A Causal Model of Nigerian Teacher Characteristics and Their High School Students' Achievement in Some Ecological Concepts

J.B. Bilesanmi-Awoderu*

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Introduction

The literature is replete with studies that have indicated under-achievement of secondary school students in Biology, (Usua, 1974; Soyibo, 1982; Fakunle, 1986; Okebukola, 1986; Bilesanmi, 1994). Additionally ecological concepts have been identified as difficult for students to conceptualise, consequently contributing to students' poor performance (Moses et. al., 1979; Oyewole, 1982; Okeke et. al., 1986; Lagoke et. al., 1986; Fakunle, 1986, WAEC Chief Examiner's Report, 1987; Bilesanmi 1994; Abimbola, 1998).

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This deplorable and demoralizing situation has no doubt informed so many research efforts which have been pre-occupied with issues such as what factors are responsible for this state of affairs and what concerted efforts should be exerted to arrest such situation. Some of the reasons given include faulty teaching methods employed by the biology teachers (Moss and Teobald 1979), lack of interest in the concept by both the students and the teachers (Amobi, 1980), non-specification of the teaching objectives (Okeke 1981), and its being abstract and conceptually difficult (Fatubarin 1981). Of all the factors highlighted, the investigator is most interested in the teacher factor. Partly, this is because the teacher is capable of turning a seemingly hopeless learning condition to a motivating or conducive one thereby influencing positively the effectiveness of the teaching-learning process.

The position is supported by Oriafor (1982) when he opined that the amount and quality of learning that takes place in the school depends on the competence of the teachers in the school; efforts aimed at the improvement of education should be focussed on the preparation of the teachers. In line with the thinking of Oriafor is the axiom that "no education system can rise above the quality of its teachers' (FGN, 1981). Hence, this statement aptly and succinctly underscores the decisiveness of the teacher-factor in any educational system (Akhilomen, 1992). Warwick and Jatoi (1994) examined the extent to which teacher gender predicts students' achievement in Science and Mathematics. Results showed that rural students of male teachers had significantly higher achievement score than rural students of female teachers.

Arubayi (1987) and Chacko (1981) concluded that teacher qualification is important in explaining variance in students' learning outcomes.

The need to study the teachers' scientific attitude springs up from the fact that some studies (Geisert, 1975; Morrisey, 1981) have indicated that teachers' scientific attitudes towards science, among other

factors, influence the efforts they exert to teach it. This may be an indication that a strong relationship could exist between the teacher, scientific attitude and teaching style (James 1971; Welch, 1972). Anderson (1981) documented that teacher experience is an important factor in student achievement.

Studies such as those of Goodenough (1976) and Krywgniuk and Dar (1976) have shown that cognitive style has a significant influence on how individuals learn. Furthermore, Witkin (1967) has argued that the knowledge of a child's cognitive style is likely to be very useful in teaching him. Based on this, we are now projecting that this variable, that is, the cognitive style of the teacher is of interest in this study in that it had influenced how the teacher had attained his scientific concepts and in fact could affect how he now discharges his teaching duties.

Self-concept is central to man's behavior. As the perception of the self changes, behavior changes. Available researchers (Maslow 1971; Pizzini 1976) indicated that the way teachers become effective in relating to students seems to rely on the forces of what they themselves believe and do. Such findings have long-range implications for teacher education. Assuming that behavior is affected by the self-concept of students, it seems logical that teacher education programmes especially pre-service programmes attempt to stimulate the positive growth of self-concept of the prospective teachers.

A close examination of the existing literature indicates that not many of the variables were taken together at the same time in any particular study. Hence, the variables were correlated with learning outcomes using methods involving one to one variable mapping. Perhaps, a more important point to note is the fact that the previous researchers have mostly analyzed their data using t-test analysis, one-way analysis of variance and correlation co-efficient without explaining the interactions got in terms of causal linkages in a multivariate analysis. It thus seems that not much progress has been made in identifying

the sequence, pattern and extent of interactions between teacher characteristics and students' achievement in biology especially when many of these characteristics and achievement are taken together.

The main emphasis in this study is on causal thinking and modeling. Duncan (1966), and Bryant and Doran (1977) have identified three fundamental factors for generating a hypothesized causal model and these have essentially been used in the selection of variables in the study.

Temporal Order: If a variable occurs in time before another one with which it is known to be causally related, it is obvious that the latter variable will be a function of the former, and not vice versa.

Research findings: Research can identify a causal order among a number of variables. For example, there was a debate about which causes which –"achievement" in science and "attitude" towards science – until research confirmed categorically that it is "attitude" that causes "achievement" and not vice versa as was previously thought (German, 1988).

Theoretical grounds: A particular causal order can be hypothesized by a researcher who then goes ahead to test his theory. Based on the above factors, the linkages among variables x_i = (I, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11) were considered as shown in Figure 1.

Definition of Terms

Causal Modeling: This is a technique of selecting variables that are potential determinants (causes) of the effects and then isolating the unique contributions to the effects made by each predictor variable or cause by applying the techniques of path analysis using multiple regression analysis.

Path Analysis: This refers to a series of regression analyses developed to study the direct and indirect effects of variables as causes of variables taken as effects.

Multiple Regression Analysis: This is a method for studying the effects and the magnitudes of the effects of more than one independent variable on a dependent variable using principles of correlation and regression.

It is therefore the problem of this study to construct and test a 12-variable model for determining the extent to which some teachers' characteristics (gender, qualification, scientific attitude, mode of study, experience, cognitive-style, understanding of science, self-concept, attitude to teaching profession, attitude to biology teaching and teaching style) provide a causal explanation of students' achievement in secondary school ecology class.

Specifically, this study sought to provide answers to the following questions:

- What is the most meaningful causal model (involving the listed teacher variables) for students' achievement in secondary school ecology?
- What is the direction as well as the estimates of the strengths of the causal paths (path-coefficients) of the variables in the model?
- What are the direct and indirect effects of the variables on achievement in secondary school ecology?
- What proportion (%) of the total effect are: (i) direct and (ii) indirect?

Methodology

Using the judgmental sampling technique, one hundred secondary schools in Ogun State were chosen for the study. The eligible biology

teachers in the participating schools automatically became the teacher sample: (N =100; males=62, Females = 38). The student sample was made from the randomly sampled students from each of the participating schools (N=1,000; Males = 500, Females = 500).
Data collection involved the use of the seven valid and reliable instruments for the teacher and one instrument for the students.

The teacher instruments were:

- Teacher Nature of Science Test (TNOST) consisting of 20 items of Agree (a) No Option (N) and Disagree. (Cronbach alpha value = 0.85).
- Teacher Scientific Attitude Inventory (TSAI) consisting of thirty attitudinal statements placed beside four point scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). (Cronbach alpha value = 0.78).
- Sigel's Cognitive Style Test (SLCOST) consisting of twenty cards numbered 1 – 20 with each card containing three pictures of which two of them could have one thing or another in common. (Test-retest reliability value = 0.76).
- Classroom Observation Schedule (COS) consisting of seven behavioral categories placed beside a row of boxes in which the investigator was expected to tick prevalent classroom behavior occurring every 30 seconds. (Test-retest reliability value = 0.92).
- Attitudes Towards Biology Teaching Scale (ATBTS) consisting of 25 items placed beside a four-point scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). (Cronbach alpha value = 0.80).
- Attitudes Towards Teaching Profession Scale (ATTPS) consisting of 20 items placed beside four-point scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). (Cronbach alpha value= 0.85).
- Personal Data Inventory (PDI) consisting of 25 items in which the respondents were expected to scale the

behaviors that were "most like them" ranging from 5 to 1. The reverse is also true. (Cronbach alpha value = 0.82).

The student instrument was Ecology Achievement Test (EAT) consisting of 50 multiple-choice items. Its content validity, established by using the Educational Testing Service (ETS) of United States pattern of classification of educational objectives, yielded an outcome of 13 items (25%), 18 items (36%) and 19 items (38%) at the cognitive levels of remembering, understanding and thinking (K-R 21 reliability value = 0.85).

Data Collection and Analysis

Data collection lasted for two months. The data for this study was analyzed using the two closely related multivariate analytical techniques of multiple regression and path analysis. The multivariate approach is most suitable since all the eleven independent variables act simultaneously with one another as well as with the dependent variable. These two techniques are integral parts of the confirmatory causal modeling employed to analyze the data for this study.

The basic assumptions for path analysis include:

- The relations among the variables in the model are linear, additive and causal.
- Residuals are neither correlated with variables preceding them in the model nor among themselves.
- There is a one-way causal flow in the system. That is, reciprocal causation between variables is ruled out.
- The variables are measured in an interval scale.

The confirmatory causal modelling technique (Bryant and Doran 1977, Champagne and Klopfer 1982) employed in this study involves:

- selecting the variables that are postulated to be the causes of the effects;
- hypothesizing and selecting the "correct" theoretical causal model (an arrow diagram: Figure 1) that shows causal relationship among the study variables;
- constructing the structural equations associated with the arrow diagram;
- identifying and trimmings the paths of the model using the criteria of significance ($p < 0.01$) and meaningfulness (resulting in a more parsimonious model) and
- validating the more parsimonious model (Figure 2).

Results

Testing the significance of the path co-efficients in the hypothesized causal model resulted in data which showed that only 30 out of 46 paths in the hypothesized model met the criteria of significance (at 0.05 level) and meaningfulness. The hypothesized model was therefore trimmed to produce a more parsimonious model with 30 surviving paths (Fig. 2).

The original correlation data were reproduced using the normal equation and the path co-efficient in the more parsimonious model. The differences between the original and the reproduced correlations were considered very minimal (0.05). This is an indication that the pattern of correlation in the observed data is consistent with the more parsimonious model. The model is therefore considered tenable in explaining the causal interaction between the predictor variables (X_1 to X_{11}) and the criterion variable (S_{12}). Figure 2 thus shows the most meaningful causal model (involving gender, qualification, scientific attitude, mode of study, experience, cognitive style, teacher understanding of science, self-concept, attitude to teaching profession, attitude to biology teaching and teaching style) in

predicting students' achievement level in Ecology. This is my main submission.

The directions of the causal paths of the variables in the model are the paths which are significant and meaningful, and have a link with the criterion variable (X12). Altogether these paths are 66 in number and the path co-efficients give the estimates of the strengths of the causal paths of the variables in the model.

Table 1: Effects of Eleven Independent Variables on Students' Achievement in Ecology

Xi	Xj j=1,2, 3,... 11	Total Effect (TE) (a)	Direct Effect (ED) (b)	% of DE Relative to (b/Ta x 100)	Indirect Effect (IE)	% of IE Relative to TE a - b x 100 Ta
Variable 12	1	-0.009	-	-	-0.009	-1.89
	2	0.042	-	-	0.042	8.84
	3	0.002	-	-	-0.002	-042
	4	0.014	-	-	0.014	2.95
	5	0.187	0.1140	24.00	0.073	15.37
	6	-0.092	-0.1280	-26.95	0.036	7.79
	7	0.198	0.1437	30.25	0.0543	11.43
	8	0.127	0.0864	18.19	0.0406	8.55
	9	-0.035	-	-	-0.035	-7.37
	10	-0.073	-0.1005	-14.97	0.0019	0.40
	11	0.117	0.1005	21.16	0.0165	3.47
	Total	0.475	0.2455	51.68	0.2333	49.12

Note:
Absolute values of the total effect and direct effects are used for computation.

X_1 = X_{12} = the criterion variables (X_{12})
X_j = (1,2,3, ...11) = Predictor variables (X_1 to X_{11}).
D.E.= Direct Effect = Pijs (where i = 12, j = 1,2, ... 11).
P = Path Coefficient
T.E. = Total Effect = rjs (where r = original correlation coefficient)
Ta = Grand Total of T.E.
B = Grand Total of D.E.

Out of the significant and meaningful 66 paths, only 6 are direct while the remaining 60 are indirect. The total effect (i.e. direct plus indirect) of all the eleven predictor variables are shown in Table 1. The

proportion of the total effect that is direct and indirect is also evident from the table.

Discussion

The available information shows that 8.3% of the variability in students' achievement in Ecology (X_{12}) is accounted for by all the eleven predictor variables when taken together. Again, since the magnitude of beta weight is assumed to be directly proportional to the degree of the effects of the influencing variable, it could be seen from Table 1 that only six variables: understanding of science (VAR. 7); experience (VAR.5); self-concept (VAR.8); teaching style (VAR.11); attitude to biology teaching (VAR. 10); and cognitive style (VAR. 6) have direct causal influence on students' achievement in Ecology.

Teacher understanding of Science has the most potent causal influence on students' achievement in ecology. As shown in Table 1, VAR. 7 has a path coefficient of 0.1437 significant at 0.05 level and accounts for 41.68% of the total effect of the independent variables on students' achievement in secondary school Ecology. This is consistent with the findings of Aghadiuno (1992). This confirms the common sense that the teacher should have the knowledge and should understand the principles, laws and theories of Science before he can effectively impart such a knowledge to the students. This position is strongly supported by Aikeweze (1991) who opined that it is unnatural for people to offer what they do not have.

Therefore, any teacher at any level must, among other qualities, be a master of his or her subject. He or she is expected to be versatile; a good source of knowledge and information to his or her [illegible]
Also, Figure 2 shows the cognitive style (VAR. 6), ex[illegible]
(VAR.5), Qualification (VAR. 2) and Gender (VAR. 1) sig[illegible]
affect VAR. 7 directly while the other two variables – Scientifi[illegible]
(VAR.3) and Mode of study (VAR. 4) do so indirectly.

Teacher experience (VAR.5) is the next important variable that has direct causal influence on students' achievement in Ecology. It has a path co-efficient of 0.114 and accounts for 38.37% of the total effect. The finding corroborates the works of Comber and Keeves (1973), Chacko (1981), Arends (1994), and Chidolue (1996).

The third most important cause of variation in students' achievement in Ecology is teacher self-concept (VAR.8) with a path-coefficient of 0.086. VAR. 8 accounts for 26.74% of the total effect.

The direct causal linkage between self-concept (VAR.8) and Achievement (VAR. 12) confirms the earlier findings of Rothman et. Al. (1969), Pizzini (1976) and Arends (1994) who reported that VAR. 8 predicts students' academic achievement. For instance, Rothman et al. (1969) submitted that teacher personality among other factors is more strongly related to changes in students' learning outcomes in the Sciences than the extent to which teacher preparation in the sciences and years of teaching experience relate to these changes.

Teaching style (VAR. 11) has the next causal influence on students' achievement in Ecology. It has a path coefficient of 0.101 and accounts for 24.63% of the total effect. This significant causal linkage lends credence to the earlier findings of Okpala (1985), and Okebukola (1986) among others. The consumers are that the laboratory method/student centered strategies always tend to enhance higher academic achievement in students than the lecture method/teacher-centered strategies.

Attitude to biology teaching (VAR. 10) has a negative causal influence on students' achievement in Ecology. It has a path coefficient of –0.101 and account for –14.57% of the total effect. In effect, while the teacher attitude to biology teaching increases, students' achievement in biology decreases. This result runs contrary to the works of Mackay (1971) and Soyibo (1986) who predicted students' achievement from teachers' attitude to biology teaching.

However, the finding of this study can be explained against the background that parents and guardians alike (especially the educated ones) have lost faith in the school system. Hence, they have employed other means to see that their children and/or wards succeed despite the attitude of the teachers of biology. Some of the intervention strategies included the enrolment of their children and/or wards in private lesson, the use of computer-assisted learning programmes, remedial classes, older siblings assisting the younger ones and probably the students' determination to succeed despite the type of attitude exhibited by their teachers.

These strategies could have been possible because of the peculiarities of the sampled schools, which were not strictly boarding schools. Hence, since most of the schools were day schools, the parents/guardians could have a lot of influence or impact on the students' academic achievement through personal efforts.

Cognitive style (VAR. 6) has a negative causal influence on students' achievement in Ecology. The path coefficient is –0.128 and accounts for-19.16% of the total effect. This finding suggests that as a teacher's cognitive style becomes more analytical in nature, students' achievement in ecology decreases. This result is contrary to those of Ramirex (1972) and Barnett (1974).

However, the present result can be explained against the background that teachers with analytical minds do not produce students with high achievement. In other words, the analytical nature which have hitherto been associated with science learning appears not to have an effect in the results of their teaching. It does suggest that the teachers do not appreciate and/or utilize their personal attributes. This could probably be because they do their job as an official business due to several factors ranging from public low image, economic stress to total dissatisfaction with the job. The researcher feels the students have realized this and have derived other means and strategies of high achievement in their studies irrespective of their teachers' cognitive style.

Conclusion

A major finding of this study is that students' achievement in Ecology is directly influenced by six potent teacher characteristics. The implication is that curriculum planners should on the basis of this finding re-plan, re-organise and review the existing biology methodology curriculum/ courses to conspicuously feature and integrate these potent characteristics.

For instance, since Ogunniyi (1985) believes that science/biology teachers still hold an unwholesome view of Science and are not teaching the nature of science, perhaps because they do not know it, it is hereby suggested that there should be additional courses which would lead to better and meaningful understanding of the nature of science. This step is intended to solve the problem of the teachers' lack of understanding of the nature of science.

Also, efforts should be made to provide enough impetus during training to stimulate positive growth of self-concept of the prospective teachers.

The finding of this study no doubt should get to the practicing biology teachers through workshops, conference and seminars. Hence the potency of the six direct teacher characteristics in predicting students' achievement in ecology would be known. The practicing teachers therefore would enhance these factors in their interactions with the students and in turn, this is expected to bring about a higher performance on the part of the students in ecology.

In conclusion, the various linkages shown in the parsimonious model (Figure 2) should be noted by curriculum developers and science educators since these could provide a strong basis for developing a more effective theory and technique for efficient nation-building through effective Science Education.

Limitation of the Study

This study was restricted to the characteristics of the biology teachers and hence, this could make the generalisations of the findings difficult in some other subjects except when done with great caution. Also, only some biological concepts (ecology) were used for this study.

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