

Development of a Causal Model of Variables Affecting Secondary School Students' Achievement in Physics in Plateau State

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ABSTRACT

The study examines the development of a Causal Model of Variables affecting Secondary School Students' achievement in Physics in Plateau State. An ex-post facto research design with the use of questionnaire as instrument for data collection was employed. A disproportionate stratified random sampling technique was used in selecting a total of 50 Physics teachers and 150 Senior Secondary two from three Local Government Areas in the three Senatorial Districts of Plateau State. Three hypotheses were formulated and tested at 0.05 level of significance. The study used three instruments namely: – students' variable Questionnaire (SVQ), Teachers' Variable Questionnaire (TVQ) and School Environment Variable Questionnaire (EVQ) to develop the Causal Model to determine the achievement of Physics students'. Reliability indices of SVQ and TVQ were estimated and found to be 0.83, and 0.84 using Cronbach Alpha. This shows that the instruments were reliable. Data generated from these instruments were analyzed using the Path Analysis technique and multiple regression analysis. The finding shows that Default Model and the Saturated Model shows that the chi (19) = 0.826 < 0.03, since the p-value of 0.03 is less than the significant level of 0.05. The implication of this finding is that Physics teachers, students and the environment determine students' achievement in Physics, also the default Model has more variables to be explored than the Saturated Model. It is recommended that Government should motivate the teachers in every way possible, so that the reflection is seen in the commitment and quality of teaching and also students' passing their Examinations with excellent grades.

Keywords: Development, Causal Model, Student, Teacher, Environment, and Achievement,

INTRODUCTION

Physics is a science that deals with the structure of matter and the interactions between fundamental constituents of the observable universe. It is a subject that is concerned with all aspects of nature on both the macroscopic and submicroscopic levels. It encompasses not only the behaviour of objects under the action of given forces but also the nature and origin of gravitational, electromagnetic, and nuclear force fields. Its ultimate objective is the formulation of comprehensive principles that bring together and explain all phenomena (Weidner & Brown, 2021). This implies that the knowledge of Physics is aim to analyze and explains the natural phenomena of the universe; it is also concerned with the laws of nature and can be used to predict the behaviour of the world and all kinds of machinery. Fried (2021) opined that many of the everyday technological inventions resulted from discoveries in Physics.

The contributions of Physics to National Development cannot be over-emphasized, because Physics is the most basic of sciences and its concepts and techniques underpin the progress of other branches of science. It

is also a cross-cutting discipline that has applications in many sectors including health, agriculture, water, energy and information technology (Murenzi, 2014).

The role of Physics in sustainable development was recognized by the United Nations Millennium Summit in September 2000 where Politicians, Educators and Physicists from all over the globe met in Durban, South Africa; they considered the role of Physics in creating and accessing the right equipment for diagnosis of diseases and the efficient communication of medical data, acquiring a Computed tomography Scanner, basic medical equipment to all rural health centres to diagnose and treat diseases like malaria and other related cases.

The knowledge of Physics has used simple gravimetric techniques to bring water from valleys up to higher altitudes and through rain-water harvesting and irrigation techniques is made possible. Physics has been involved in energy generation, exploitation and distribution; among other agencies that have developed the nation through its knowledge are Research Institutes like University of Science and Technology, National Science Fair Centre, Nigeria-Satellites-I and II, Nigeria Communication-Satellite-I.

Physics helps industries to understand the world around them, find quantitative physical laws for everything, for example a car that moves from one place to another has to have an engine that provides the Momentum. The calibration of engine together with the combustion of the fuel has to have a mechanical force that will move it. Physics has helped shape the industries in making work easier. It brings a broad perspective to any problem and satisfies curiosity. It studies some of the things that take place in the universe, including particles, natural phenomena and energy, and their relationship to each other. Physics is characterized by precision, which motivates scientists always to invent new tools and methods that take care of the accuracy and results of physical experiments.

Available evidences shows that the achievement of students in Physics in WASSCE and NECO SSCE has not been very impressive with a greater percentage of students' scoring below credit pass, Researchers have made concerted efforts towards finding solutions to the causes of students' low achievement in the subject but students' achievement in the subject continues to fluctuate. The trend in students' poor achievement in Physics is reflected in external examination results such as the West African Senior School Certificate Examination of (WASSCE) results and National Examination Council (NECO) SSCE, for instance, NECO Senior School Certificate Examinations (SSCE) results for the years 2012-2016 shows that Physics students' recorded percentage failure of 59.60 %, 59.20 %, 85.80 %, 40.99 %, 42.06 % respectively (State Secondary Examination Board, 2016).

Some reasons that have been held for students' fluctuating achievement in Physics include abstract nature of the subject, mathematical nature of the subject, Teachers' variables such as qualification, years of teaching experience, students' attitude, teaching methodologies and school environment (Chief Examiners Report, 2014). Efforts so far made by Government as well as examination bodies like WAEC and NECO, Science Teachers Association of Nigeria (STAN), Mathematical Association of Nigeria (MAN) and Nigerian Educational Research and Development Council (NERDC) to provide training, workshops and seminars to teachers to reduce students' failure in examinations being internal or external have not yielded the required results.

The consequences of students' continual poor achievement is that many students' will not be given admission to study Physics related courses and the country will experience underdevelopment in some major sectors like technological infrastructure, few personnel to make scientific advances and discoveries, few engineers, and computer scientists.

There is the need to have a little knowledge of a Causal Model which is regarded as an abstract model that

describes the causal mechanisms as a system, and the model must express more than correlation because it does not imply causation (Streiner, 2015) the Causal modeling, or Path Analysis (PA), hypothesized causal relationship among variables and testing of the unobserved (latent) indicators by many observed indicators are measured using pictorial form.

In particular, a causal model entails the true value, or the probability of counterfactual claims about the system; it predicts the effects of interventions; and it entails the probabilistic dependence or independence of variables included in the model. Causal models also facilitate the inverse of these inferences: Probabilistic correlations among variables, or the outcomes of experimental interventions, have helped to determine which causal models are consistent with these observations.

A Causal Model is a diagram of the relationships between independent, control, and dependent variables. A causal diagram is a visual representation of the relationships between different variables and their direction of causality in a system or process. Absence of an edge implies no causal relationship. A causal diagram is a visual representation of the relationships between different variables in a system or process, with arrows indicating the direction of causality (from cause, to effect).

It is a tool for understanding cause-and-effect relationships and identifying potential sources of bias in statistical analyses. Causal diagrams are commonly used in fields such as Physics, epidemiology, economics, and social sciences to help researchers understand the complex relationships between different factors that may contribute to a particular outcome. They can also be used to identify potential confounding variables or other sources of bias that may affect the accuracy of statistical analyses.

According to Jega and Bashir (2018) teachers' qualification affects students' interest and achievement in a subject. Qualify teacher is a teacher who has a positive impact on students' learning and development through a combination of content mastery, command of a broad set of pedagogic skills, and communications/interpersonal skills.

Qualify teachers are life-long learners in their subject areas, they teach with commitment, and are reflective upon their teaching practice. They transfer knowledge of their subject matter and the learning process through good communication, diagnostic skills, understanding of different learning styles and cultural influences, knowledge about child development, and the ability to marshal a broad array of techniques to meet students' needs. They set high expectations and support students in achieving them. They establish an environment conducive to learning, and leverage available resources outside as well as inside the classroom. Teachers have been recognized as indispensable factor and the most important elements in the cause of transmission of knowledge and academic success.

The school environment refers to the physical and social conditions under which students' learn. It includes both physical setting of the school, such as the buildings and its facilities, as well as the culture and climate of the School, policies, practices and interactions among students and Staff. Some specific elements of the school environment that can affect students' learning are: physical setting, social and emotional atmosphere, resources and Technology, pedagogy, curriculum and extra-curricular activities. A good school environment can have a significant impact on students' achievement and well-being, while a bad environment can hinder learning and lead to negative outcomes such as absenteeism, behavioural problems, and low academic achievement (Kipngeno, 2018).

Then, there is the need to address this problem by developing a Causal Model of variables affecting secondary school students' achievement in Physics. The broad question of this study therefore is what is the most meaningful Causal Model of variables affecting secondary school students' performance in Physics that can be used to improve their achievement in Physics?

AIM AND OBJECTIVES

The aim of the paper is to develop a Causal Model of variables affecting Secondary School Students' achievement in Physics in Plateau State. The specific objectives are to:

1. develop a meaningful Path Model of variables that affects secondary school students' achievement in Physics in Plateau State.
2. determine the estimates of Causal links among teacher-related, school-related, students'-related variables on secondary school students' achievement in Physics in Plateau State.
3. determine the regressing weights of direct and indirect Causal links of teachers'- related, school environment-related and students'-related variables on secondary school students' achievement in Physics in Plateau State.

HYPOTHESES

The following null hypotheses were tested at 0.05 level of significance.

HO_1 : There is no significant difference between the default Model and the saturated model of variables affecting SSII Students' achievement in Physics.

HO_2 : There are no significant Causal links among teacher-related, school environment-related and students'-related variables on SSII students' achievement in Physics.

HO_3 : The regression weights of direct and indirect Causal links of teachers'-related school environment-related and students'-related variables do not have significant differences on students' achievement in Physics.

METHODOLOGY

The study utilized the quantitative approach involving the use of questionnaire. Ex-post-facto survey design was used for the study. The population focuses on all Public Senior Secondary Two students' and all Physics teachers in Plateau State. The sample of the study consisted of 150 SSII Students' and 50 Physics teachers from three Local Government Areas. The selection was through a disproportionate stratified sampling technique

A-5-point Likert scale questionnaire was used as instrument for data collection. The Students' Variable Questionnaire (SVQ), Teachers' Variable Questionnaire (TVQ) and School Environmental Variable Questionnaire (EVQ) were used to generate the data from the selected areas.

Path Analysis technique was employed for data analysis for the null hypotheses using Chi-square. The hypotheses were tested with regression statistics at 0.05 level of significance. For the acceptance or otherwise of the hypotheses, the criteria was to reject the null hypotheses if the p-value is greater than 0.5 level of significance and accept the alternative.

RESULTS AND DISCUSSION

HO_1 : There is no significant difference between the default Model and the saturated model of variables affecting SSII Students' achievement in Physics.

Table I

Model	NPAR	CMIN	DF	P	CMIN/DF	Sig.
Default model	19	0.826	3	0.03	0.05	0.05

Source: Field Survey Results (2024)

Key

NPAR=number of parameters in the Model

CMIN=chi-square compared to independent Model

CMIN/DF=stands for CMIN/DF

DF= degree of freedom

Table I shows that the default model and the saturated model shows that the $\chi(19) = 0.826 < 0.03$ since the p-value of 0.03 is less than the significant level of 0.05 it is concluded that there is a significant fit between the default model and the saturated model. The result indicates the contributions of each variable toward students' achievement in Physics are statistically adequate.

HO₂: There are no significant Causal links among teacher-related, school environment-related and students'-related variables on SSII students' achievement in Physics.

Table II Results of the model fit summary of causal link among teachers, school and students related variables

Model						
Model	NPAR	CMIN	DF	P	CMIN/DF	Sig.
Default model	12	0.613	0.08	0.02	361	0.05

Source: Field Survey Results (2024)

Key

NPAR=number of parameters in the Model

CMIN=chi-square compared to independent Model

CMIN/DF=Stands for CMIN/DF

DF= degree of freedom

The results of the model fit summary on Table II reveals that the $\chi(12) = .613$, since the p-value of 0.02 is less than the significant level of 0.05 this implies that there is a significant causal link among teachers-related, school environmental-related and students'-related variables, the null hypothesis is therefore rejected. The result indicated that students' achievement in Physics is statistically adequate.

HO₃: The regression weights of direct and indirect Causal links of teachers'-related, school environment-related and students'-related variables do not have significant differences on students' achievement in

Physics.

Table III The results of the regression weights of direct and indirect causal link of teachers, school environment, students' variables with students' achievement in Physics

Regression weights summary						
Model	NPAR	CMIN	DF	P	CMIN/DF	Sig.
Default model	8	0.493	10	0.01	0.360	0.05

Source: Field Survey Results (2024)

Key

NPAR=number of parameters in the Model

CMIN=chi-square compared to independent Model

CMIN/DF=stands for CMIN/DF

DF= degree of freedom

The results of the analysis from Table 3 reveals that the chi (8) =.493 since the p-value of 0.01 is less than the significant level of 0.05. This implies that the Model used to relate students' variable, teachers' variable and environmental variable is statically adequate. The null hypothesis is rejected. Thus, it is upheld that the Causal Model has significantly improves students' achievement in Physics.

The results revealed that there is no significant difference between the default model and the saturated model of variables affecting Physics students' achievement that is default model and the saturated model shows that the chi (19) =0.826 < 0.03 since the p-value of 0.03 is less than the significant level of 0.05. It is concluded that there is a significant fit between the default model and the saturated model. This is in agreement with the findings of Udompong, Traiwichilhun and Wongwanich (2014) who reported that the default model and the saturated model were the same. The implication of this finding is that the contribution of teachers'-variables, students'-variables, and environmental-variables remained unchanged when the model was redeveloped to a saturated level. The implication of this finding is that Physics teachers, students and the environment determine students' achievement in Physics.

Again, the result revealed that there is a significant difference between the default model and the saturated model of variables affecting Physics students' achievement. This is in accordance with the findings by Cahyawati and Prabawato (2019), who found a significant difference in the default model and saturated model on students' achievement in statistics. The implication of this finding is that the default model has more variables to be explored than the saturated model. This implies that all the Causation have been exhausted when the model reached it saturation level

The Findings from the result revealed that there is no significant difference between the direct and indirect Causal path between teacher-related, school environment -related and students'-related variables on SSII students' achievement in Physics. This finding is in accordance with studies by Nwanze & Okoli (2020) who reported that some factors directly affect students' achievement while others indirectly affect students' achievement. The implication of this finding is that some variables directly or indirectly affects students' achievement in Physics.

CONCLUSION/RECOMMENDATIONS

The results of the analysis of Causal relationship among variables in the hypothetical model showed that the significant influence factor on students' academic achievement improves the learning of Physics. The factor analysis conducted showed that the three instruments used for the study measured one construct each and there is a significant proportion of regression weight of causation of teachers-related variables of, school environment-related variable and students'-related variable on students' achievement in Physics. The goodness of FIT indices of the reproduced Path/Causal of variables significantly has a direct effect on students' achievement in Physics.

It is therefore recommended that teachers should know their roles since from the Saturated Causal Model developed teachers'-related variable contributes (0.72), students'-related variables contributes (0.53) and school environment-related variables contributes (0.13). Government should motivate the teachers in every way possible, so that the reflection is seen in the commitment and quality of teaching and also students' passing their Examinations with excellent grades. Adequate infrastructure and Laboratory equipment should be supplied accordingly to all the Public schools. This also mean that all the variables are important which complement one another. The teacher should know that he has more influence on the achievement of students' in all Examinations.

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