessarily produce the ingredients for the actualization of the achievement of the objectives of teaching physics in secondary school. The decline in the performance of students in physics WASSCE can be attributed to several factors including students', teachers', parents' and environmental related factors. According to Agba, Ushie, Ushie, Bassey and Agba, (2009), government's inability to effectively sponsor education and motivate teachers to enhance their productivity contributes to the poor performance of students in physics. Adodo (2005) argued that one factor for the success of students' academic achievement in a given subject is the teacher. Thus, the ugly trend in the students' achievement in WASSCE physics could also be attributed to teachers' classroom variables such as teachers' classroom practices, professional development and characteristics external to classroom practices. Besides, teacher factor stands as a major pivot in students' general achievement particularly physics (National Centre for Education Standards, 2000.

Literature shows that most researchers in physics education concentrate on the effect of teaching methods paying little attention to other variables such as teacher variables (Francis, 2007; Minkee & Jinwoong, 2010 and Gbore, 2013).

Thus, Lee, Bryk, and Smith (1993) opined that school characteristics can have a greater influence on students' learning outcomes than would be expected of students' background. But while the research in support of this contention does find significant influence of school characteristics, the magnitude of these influences tend to be overshadowed by the influence of teachers' background characteristics. Despite that studies have been carried out on the influence of teacher variables on students' achievement in physics, few of such considered the teacher characteristics which literature had confirmed to have potential influence. Buttressing this, Gbore (2013) revealed that teacher's classroom interactions with the students greatly influence their achievement.

It has been asserted that teacher's characteristics such as professional development, pedagogical content knowledge and classroom practices determine students' achievement. However, available literature indicates that such study had not been conducted within the context of Structural equation modelling (SEM).

According to Grace (2008), SEM is an alternative method for testing understanding of complex relationships. In SEM, complex interactions are first translated into a network of directional paths linking variables and are then evaluated against multivariate data. These paths postulate direct and indirect effects among variables as well as spurious associations between variables that may be attributed to common causes (Grace, 2008). This approach is based on David Hume's theory of causation. According to Bryne (1994) SEM is applied in the following areas: causal modelling, or path analysis, confirmatory factor analysis, second order factor analysis, regression models, covariance structure models and correlation structure models. This approach of multivariate analysis is different from other simple analysis like analysis of variance (ANOVA) and multiple regression analysis.

Francis (2007) developed a model for the explanation of achievements in chemistry in terms of student variables – gender, study habit, mathematical ability and teacher's variables – gender, age, qualification and years of experience. Only four of the variables-teacher age, teacher gender, qualification and experience had direct causal effect on students' achievement in chemistry (Francis, 2007). However, the study did not establish the strength of such direct causal effect on the students' achievement. Minkee and Jinwoong (2010) developed a confirmatory structural equation model of achievement in science estimated attitudes, interest, and conceptual understanding. According to Minkee and Jinwoong, student's intrinsic attitude to science stimulates their school achievement in both graders.

Based on literature, only few studies were found in Nigeria and those studies adopted multiple regression analysis rather than path analysis. Besides, most of such studies were centred either on few teacher variables or student variables. The works done outside Nigeria are similar to the present study for the fact that the studies examined the teacher variable influence on students' achievement which is one of the aims of the present study. However, none of those studies was done in physics rather most of them centred on mathematics and science generally. Therefore, the following hypotheses were tested.

- There is a significant model fit of the data for the explanation of the physics students' achievement.
- There is no significant influence of the parameter estimates of the decomposed variables on the achievement of students in physics.

THEORETICAL FOUNDATION OF THE STUDY

Regularity Theory of Causation by David Hume (1751)

This theory was propounded by David Hume in the year 1751. According to regularity theory, causation is seen in terms of observable phenomena. Hume (1751) defined causation in terms of repeated conjunctions of events. Consequently, Hume (1751) argued that causality could only be adequately defined in terms of empirical regularities involving classes of events. Thus, the basic tenets of this theory is that the cause and effect relationship among variables can only be understood by calling to mind their constant conjunction in all past instances. In this case, one is called the cause and the other effect. Under this framework, causation was defined purely in terms of empirical criteria, rather than unobservable assumptions. In other words, Hume's definition of causation and his mode of inference were one and the same. The above model is relevant to the study in the sense that the study established a causal model between teacher and student variables and the students' achievement in physics. In line with the regularity models of causation, teacher and student variables are the causes while students' achievement in physics is the effect.

METHODS

Design of the Study

This study adopted a correlational survey research design in order to determine the association between the independent variables (teacher variable) and the dependent variable (physics students' achievement).

Study Participants

A sample size for the study was 630 respondents drawn from a population of 5,935 senior secondary three (SS3) physics students for 2015/2016 and 262 physics teachers in all the public secondary schools in Obollo-Afor and Nsukka Education Zones of Enugu State, Nigeria was used for the study. The sample comprised 585 SS3 physics students and 45 physics teachers in the sampled schools. The sample size was arrived at using multi-stage sampling procedure involving purposive and stratified random sampling techniques. Firstly, two education zones from the six education zones in Enugu State were sampled using purposive sampling technique. Secondly, 20 schools from a population of 50 schools in Obollo-Afor Education zone and 25 schools from a population of 59 schools in Nsukka Education Zone were sampled using proportionate stratified random sampling technique. Finally, one SS 3 physics teacher was purposively selected for the study from each of the sampled schools to satisfy the intension of the researchers. It was the intention of the researchers to use a physics teacher who must have taught the students in their previous term. Thus, a total of 45 physics teachers was the sample. Besides, 13 physics students from each of the 45 senior secondary schools were sampled using disproportionate stratified sampling technique. That gave a total of 585 physics students.

Measures

Teacher Variable Questionnaire (TVQ), was used to gather data on the teacher variable while Students Achievement score proforma was used to collect information on students' variable. TVQ was a 20-item questionnaire structured on 4-point likert scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The instruments were validated by two experts in measurement and evaluation unit, and one expert in physics education unit. An internal consistency reliability index of the items of TVQ was estimated to be 0.948 using Cronbach Alpha.

Data Collection Procedure

Before the commencement of the survey by the researchers in August 2016, written permission to carry out the survey was gotten from each of the sampled school authorities. Informed written consents to participate in the survey were also obtained from both the physics teachers and students. Five of the researchers (4 males and 1 female) actually carried out the survey.

Data Analysis Procedure

In order to analyse the collected data, the researchers adopted both path analytic and multiple linear regression statistical approaches. The analysis was done using IBM-AMOS version 16.0 and SPSS version 22.0.

RESULTS

What is the causal model for explaining the influence of teacher variable on physics students' achievement?

A recursive model was developed in this study as can be seen in Figure 2. The model is recursive because some variables that are exogenous for the endogenous variable (achievement) were found to be endogenous to other exogenous variables

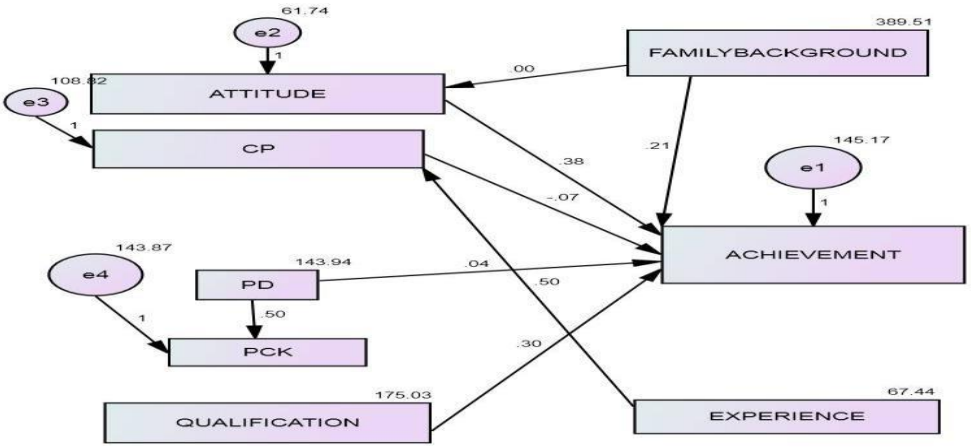

Figure 2: Observed Path Diagram (Recursive Model)

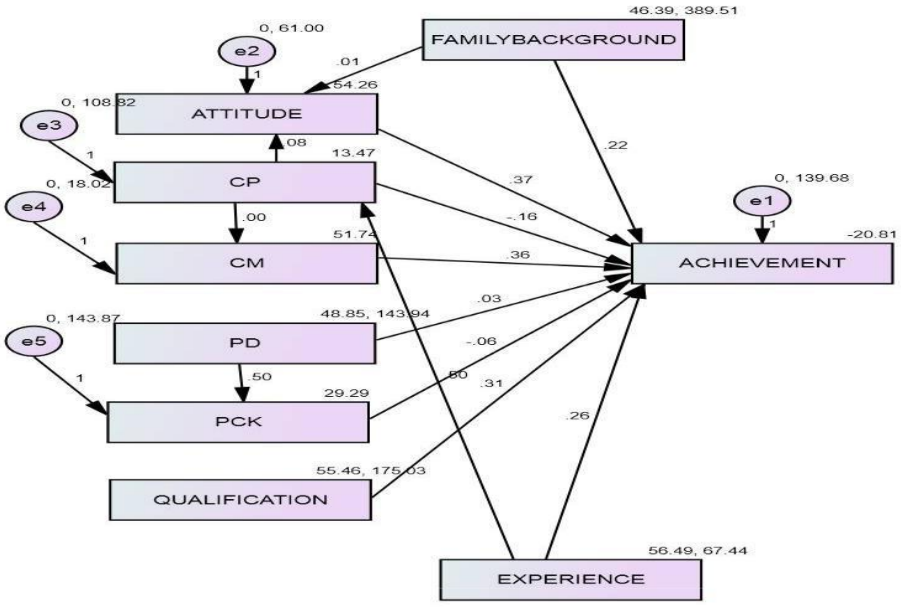

Figure 3: Theoretical Path Diagram

Figure 3 was the proposed or theoretical path diagram formed by the researchers where Y represents the dependent variable (students' achievement), a represents regression constant, X_1 stands for attitude, X_2 stands for CP, X_3 represents PCK, X_4stands for qualification, X_5 stands for PD, X_6 stands for CM, X_7 represents family background and X_8 stands for experience. The analysis revealed that some of the proposed exogenous variables did not have significant relationship with the endogenous variable (achievement) and thus were not included in the final observed path diagram (model) Figure 2. Besides, experience and PD did not have significant relationships with achievement but were included in the observed path diagram because they had significant relationships with CP and PCK respectively. Thus, Figure 2 was obtained through model trimming of Figure 3.

Hypothesis One: There is a significant model fit of the data for the explanation of the physics students' achievement.

The model fit for the recursive model developed was tested using Chi-Square goodness of fit test and Root Mean Square Error of Approximation (RMSEA). The developed model had a Chi-square value of 22.16 with a probability value of 0.51. Also, the model had RMSEA value of 0.00 with a probability of 0.63. Thus, the Chi-square value of 22.16 and RMSEA value of 0.00 showed that the data used for the study fitted the model. This implies that there is a significant model fit of the data for the explanation of the physics students' achievement.

What are the influences of the parameter estimates of the decomposed variables on the achievement of students in physics?

Table 2: Regression Weights and Significance of the Decomposed Variables

		Variables	Estimate	S.E.	t	P
Cp	<---	Experience	.50	.15	3.37	.00
Attitude	<---	Familybackground	.01	.05	.26	.79
Cm	<---	Cp	.00	.04	.04	.97
Pck	<---	Pd	.50	.12	4.29	.00
Attitude	<---	Cp	.08	.08	.96	.33
	<---	Attitude	.37	.18	2.08	.03
	<---	CP	-.16	.13	-1.19	.23
	<---	PCK	-.06	.12	-.48	.63
Achievement	<---	Qualification	.31	.11	2.94	.00
	<---	PD	.03	.13	.24	.81
	<---	CM	.36	.33	1.11	.27
	<---	Familybackground	.22	.07	3.16	.00
	<---	Experience	.26	.18	1.43	.15

Table **2** shows the regression weights for the relationships that exist among the variables of the study in the observed recursive model. It reveals that with respect to the achievement of students in physics, teachers' attitude to physics had the highest relationship with a path coefficient of 0.37. Teachers' attitude to physics having a path coefficient of 0.37 with students' achievement in physics implies that when teachers' attitude increases by 1 unit, students' achievement increases by 0.37 units. The second to the highest relationship is that of the classroom management of physics teachers which had path coefficient of 0.36. This implies that when classroom management of physics teachers changes by 1 unit, students' achievement increases by 0.36 units. Qualification had a positive relationship with achievement with path coefficient of 0.31. This implies that when qualification of teachers changes by 1 unit, students' achievement in physics increases by 0.31 units. Family background of students had a path coefficient of 0.22 implying that as family background of teachers changes by 1 unit, students' achievement increases by 0.22 units. Experience had path coefficient of 0.26 meaning that as teachers' experience changes by 1 unit, students' achievement increases by 0.26 units. Other independent variables such as teachers' professional development, classroom practices, and pedagogical content knowledge had path coefficients of 0.03, -0.16 and -0.06 respectively. Teachers' professional development having a path coefficient of 0.03 with students' achievement in physics implies that as teachers' professional development increases by 1 unit, students' achievement increases by 0.03 units. Classroom practices of physics teachers having path coefficient of -0.16 with students' achievement in physics means that as classroom practices changes by 1 unit, students' achievement goes down by 0.16 units. Similarly, when pedagogical content knowledge of teachers with path coefficient of -0.06 changes by 1 unit, students' achievement goes down by 0.06 units.

On the other hand, the observed recursive model shows that variables such as classroom practices, attitude, classroom management, pedagogical content knowledge are being influenced by other independent variables. In this recursive model, experience had path coefficient of 0.50 with classroom practices implying that when experience changes by 1 unit, classroom practices go up by 0.50. This relationship was significant at 0.05 level of significance. Family background had a path coefficient of 0.01 with attitude meaning that as family background changes by 1 unit, attitude of students goes up by 0.01. This relationship was not significant at 0.05 level of significance. Classroom practices had path coefficient of 0.00 with classroom management implying that as classroom practices changes by 1 unit, classroom management goes up by 0.00. Professional development had path coefficient of 0.50 with pedagogical content knowledge implying that as professional development of teachers changes by 1 unit, pedagogical content knowledge increases by 0.50.

Hypothesis Two: There is no significant influence of the parameter estimates of the decomposed variables on the achievement of students in physics.

Table 3: t-test Analysis of significance of the Parameter Estimates for the Decomposed Variables

Model	Variables	Unstandardized Coefficients		Standardized	t	Sig.
				Coefficients		
		B	Std. Error	Beta		
	(Constant)	-20.81	28.72		-.72	.47
	Familybackground	.22	.08	.32	2.89	.01
	Experience	.25	.20	.16	1.31	.19
	Qualification	.31	.12	.30	2.63	.01
1	Pd	.03	.14	.03	.21	.83
	Pck	-.06	.15	-.05	-.37	.71
	Cm	.36	.37	.11	.99	.32
	Cp	-.16	.16	-.13	-1.01	.32
	Attitude	.37	.21	.21	2.78	.01

a. Dependent Variable: ACHIEVEMENT

Table 3 shows that the t-values for the influences of family background, qualification and attitude on students' achievement in physics are 2.88, 2.63 and 2.78 with associated probability values of 0.01, 0.01 and 0.01 respectively. This implies that family background, qualification of teachers and attitude significantly influence students' achievement in physics since their associated probability values are less than the .05 level of significance. The t-values for the influences of experience, PD, PCK, CM and CP on students' achievement in physics are 1.31, 0.21, -0.37, 0.99 and -1.01 with associated probability values of 0.19, 0.83, 0.71, 0.32 and 0.32 respectively. Thus, CM was not included in the final recursive model (Figure 2) because it neither had significant path with achievement nor any other variable. PCK and CP were included in the final model because they were influenced by PD and experience respectively.

DISCUSSIONS OF THE RESULTS

The findings of the study showed that the most meaningful causal model for the explanation of influence of teacher variable on physics students' is the recursive model involving, students' family background, teachers' qualification, attitude, pedagogical content knowledge, professional development, teaching experience and classroom practices. The data used for the study fitted the model. The results of the study showed that 25.3 percent variation in students' achievement in physics can be attributed to the combined influence of teachers' family background, qualification, attitude, pedagogical content knowledge, professional development, teaching experience and classroom practices. Among the eight exogenous variables for the stud, the variables that had significant influence on students' achievement in physics, are those of family background, qualification of teachers and teachers' attitude to physics. Other exogenous variables such as the professional development of teachers, teachers' pedagogical content knowledge, teaching experience, classroom management and practices were found to have no significant influence on students' achievement in physics.

These results agree with those of Francis (2007), Mohamed, Al-Agili, Bin, Lazim and Hamdan (2012) and Akpo (2012). This is an indication that teachers' family background, teaching experience and attitude to physics teaching play significant roles in the achievement of students in physics. Thus, the better these variables are, the more the students will achieve in physics instructions.

The result of the study showed that are thirteen causal paths among the exogenous and endogenous variables of the study. The causal paths are those of classroom practices and experience; classroom management and classroom practices; pedagogical content knowledge and professional development; attitude and classroom practices; achievement and attitude; achievement and classroom practices; achievement and pedagogical content knowledge; achievement and qualification; achievement and professional development; achievement and classroom management; achievement and family background; achievement and experience. The result showed that with respect to students' achievement in physics, only family background, qualification of teachers and teachers' attitudes to physics teaching had significant causal paths with it. This result is in concordance with the results of Francis (2007), Mohamed, Al-Agili, Bin, Lazim and Hamdan (2012) and Akpo (2012) who had similar findings. The result also showed that there are significant causal paths between experience & classroom practices; and professional development & pedagogical content knowledge. Thus, these variables influence students' achievement and on the other hand are being influenced by other exogenous variables. These showed the complex relationships that exist among the teacher variables and students' achievement.

CONCLUSIONS AND RECOMMENDATIONS

This study developed a recursive causal model for the explanation of the influence of teacher variable on physics students' achievement based on eight selected teacher variables. The model showed that students' achievement in physics is significantly influenced by teacher variables including qualification, professional development among others. The researchers therefore recommended that:

- Teacher variables that could actively affect students' achievement in physics especially family background, attitudes to physics teaching and qualification of teachers should be emphasized during teachers' workshop or seminar.
- Physics teachers should be provided with the opportunity for in-service training by the government in order for them to improve their professional development as well as their pedagogical content knowledge.
- Government should employ only the qualified personnel or those who have requisite professional experience as physics teachers.

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