Journal of Classroom Interaction, ISSN 0749-4025. Copyright © 2004, Vol. 39.2, pages 24–31.

Classroom Interaction Patterns, Teacher and Student Characteristics and Students' Learning Outcomes in Physics

Iroha Kalu
UNIVERSITY OF CALABAR, NIGERIA

A. N. Ali
UNIVERSITY OF NIGERIA, NSUKKA

ABSTRACT

The purpose of the study was to determine the patterns of interdependency among classroom interaction patterns, teacher and student variables and students' learning outcomes in physics, comprising their post-instructional attitude and achievement in "low" and "high" academic tasks. Seven instruments were used in collecting data from 516 Senior Secondary One (SSI) physics students (239 boys and 277 girls) and 15 physics teachers drawn from 15 selected secondary schools in Calabar Education Zone of Cross River State, Nigeria. The schools were constituted by the purposive sampling technique. The data generated with the instruments were analyzed using canonical analysis technique. The results indicate (1) that the sets of independent and dependent variables are strongly related in three independent ways (Rc = .98, .93 and .92), corresponding to three named canonical factors/variates, and (2) about 89% of the variance in students' learning outcomes is redundant to the variance of interaction pattern and teacher and student variables. The three identified factors respectively contributed 33%, 29% and 27% of the redundant or common variance of the two sets of variables.

INTRODUCTION

In Nigeria, government pronouncements and activities geared towards encouraging secondary school students to study the sciences abound. In spite of these, few students enroll for physics and the performance of these few in School Certificate Examinations are poor.

Spirited attempts have been made through research to shed light on students' poor learning outcomes. However, the studies are mostly of the presage-product variety (e.g. Chacko, 1980; Onocha and Okpala, 1985) with very few process-product studies (e.g. Olanrewaju and Balogun, 1984). In spite of its potentials, observation of classroom processes is not a popular research orientation in Nigeria. Thus, the literature on observation of classroom interactions in Nigerian schools is sparse. Apart from Udeani (1992), the few studies that involved observation of classroom processes (e.g. Akuezuilo, 1987; Ajayelami, 1983; Domike, 2002; Emah, 1998; Iyewarum, 1983; Mani, 1986; Ogunniyi, 1981; Okafor, 1993; Okebukola, 1985; Okebukola & Ogunniyi, 1984; Ogunkola, 1999) did not consider the presage, process and product variables in science education in concert. Obviously, as Anania (1983) has argued, whereas the presage-product studies direct attention away from the teaching-learning process by implying that solutions to students' poor learning outcomes lie outside the domain of schools and educators, the process-product studies absolve the students' and teachers' characteristics and backgrounds by implying that students' learning outcomes are solely predictable on the basis of the teaching-learning process. These implications are, however, false, having been derived from an artificial dichotomizing of a continuous, interacting web of variables in school learning.

In an effort to lay the foundation for a model of the teaching-learning process, Harnischfeger and Wiley (1976) identified five major weaknesses of previous research in education that applies especially to the Nigerian situation. Three of these weaknesses are relevant here. Firstly, despite the fact that the classroom situation is extraordinarily complex, much research in education greatly oversimplifies the situation by using laboratory settings or by focusing on only a few selected factors in a natural setting. Secondly, instead of considering simultaneously student activities, teacher activities and the curriculum, many research efforts fragment the triad of students, teachers and the curriculum. Many studies link achievement directly to teacher behavior or the curriculum and ignore the most important mediating factor – student learning behavior. Thirdly, the educational research community concentrates too much on experimental studies as opposed to studies in natural settings, and on design-based analyses rather than exploratory analyses.

One implication of Harnischfeger and Wiley's (1976) first two criticisms of educational research is that if results are to be meaningfully used in improving the efficiency of the educational system and the quality of its products vis-à-vis the learning outcomes, the research methodologies must reflect a level of complexity commensurate with, or at least similar to, the educational process. In agreement with the third criticism, we cannot go beyond the extent to which research is conducted in a setting similar to the school situation, or the extent to which research is performed at a level of complexity in which actual educational problems exist in making extrapolations from it to the classroom millieu (Shulman, 1976).

As Shulman (1976, p.180) has pointed out, most conceivable educational settings are commonly characterized by:

1. "Simultaneous input of multiple influences and the likely output of multiple consequences, some of which are predicated and others not" and
2. "Variability of reaction to ostensibly common stimuli, that is, not all learners learn equally or react similarly to specific acts of teaching."

Thus, the ideal research setting that is congruent with the educational process is one that is multivariate at the level of both independent and dependent variables, and consistent with that, differential, in the sense that student and teacher variables are treated as data of major interest in the research. Okebukola (2002) recommended the use of multivariate techniques in science education research because it is based on the assumption that teaching and learning of science involves an interplay of a multiplicity of variables. He argues that "to make dramatic progress in science education, we must be able to understand the mutually interacting and complex dynamics of the whole system, and to strategically design interventions that deal with the system as a whole" (p.32). Borrowing the ideas of Salisbury (2000) he therefore advocated for the adoption of systems-thinking in science education research, which involves looking at science education as a whole with its inputs, processes, outputs and outcomes, rather than viewing it as a set of separate and distinct activities.

Earlier, Udeani (1992) investigated student learning outcomes in integrated science as related to teacher and student characteristics and classroom interaction patterns and found that teacher characteristics (experience, content knowledge and qualification, in decreasing order of importance) contributed significantly to the variance in students' cognitive achievement, attitudes and acquisition of process skills. Also, teacher personality traits stood out in explaining variances in achievement and process skill acquisition while classroom interaction (teacher and student activities) accounted for about 74%, 71% and 30% of the variation in cognitive achievement, process skill acquisition and attitudes to science respectively. On the other hand, student characteristics (sex and socio-economic status, SES) had virtually no relationship to students' learning outcomes, and most of the determinant variables did not exert much influence on students' attitudes to integrated science.

Noonan and Wold (1980) obtained a similar result in a Partial Least Squares (PLS) path modeling with latent variables of school survey data, but also found that home background had an indirect effect on science achievement, operating mainly through science activities and school atmosphere, while students' verbal ability had strong direct and indirect effects on students' science achievement. Similarly, Power (1973), in a study designed to ascertain the unintentional consequences of science teaching, found that a fortuitous combination of personal characteristics and environmental conditions appear to enhance a high degree of academic success, positive attitudes and high socioeconomic status.

These studies have made important contributions in redressing the conceptual and methodological weaknesses in research on students' learning outcomes. In particular, Udeani's (1992) study addressed the Nigerian situation. However, the scope of student variables considered in the study is limited (sex and SES only) and it was conducted in junior secondary schools where all subjects are compulsory. Again, it implicitly assumed that there are no linkages among the students' learning outcomes. The present study was designed to determine the nature of the links or patterns of interdependency among teacher variables (experience, attitudes towards teaching generally and inquiry instructional strategy), student variables (general ability, SES, achievement motivation, prior knowledge of and attitude towards physics), classroom interaction patterns, and students' learning outcomes in physics, comprising post-instructional attitude and achievement in academic tasks requiring students to understand and reproduce information encountered during instruction (low academic tasks) and those that require students to apply the information and draw inferences (high academic tasks).

METHOD

Sample

The sample consisted of 516 SSI physics students (239 boys and 277 girls) and 15 physics teachers drawn from 15 selected secondary schools in the Calabar education zone of Cross River State, Nigeria. The schools were constituted by the purposive sampling technique. Only those schools that taught the focal units of physics on which the achievement test for the study was set, during the second term when the study was conducted, were selected for the study. Only one stream of SSI physics classrooms was used per school. In schools with more than one stream of SSI physics classrooms, a stream was randomly drawn for the study.

Instruments

Seven instruments were used in data collection, namely, Physics Teachers Questionnaire (PTQ), Students' Physics Attitude Scale (SPAS), Students' Achievement Motivation Scale (SAMS), Students' Background Questionnaire (STUBAQ), Test of Mental Ability (TEMA), Physics Achievement Test (PAT) and Science Interaction Categories (SIC). PTQ is a composite Likert-type instrument designed to measure teachers' attitudes towards teaching generally (Part I) and the inquiry method of teaching science (Part II) and to obtain information regarding their teaching experience. Part I consists of 24 items and sample items are as follows: "Teaching is exciting," "As a teacher, I have fun while interacting with my students," "I consider the teaching profession as a stepping stone for an ambitious person." Part 2 also consists of 24 items and the statements reflect expectations of teacher and student activities in an inquiry and traditional classroom. The statements that are positive with regards to traditional classroom teaching constitute negative statements with regards to the inquiry teaching strategy. It is actually an adaptation of the instrument used by Jones and Harty (1978) to ascertain the instructional and classroom management preferences of secondary science teachers. Sample items are "Lab investigations should follow specified directions and procedures predesigned to illustrate a concept," "Instructional materials should encourage students to formulate alternative ideas of concepts encountered."

SPAS is a twenty six-item four-point Likert-type questionnaire designed by the researcher to measure students' attitude toward physics before and after instruction in the focal units of the SSI physics curriculum under study. The items are statements of students possible opinions and feelings towards physics as a subject, its importance to their daily lives, their interest or otherwise in the subject, etc. Sample items are "I feel happy when it is time for a physics lesson," and "Physics is not an interesting subject."

SAMS is a 23-item four-point Likert-type scale used to measure students' achievement motivation (n.Ach). It consists of statements which depict the possible standards of success students have set for themselves, below which they deny themselves any sense of gratification for their efforts (cf Bower & Hilgard, 1986). It is an adaptation of the instrument used by Duda & Nicholls (1992). Sample items are as follows: "I do my very best in my class work," "Getting a passmark in a test or examination is just enough for me."

STUBAQ was used to measure SES, which was conceived as being functionally dependent on the parents' educational attainments, occupational status and the quality and quantity of household items. From a simple list, the students were expected to tick only those educational levels and occupational status which apply separately to their fathers and mothers or guardians, as well as the household items available in their homes.

TEMA, which was used to measure students' general ability, is the non-language, pictorial, standardized intelligence test, "Test of 'g' CULTURE FAIR, Scale – 2, Form A," prepared by R. B. Cattel and A. K. S. Cattell. It has been validated and successfully used by other researchers in Nigeria (e.g. Nenty, 1979). The four subtests of the intelligence test involving series, classification, progressive matrices and mirror images were used without modification in the study. As it is in the original test package, the respondents' conception of what is required of them in each of the subtests was made to depend more on worked examples than on verbal instructions.

PAT is a thirty-item multiple-choice objective test developed by the researcher to collect data on students' achievement in low and high academic tasks in physics. It was based on the following topics commonly taught in SSI during the second term when data was collected for the study: Speed and velocity/rectilinear acceleration; work, energy and power; electric charges; description and properties of fields; and gravitational field. Sample items are: "What type of energy is possessed by a wound spring? (A) Potential energy (B) Chemical energy (C) Mechanical energy (D) Kinetic energy (E) Heat energy," and "A charged body X placed in the force field produced by a negatively charged body Y experienced a repulsive force. What is the nature of the charge on X? (A) Negative (B) Positive (C) Neutral (D) Negative and Positive (E) Positive and Neutral." Eighteen of the items are knowledge and comprehension questions (low academic tasks) while the remaining 12 items are higher order cognitive questions (high academic tasks).

SIC was used to code and analyze the interaction patterns during physics lessons in the selected schools used for the study. The original SIC developed by Ogunniyi (1981) is an adaptation of Flanders' Interaction Analysis Categories, FIAC, (Flanders, 1970). It was designed to measure teacher and student behaviors in science classes. The original SIC has 15 categories – 9 of teacher behaviors and 6 of student behaviors. It was modified in the present study by creating an additional behavior category, pupil-pupil interaction, and subcategories of teacher behaviors. A distinction was made between teacher criticisms and rewards of student behaviors that are content- or subject matter-specific and those that are social in nature. Verbal rewards and criticisms of students' appearance or behaviors that are quite unrelated to the topic being taught were classified as being social. Also, teacher questions were classified into those that require a specific answer (closed questions) and those that do not require a specific answer (open questions). In the final analysis, SIC, as used in the study, has the following 9 categories of teacher behaviors:

(1) Accepts feelings
(2) Gives verbal reward (i) content-specific (ii) social
(3) Reinforces response,
(4) Questions (i) closed (ii) open
(5) Lectures,
(6) Directs,

(7) Criticizes (i) content-specific (ii) social,
(8) Manipulates apparatus, and
(9) Supervises.

It also consists of 7 categories of student behaviors:
(10) Responds to questions
(11) Questions
(12) Initiates talk
(13) Experiments
(14) Reads, writes and or draws
(15) Non-productive activities, and
(16) Pupil-pupil interaction.

Validation of Instruments

Each of the instruments was face-validated and pilot-tested. PTQ was pilot-tested using 20 science teachers who were not part of the study. The internal consistency of the two parts were separately determined by computing the cronbach alpha and found to be 0.82 for Part 1 and 0.76 for Part 2. SPAS, SAMS, STUBAQ and PAT were pilot-tested by administering them on 40 SSI physics students from one school, not used for the study. SPAS has an internal consistency of 0.84 and a test-retest reliability of .79 while SAMS has an internal consistency of 0.80. The test-retest reliability of STUBAQ was found to be 0.62. For PAT, only 30 items with difficulty index $0.3 \leq P \leq 0.7$ and discrimination index $D > 0.3$ were retained. The internal consistency was estimated with the Kuder-Richardson Formula 20 to be 0.72 while the test-retest reliability was estimated as 0.81. The inter-observer reliability was established to be 0.90 after a two week in-school training session (towards the end of the first term preceeding data collection) on how to use SIC to code classroom interaction behaviors during physics lessons.

Data Collection Procedure

Data for the study were collected during the second term of the secondary school academic session. During the third week of the term, prior to instruction on the topics on which PAT was based, PAT and SPAS were administered to the students by the first author and/or his assistant in the 15 schools selected for the study. During the 4th and 5th week of the term, the instructional processes in each of the 15 selected physics classrooms were observed and the interaction patterns coded using SIC. Each physics classroom was observed for 4 lesson periods spaced over a period of 8 weeks when the focal units of physics were taught in the schools. Only interactions during physics lessons were observed and coded. Practical classes and free periods were not observed for purposes of coding and analyzing the interactions occurring therein. The observed events were coded every 5 seconds and in cases of ambiguity or when two events occurred simultaneously both events were coded. In mixed schools 7 categories of teacher behaviors and all categories of student behaviors were coded separately for male and female students. Each classroom was observed at least once by each of the observers.

Staring from the 6th week, classroom observation and the administration of STUBAQ, SAMS and TEMA were respectively alternated on a weekly basis. At the end of the eight-week instructional period, when the topics in the focal units of physics had all been taught, PAT and SPAS were again administered to the students. Also, the physics teachers were given the PTQ to fill out then.

ANALYSIS AND RESULTS

The frequency of occurrence of each behavior category of SIC for the 4 sets of observational data for each teacher/classroom group were combined, tabulated and converted into a composite matrix of interaction behavior categories by teachers. The matrix consisted of the occurrence of each behavior category expressed as a percentage of the total frequency of all the behavior categories. The Indirect/Direct (I/D) ratio which served as an index of interaction pattern per classroom group was then computed. Specifically, the I/D ratio is the ratio of the frequency of occurrence of indirect teacher behaviors to direct teacher behaviors. In terms of the behavior categories adumbrated earlier, it is the ratio of the sum of percentage of occurrence of categories 1, 2, 3 and 4 of teacher behaviors to the sum of percentage of occurrence of categories of 5, 6, 7, 8 and 9 of teacher behaviors (see Kalu, 1999 for detailed specific results per classroom group).

In order to determine the nature and number of statistically significant links or interdependencies between interaction patterns, teacher and student variables as a set, and students' post-instructional attitude and achievement in low and high academic tasks, canonical correlation analysis was performed. The latter is an analysis technique which provides information on the number of independent ways in which any two sets of variables are related. Besides determining the significant correlation coefficient for the two sets of variables, it was also of interest to interpret the canonical factors corresponding to the significant correlation coefficients. That is, it was desired to determine which specific variables in the two sets contributed most heavily to each pair of maximally correlated canonical factors. To do this, a canonical structure matrix (Cooley & Lohnes, 1971) of the correlations of the canonical factors with the original variables was used instead of canonical weights because the latter is not substantive, not appropriate (Levine, 1977; Rhandawa, 1983). The zero order correlations of the variables and the results of canonical analysis are shown in Tables 1 and 2 respectively. The results in Table 2 were obtained by using the computer package program, "Matlab," to perform the matrix operations in canonical analysis following the examples in Pedhazur (1982). Though the standardized canonical weights are reported, only the structure coefficients will be used in the interpretations.

TABLE 1

Zero Order Correlations Among Interaction Patterns, Teacher and Student Variables and Students' Learning Outcomes

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Prior Knowledge (PRIK)	1	.36	.79	.83	.31	.01	-.70	.38	.33	-.10	.78	.07
2. Pre-instructional Attitude (PRIAT)		1	.14	.57	.05	.14	.17	-.36	.41	.81	.37	-.07
3. Socioeconomic Status (SES)			1	.63	-.05	-.27	-.68	.32	.37	-.26	.81	.03
4. General Ability (GENAB)				1	.38	.09	-.51	.24	.48	.17	.75	.20
5. Achievement Motivation (n.ACH)					1	.25	-.22	.47	.01	-.21	.17	.70
6. Teachers Attitude Towards Teaching (TATT)						1	.08	.42	-.12	.19	-.15	.42
7. Teachers Attitude Towards Inquiry (ATINQ)							1	-.53	-.04	-.63	.24	.49
8. Teaching Experience (TREXP)								1	.12	.43	-.38	-.10
9. Classroom Interaction Pattern (CLIP)									1	.28	.60	.03
10. Post-Instructional Attitude (POSIAT)										1	-.03	-.23
11. Low Academic Task Achievement (LOTACH)											1	.14
12. High Academic Task Achievement (HITACH)												1

The results in Table 2 indicate that the two sets of variables maximally correlated or are linked in three independent ways corresponding to three canonical factors. The 3 pairs of canonical variates or factors correlated rather strongly (R_{c1} = .98; R_{c2} = .93; R_{c3} = .92). Bartlett's chi-square test of Wilk's Lambda shows that the canonical correlation for the first two factors are significant at the .05 level, but suggests that the third factor, in spite of its high value, could have arisen only by chance (p >.05). Nevertheless, using the criterion of meaningfulness (cf Cooley and Lohnes, 1971: 176; Pedhazur, 1982: 727) whereby for R_c^2 greater than 10%, the Rc is treated as meaningful even if it is not significant, the third factor with R_c^2 = 84% was considered meaningful and retained for further analysis.

The results in the table also indicate that the redundancy for Factors 1, 2 and 3 are respectively .33, .29 and .27. This implies that about 33%, 29% and 27% of the variance of the dependent variable set are redundant to or can be accounted for by the independent variable set in Factor 1, 2 and 3 respectively. The total redundancy coefficient for the three factors taken together is .89, indicating that about 89% of the variance of the set of students' learning outcomes in physics is redundant to the variance of the independent variable set consisting of classroom interaction patterns, teacher and student characteristics.

The results in the table also indicate that the proportion of the total variance of the independent variables (PVx) extracted by Factor 1 is about 19% (i.e., .19 x 100%), while about 34% (i.e., .34 x 100%) of the total variance of the dependent variables (PVy) was extracted by the same factor. Similarly, about 28% and 34% of the total variances of the independent and dependent variables were respectively extracted by the second factor while the third factor extracted about 15% and 32% of the total variances of the independent and dependent variables respectively.

With regard to the individual variables, the results indicate that Factors 1, 2 and 3 accounted respectively for about 15.21% ($-.39^2$ x 100%), 42.25% ($.65^2$ x 100%) and 12.25% ($.35^2$ x 100%) of the variance of PRIK. Similarly, about 84.64%, 7.29% and 7.29% of the variance of POSIAT can be explained by Factors 1, 2 and 3 respectively. Other structure coefficients (or loadings) can be similarly interpreted. Of more importance is the meaning of the factors.

In order to determine the substantive content of the factors, a rule of thumb (cf Pedhazur, 1982) was adopted as follows: structure coefficients greater than or equal to .30 were considered meaningful. Using this criterion, it can be observed that the variables PRIK, RRIAT, SES, TATT, ATINQ, TREXP, POSIAT and LOTACH all have meaningful loadings on Factor 1. The factor, however, has a bipolar dimension loading positively on some of the meaningful variables and negatively on others. This suggests that it is a comparative measure of the constituent meaningful independent and dependent variables. It can therefore be interpreted as a comparative

measure of the antecedents of students' post-instructional attitude towards physics relative to their low academic task achievement. That factor may be called the "Comparative Affective/Cognitive Outcomes Press." Factor 2 loaded meaningfully and positively on all the variables except TATT, ATINQ, TREXP and POSIAT. None of the teacher variables are meaningful. Apparently, the factor is a measure of the press of the antecedents of students' academic achievement in a general sense, that is, for both low and high academic tasks. We may therefore define it as the "General Academic Achievement Press." It indicates that in classrooms where, on the average, students were knowledgeable in the content and had positive attitudes towards physics prior to instruction, of high SES and achievement motivation, and where the teachers used predominantly indirect instruction, the students tended to achieve highly in academic tasks that required memory and comprehension only, as well as those that required application and higher mental processes. The tendency was higher for tasks that demanded memory and comprehension only. Factor 3, like Factor 1, is bipolar, with positive and meaningful loadings on PRIK, PRIAT, SES, CLIP and LOTACH and negative but meaningful loadings on n.ACH, TATT, TREXP and HITACH. It appears to specify the independent variables that press for a particular type of academic achievement relative to the other. Apparently it indicates that a fortuitous combination of students' good characteristics (excluding general ability and need to achieve) and predominantly indirect instruction press more towards low academic task achievement compared to high academic task achievement, while a combination of students' need to achieve, teachers' attitude towards teaching generally and teaching experience press more towards high academic task achievement compared to low task achievement. We may therefore define Factor 3 as "Comparative Low and High Academic Task Achievement Press" or simply "Comparative Cognitive Outcomes Press."

TABLE 2

Matrix of Standardized (β) and Structure (S) Coefficients of the Variables and Other Related Statistics for the Canonical Factors Extracted

	Factor 1		*Factor 2*		*Factor 3*	
Variables	β	S	β	S	β	S
PRIK	-.57	-.39	-.39	.65	1.21	.35
PRIAT	.82	.62	.19	.63	.09	.34
SES	-.36	-.56	1.10	.58	-.87	.40
GENAB	-.27	-.10	.17	.81	.23	.22
n.ACH	.01	-.17	.61	.41	-1.05	-.62
TATT	.39	.30	.41	.16	-.64	-.48
ATINQ	-.68	.54	.25	-.19	.26	-.07
TREXP	-.46	-.63	-.31	.18	.29	-.41
CLIP	.26	.04	.21	.65	.01	.33
POSIAT	.94	.92	.40	.27	.08	.27
LOTACH	-.38	-.39	.78	.84	.51	.38
HITACH	.13	-.14	.47	.49	-.91	-.86
PVx	.19		.28		.15	
PVy	.34		.34		.32	
Factor Redundancy	.33		.29		.27	
Total Redundancy			.89			
Canonical Correlation (Rc)	.98		.93		.92	
Chi – Square	55.08		28.70		13.92	
df	27		16		7	
Significance Level	p <. 01		p <.05		p >.05	

DISCUSSION

The results of canonical correlation and redundancy analyses seem to demonstrate that classroom interaction patterns, teacher and student characteristics as a set and students' affective and cognitive learning outcomes in physics have substantial redundancy, commonality and overlap. The fact that 89% of the variance in students' learning outcome as a set can be accounted for by interaction patterns and by teacher and student characteristics illustrates that students' classroom level learning outcomes in physics can be predicted with a high degree of confidence if the independent variables included in this study are known. This result appears to be a vindication of Bloom's (1976) theory of school learning. In "an attempt to determine a small number of variables which will account for much of the variation in school learning" (p.10), Bloom marshalled evidence from the research literature to estimate that about 90 percent of the variation in student learning (comprising level and type of achievement, rate of learning and affective outcomes) is a direct function of students' cognitive and affective entry characteristics and quality of instruction. Teacher characteristics was not part of Bloom's independent variables, while rate of learning was not a dependent variable in the present study and that may account for the disparity in the two results.

Given the convincing nature of Bloom's marshalling of evidence and reasoning, as well as the substantive content of Factor 2, one may be tempted to concur with the conclusions of some reviews of research on teaching (e.g. Rosenshine, 1977) that teacher characteristics play a minor role in determining how much students learn. However, teacher characteristics may not be that irrelevant. If its effect on student learning is not direct, it may likely be indirect, working through quality of instruction.

The results have also shown that the dependent and independent variable sets are linked in three orthogonal and meaningful ways. This tends to suggest that success in teaching, defined in terms of students' learning outcomes – attitude and achievement in low and high academic tasks – is highly contextual, being dependent on teacher and student characteristics. In particular, it shows that a particular set of classroom interaction patterns, teacher and student characteristics may not generate uniformly good results across various types of learning outcomes. Indeed, it shows that cognitive outcomes do not correlate particularly well with affective outcomes. For instance, in Factors 2 and 3, students' post-instructional attitude does not have meaningful loading as did the academic achievement, while in Factor 1 they loaded negatively and positively respectively. This corroborates the findings of Evertson, Emmer and Brophy (1980) who found that cognitive gains do not correlate well with affective gains of students.

Also, the results of the canonical analysis indicate that teacher and student variables associated with achievement in lower order cognitive outcomes are not necessarily associated with achievement in higher order cognitive outcomes. However, some characteristics such as students' prior knowledge, pre-instructional attitude, SES and achievement motivation span the two types of cognitive outcomes. Students' general ability appears to conduce specifically to achievement in low academic tasks.

If the evaluation of teaching and teachers is to serve any meaningful and useful, practical purposes, it must identify their influence both constructive and negative in determining achievement in the subject as well as positive attitude towards the subject.

In this study, this was given by the loadings of the variables in each of the factors. The positive loadings of pre-instructional attitude and teachers' positive attitudes towards teaching generally in Factor 1 indicate that they exert a constructive influence on students' post-instructional attitude, while the negative loadings of students' prior knowledge, SES, and teachers' attitudes towards inquiry, instructional strategy and teaching experience on the same factor suggests that they tend to mitigate the development of positive post-instructional attitude towards physics by the students.

It is difficult to explain the mitigating influence of these variables on students' post-instructional attitude. Perhaps they do not really exert mitigating influences. It may be a matter of the degree to which the variables exert a comparative influence on the affective and cognitive outcomes. Since the cognitive outcomes have negative loadings on Factor 1 as the variables in question, it perhaps means that the variables exert greater influence on the cognitive outcomes compared to the affective outcomes. This speculation informed the decision to label Factor 1 a comparative measure of the press towards Affective/Cognitive Outcomes. The real explanation therefore appears to lie not in the variables per se but rather in the reason why the same teaching behaviors and context failed to generate positive loading or relationship across the two types of learning outcomes, post-instructional attitude and academic achievement. The same line of argument applies to the meaningful variables in Factor 3 with regards to the antecedents of low and high academic task achievement.

Address correspondence concerning this article to:

Iroha Kalu
Department of Curriculum & Teaching
University of Calabar
P.M.B. 1115
Calabar, Nigeria

irohakalu@yahoo.com

REFERENCES

Ajayelami, D. A. (1983). A study of intellectual transactions in some Nigerian chemistry classrooms and implications for Nigeria-based classroom research. *Lagos Educational Review, 3* (1), 19-24.

Akuezuilo, E. O. (1987). *Science teacher effectiveness and classroom behavior.* Unpublished Ph.D. Thesis, University of Jos, Nigeria.

Anania, J. (1983). The influence of instructional conditions on student learning and achievement. *Evaluation in Education, 7*, 1 -92.

Bloom, B. S. (1976). *Human characteristics and school learning.* New York: McGraw-Hill Book.

Bower, G. H. and Hilgard, E. R. (1986). *Theories of Learning* (5th ed.) New Delhi: Prentice-Hall of India Private Ltd.

Chacko, I. (1980). Path analysis of the effects of teacher variables on students learning outcome. *International Journal of Educational Research, 2,* 9-19.

Cooley, W. W. & Lohnes, P. R. (1971). *Multivariate Data Analysis.* New York: John Wiley & Sons Inc.

Domike, G. C. (2002), *Teacher-Pupil Interaction Patterns and Pupils' Science Achievement in Imo State.* Unpublished Ph.D. Thesis, University of Calabar, Calabar.

Duda, J. L. & Nicholls, J. G. (1992). Dimensions of achievement motivation in schoolwork and sports. *Journal of Educational Psychology, 84* (3), 290-299.

Emah, I. E. (1998). Presage variables and verbal interaction patterns in social studies classrooms in Akwa Ibom State. Unpublished Ph.D Thesis, University of Nigeria, Nsukka.

Evertson, D., Emmer, C. T. & Brophy, J. (1980). Predictors of effective teaching in junior mathematics classrooms. *Journal of Research in Mathematics Education, 11* (3), 167-178.

Flanders, N. A. (1970). *Analyzing teaching behaviour.* Reading, Massachusetts: Addison Wesley Publishing.

Harnischfeger, A. & Wiley, D. (1976). The teaching-learning processes in elementary schools: A synoptic view. *Curriculum Inquiry, 6*, 5-43.

Iyewarum, S. A. (1983). A study of the relationship between teachers' behaviour and students' achievement in science classes. *Journal of the Science Teachers Association of Nigeria, 21* (2), 45-49.

Jones, D. R. & Harty, H. (1978). Instructional and classroom management preferences of secondary school science teachers. *Science Education, 62* (1), 1-9.

Kalu, I. (1999). Analysis of patterns of teacher-student materials interactions in secondary school physics classrooms. *Benin Journal of Educational Studies, 12,* 170 -178.

Levine, M. S. (1977). *Canonical analysis and factor comparison.* London: Sage Publications.

Mani, S. (1986). Process factors and mathematics teachers' effectiveness. *Mathematique, 14* (3), 92-97.

Nenty, H. J. (1979). *An empirical assessment of the culture fairness of the Cattell culture-fair intelligence test using the Rasch latent trait measurement model.* Unpublished Ph.D Dissertation, Kent State University, USA.

Noonan, R. & Wold, H. (1980). A PLS path modeling with latent variables: Analyzing school survey data using partial least squares Part II. *Scandinavian Journal of Educational Research, 24* (1), 1-24.

Ogunkola, O. J. (1999). Interaction patterns in primary school science classrooms in Ijebu-ode, Ogun State, Nigeria. *African Journal of Educational Research, 5* (1), 51-61).

Ogunniyi, M. B. (1981). Classroom interaction relative to teacher student questioning. *Journal of Science Teachers Association of Nigeria, 19* (2), 116 -122.

Okafor, L. C. (1993). *Analysis of classroom interaction patterns in biology in secondary schools in Anambra State.* Unpublished Ph. D. Thesis, University of Nigeria, Nsukka.

Okebukola, P. (2002). *Beyond the stereotype to new trajectories in science teaching,* Ibadan: Science Teachers Association of Nigeria.

Okebukola, P. A. (1985). The relative effectiveness of co-operative and competitive interaction techniques in strengthening students' performance in science classes. *Science Education, 69,* 501-509.

Okebukola, P. A. & Ogunniyi, M. B. (1984). Co-operative and competitive and individualistic laboratory interaction patterns: Effects on achievement and acquisition of practical skills. *Journal of Research in Science Teaching, 22,* (9), 198 -206.

Olanrewaju, A. & Balogun, T. A. (1984). Attitudes and teaching methods of some integrated science teachers and students achievement. *Journal of Research in Curriculum, 2* (1), 15-23.

Onocha, C. & Okpala, P. (1985). Family environmental correlates of science achievement of pupils in primary schools. *Journal of Science Teachers Association of Nigeria, 23* (1 & 2), 150 -155.

Pedhazur, A. (1982). *Multiple regression in behavioural research.* New York: McGraw-Hill Book Company.

Power, C. N. (1973). The unintentional consequences of science teaching. *Journal of Research in Science Teaching, 10* (3), 331-339.

Randhawa, B. S. (1983). Verbal interaction of students and their teachers in junior high classrooms. *American Educational Research Journal, 20* (4), 671-686.

Rosenshine, B. (1977). Teaching behaviours and student achievement. International Association for the Evaluation of Educational Achievement, *IEA Studies, Vol. I.* London: Foundation for Educational Research in England and Wales, 201-219.

Salisbury, D. F. (2000). *Five technologies for educational change.* New Jersey: Educational Technology Publications.

Udeani, U. N. (1992). *Learning outcomes in integrated science as related to teacher and student characteristics and classroom interaction pattern.* Unpublished Ph.D Thesis, University of Nigeria, Nsukka.