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CAUSAL PATHS AND DIRECTIONS OF THRESHOLD TIME AMONG INTEGRATED SCIENCE TEACHERS IN DELTA STATE

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Abstract

There are indications that the amount and quality of science teaching and learning that take place in schools are mediated by teacher- related factors. Notable among them is the nature of teacher - pupil interactions that take place in the classroom. This study is designed to investigate the causal paths and directions of threshold time among integrated science teachers in Delta state, Nigeria. An ex-post facto design was adopted by hypothesizing a theoretical causal relationship model. The sample consisted of all 147 qualified integrated science teachers in the 25 local government areas in Delta state. Intact classes of students were purposively sampled and taught by integrated science teachers. Five instruments were used in the study. They are the Classroom Interaction Sheet (CIS), Teachers' Attitude Towards Integrated Science Teaching Questionnaire (TATISTQ), Locus of Control Scale (LCS), Self-concept Rating Scale (SCRS), and Sigel's Cognitive Style Test (SICOST). Data were collected in two phases. During the first phase, classroom observation of the teaching process using the CIS was done and recorded at fifteen seconds intervals across all categories while in the second and third phases, TATISTS, LCS, SCRS, and SICOST were administered to the teachers. Data collected were analyzed using time-series analysis of frequency and cumulative frequencies across the different behaviour categories of the CIS. The mean of the threshold time and its associated standard deviation were calculated. Data generated from the questionnaires were analyzed using multiple regression on the 8-teacher factors. A parsimonious model was produced with sixteen surviving paths at a 0.05 level of significance. This model explained the pattern of correlation of the causal interaction between the predictor and the criterion variables. The study also found 27 out of the 136 pathways through which the predictor variables caused variation in the criterion variable as significant. The study recommended that integrated science teachers should be exposed to the knowledge and benefits of threshold time through teacher education and in-service courses to enable them to manage instructional time.

Keywords: Innovation, technology, research projects.

1 INTRODUCTION

The need for effective science teaching and learning in schools made the United Nations Educational, Scientific and Cultural Organization (UNESCO) to organize the first "International Conference on the use of Integrated Approach to Science Teaching" in 1968. Others followed in Maryland, (USA) in 1973, and Niginnegnu (Netherlands) in 1978. By 1970, Nigeria Science Educators/teachers had become sensitive to the need to use an integrated approach in science teaching through the Science Teachers Association of Nigeria (STAN) Curriculum Newsletter No.1 in 1970, which contained a statement of the Philosophy, Methodology, Content, and Evaluation of Integrated Science.

There are. indications that the amount and quality of science teaching, Integrated Science teaching inclusive, that take place in schools are associated with teacher factors such as qualification [1], teaching experience [2], attitude toward science teaching [3],[4], gender [5], locus of control [6] and Cognitive style [4]. The teacher that interprets the science curriculum, thus making it possible for the planned educational objectives to be realized [6], [7],[8] found that classroom climate is a significant factor in pupils' achievement

Two approaches were used by early researchers for the observation of classroom interaction patterns: namely, the category system [9],[10],[7] and the sign system [11],[12]. The category and sign systems were combined in .the instrument called "Observation Schedule Record" (OSCAR) [13] by modifying the classroom observation procedure [10]. Flanders Interaction Analysis Categories system (FIACS) identified certain patterns associated with pupil attitude to learning, one of which is that the teacher was fully in charge in most classrooms, using his authority to control classroom activities and restrict student participation.

In Nigeria, few researchers have made use of interaction analysis systems for observing classroom climate [14],[15],[16],[17],[18],[19],[3],[20]. The reports include that introverted teachers were more effective in the science classes than extroverted teachers; that personality has a strong effect on student outcomes; that teacher-initiated interactions are positively related to attitude achievement gains more than tasks stimulated by active student participation; that most teachers spent a portion of the lesson period talking and writing notes on the chalkboard.

Using the Classroom Interaction Sheet (CIS) [3] to determine the classroom interaction patterns of Nigerian physics teacher trainees reported that monologue was predominant. These studies only examined the relationship between teacher factor and amount of science teaching, using mainly the analytical approach. Studies ([21], [22]), [23]) were done at the correlational level, establishing non-causal relationships among teacher factors, quality of classroom interactions and teacher time utilization. There appears to be a dearth of empirical studies to identify the order and strength of the causal interaction among teacher factor indices on teacher time utilization during Integrated Science lessons e.g. threshold time. There is, therefore, the need to bring into focus research at the multivariate level, which provides a causal explanation of threshold time associated with Integrated Science classrooms in terms of teacher factor.

Research questions

1 What is the meaningful causal model involving eight (8) teacher factors?

2 What are the directions as well as the estimate of the strengths of the causal paths of the variables in the model?

3 What are the direct and indirect effects of independent variables (teacher factors) on the dependent variable?

4 What proportions of the total effects are (i) Direct (ii) Indirect?

Method of the study

The research design adopted for this study was the observational technique within the ex-post facto because the researchers had no control over the independent variable. The procedure basically involves hypothesizing a theoretical causal relationship model, which shows the time spent on teaching-facilitating tasks in an Integrated Science lesson on nine teacher characteristics.

The sample for this study comprised all 147 trained (hold at least the Nigeria Certificate in Education) Integrated Science teachers in the public secondary schools in Delta State

The Research Instruments

Five major instruments were used for the study: namely,

1 Classroom Interactions Sheet (CIS) developed by [3] for direct observation of teachers during lesson. The CIS has seven categories: A - Category consists of active learning processes; hence the number of ticks in each cell was counted, each cell having a duration of the ticks being counted and recorded in minutes on the CIS.

2 Teacher Attitude towards Integrated Science Teaching Questionnaire (TATISTQ) developed by [24] was used to test Teachers' Attitudes toward Integrated Science Teaching. It had 30 items placed beside a three-point scale (Agree, Undecided, Disagree) The instrument has Cronbach's alpha coefficient value of 0.81 as a measure of construct validity, internal consistency and reliability

3 Locus of Control Scale (LCS) developed by [25], has 10 items in a four-point Likert scale: strongly agree (SA); agree (A); disagree (D); and strongly disagree (SD). Its reliability was found by Cronbach alpha coefficient to be 0.81 and by split-half reliability index to be 0.92.

4 Self-Concept Rating Scale (SCRS), a modified version of [6] to study self-concept. The instrument originally contained 19 items but was modified to 12 items placed beside a four-point scale: "Not at all" (NAA); "Some of the time" (SOT); "Most of the time" (MOT); "All the time" (ATT) with Cronbach alpha reliability coefficient of 0.87 and split-half reliability index of 0.94).

5 Sigel's Cognitive Style Test (SICOST) was developed by [26], and modified by [27] to reflect the Nigerian environment was used in this study to test Sigel's Cognitive Style. Pearson's Product moment correlation coefficient yielded reliability estimates of r= 0.62, p 0.001 to r=0.76, pO.001.

Method of Data Collection

Data collection was in three phases. The first phase was the period of classroom observation using the CIS instrument. In this phase, the classroom interactions of the Integrated Science teachers were observed by the observer during their teaching periods. The teaching process was recorded at fifteen-second intervals by recording across the categories based on established ground rules. The rules are:

1 When the behaviour occurs for more than 15 seconds, repeat coding after 15 seconds.

2 When more than one behaviour occurs within 15 seconds, code all. However, if any category lasts more than 15 seconds, code only that category.

3 Do not code until the end of the time interval (i.e. 15 seconds except if case 2 occurs).

4 When in serious doubt do not code.

The second phase of the data collection procedure was the administration of TATISTS, LCS, and SCRS instrument on the teachers. The third phase was the period of 'testing'. In this phase, Sigel's Cognitive Style Test (SICOST) was given to the teachers. Data analysis involving a time-series analysis of frequency and cumulative frequency across the different behaviour categories of the CIS was made. The mean of the threshold time and its associated standard deviation were then calculated.

Method of Data Analysis

Data generated from the questionnaires were subjected to statistical analyses using multiple regressions for the 8-teacher factors on threshold time. Multiple regression (backward solution) was used to provide information on the joint relative contributions of the 8-teacher factor variables (2,3,4,5,6,7,8 and 9) to the prediction of time spent on learning-facilitating tasks (variable 1) in an Integrated Science lesson.

Building the Hypothetical Recursive Path Model

Consider the linkages among variables 9 = (1,2,3,4,5,6,7 and8) as shown in figure 1. From common knowledge, it could be reasoned that the teacher's threshold time (X9) from exposing his typical classroom interaction pattern in Integrated Science class would depend on his attitudes toward Integrated Science teaching, X1, and attitude toward Integrated Science (X2). Available research information indicates that X1 (attitude toward Integrated Science teaching) is casually dependent on X2 (attitude toward Integrated Science), X3 (Cognitive style), X4 (Gender), X5 (Self- concept), and X6 (Locus of Control).

The construction of the hypothesized recursive path model, which addresses the linkages between the sets of variables in this study, is presented in figure I. The construction of the model was derived from previous researches' temporal order as suggested authors [28],[29],[30],[6],[24].

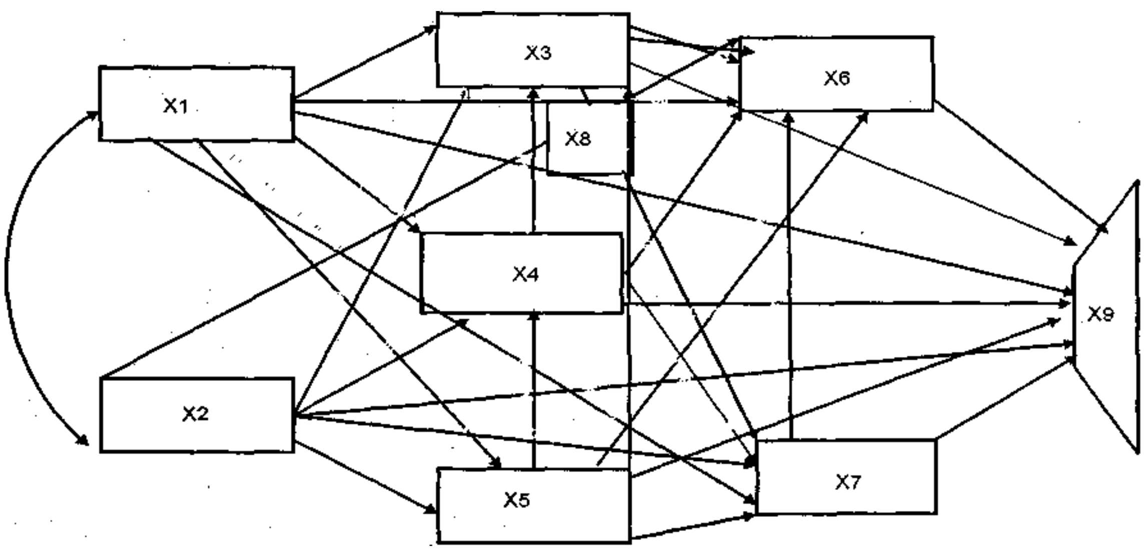

Fig. 1: Hypothesized Causal Model of the Nine Variables Showing the Path Coefficient and Zero Order Coefficients in Parenthesis.

X1 = Attitude towards integrated science teaching

X2 = Attitude towards integrated science

X5 = Gender

X3 = Cognitive style

X7= Qualification

X6 = Locus of control

X9 = Threshold time

X8 = Years of teaching experience

The Eight Structural Equations of the identified Paths of the Model

X1=e1 X2 = e2

X3 = p31x1 + P32x2x2 + P34x4 + P35x4 + e3 X4 = P41x1 + P42x2 + P45x4 + P47x7 + e4

X5 = P51x1 + P52x2 + e5 X6 = P61x1 + P62x2 + P63x3 + P64x4 + P65x5 + e6

X7 = P71x1+P72x2+P73x3 + P74x4 + P75x5 + e7

X8 = P81x1 + P82x2 + P83x3 + P84x4 + P85x5 + P86x6 + P87x7 + e8

X9 = X8 = P81x1 + P82x2 + P83x3 + P84x4 + P85x5 + P86x6 + P87x7+ e8

Results

What are the meaningful causal model involving eight (8) teacher factors and the threshold time?

The hypothesized model shown in figure 1 is reproduced as figure 2 for convenience. The numbers written on each pathway are the coefficients and zero order correlation coefficients in parenthesis. In trimming the paths in the model, however, paths were considered significant at 0.05 alpha level.

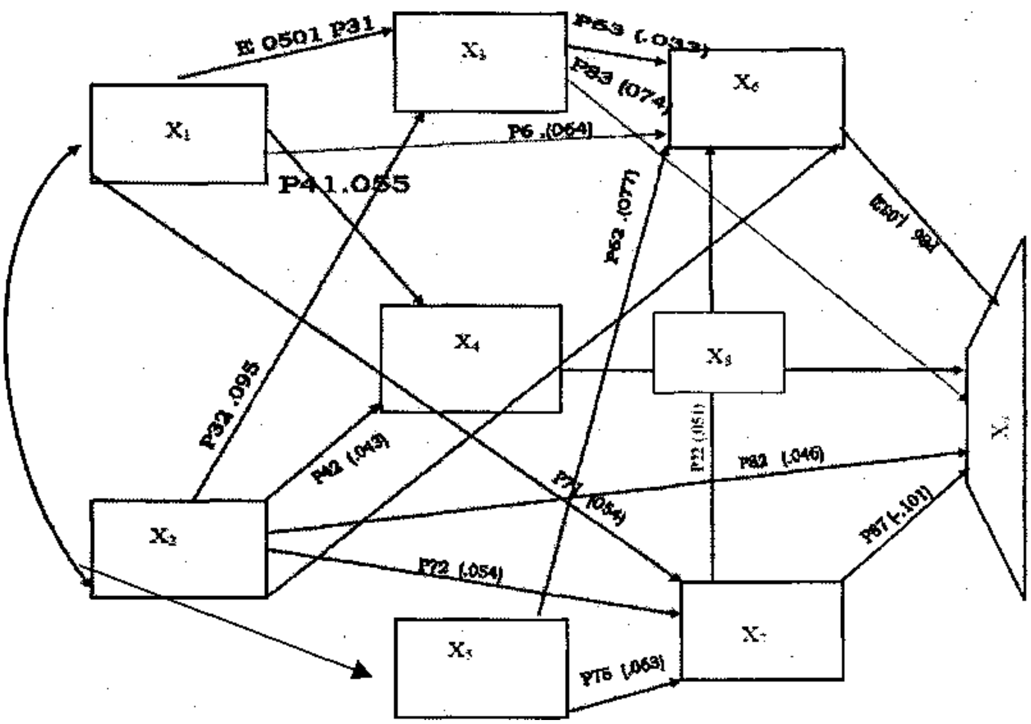

Fig. 2: The New Parsimonious Model Consisting of the Sixteen Surviving Paths.

Key:

X1 = Attitude towards integrated science teaching

X2 = Attitude towards integrated science

X3 = Cognitive style

X4 = Self concept

X5 = Gender

X6 = Locus of control

X7 = Qualification

X8 = Years of teaching experience

X9 = Threshold time

The original correlation was also reproduced using the new path model to verify the tenability of the new model (fig. 2). The correlation is presented in Table 1

The parsimonious model was obtained by trimming the hypothesized model shown in figure 1. The predictor variables (X1-X8) and the criterion variable (X9) in figure 2 show the most meaningful causal model (attitude towards integrated science teaching, attitude towards integrated science, cognitive style, self-concept, gender, locus of control, qualification and years of teaching experience) that could predict the dependent variable (threshold time for the classroom interaction).

In testing the significance of the path coefficient in the hypothesized causal model, reference was made to data presented in Table 1. It is shown in the table that 16 out of the 27 hypothesized paths were significant at .05 alpha level. This also can be observed in Fig. 2, where the hypothesized model was trimmed to produce a more parsimonious model with the sixteen surviving paths.

Table 1: Path Coefficient and their level of Significance.

Paths		Standardized Paths Coefficients	Sig. Level
1.	P31	.05*	.05
2.	P32	.095*	.05
3.	P34	0.75	NS

4.	P35	.059	NS
5.	P41	.055*	.05
6.	P42	.043*	.05
7.	P45	.051	NS
8.	P47	.073	NS
9.	P51	.001	NS
10	P52	.011	NS
11	P61	.64*	.05
12	P62	.077*	.05
13	P63	.033*	.05
14	P64	.-144	NS
15	P65	.075*	.05
16	P71	.042*	.05
17	P72	.054	NS
18	P73	.008	NS
19	P74	.103	NS
20	P75	.063*	.05
21	P81	-005	NS
22	P82	.046*	.05
23	P83	-005*	.05
24	P84	.074*	.05
25	P85	.287*	.05
26	P86	.145*	".05
27	P87	.283*	.05

Significant at .05 *level of significance.

The data in Table2 is an indication that the patterns of correlation in the observed data are consistent with the parsimonious model. This model is, therefore, a tenable explanation for the causal interaction between the predictor variables and the criterion variable.

Table 2: Correlation Matrix for the Model.

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1		.074	0.32	-0.41	.055	0.49	-.66	.32	.62
X2	.073		.097	-0.43	.009	.077	-.007	.297	.436
X3	.032	0.97		0.138	.177	-211	-.340	.074	.433
X4	-.041	-.043	.138		.108	-106	-138	.027	.054
X5	.055	.009	.177	-108		.259	.326	.173	.256
X6	0.49	.077	-211	-106	.259		.651	.032	.450
X7	-066	-.007	-.340	-138	.326	.651		.645	.241
X8	.032	.294	.074	-.027	.173	.032	-.101		.045
X9	.057	.183	.067	.055	.427	.043	.532	.231	

Note: Entries below the diagonal are the original correlation coefficients.

Table 3: The discrepancies between the original and the reproduced correlations Caused Variation in the Dependent Variable (X9, p=0.05).

Correlation	Original V	Computed 'r'	Differences
I"13	0.062	0.041	0.021
r-H	0.213	0.198	0.015
r_{15}	0.060	000	0.060
He	0.567	0.423	0.423

r"17	0.312	0.273	0.039
r_{18}	0.141	0.120	0.021
I-23	0.114	0.110	0.004
r_{24}	0.321	0.276	0.045
r_{25}	0.236	0.203	0.033
r_{26}	0.244	0.212	0.109
r_{27}	0.381	0.288	0.093
r_{2}s	0.062	0.041	0.021
r_{34}	0.352	0.328	0.024
r_{3}5	0.261	0.243	0.018
r_{3}e	0.213	0.198	0.198
r_{37}	0.116	0.116	0.000
r_{38}	0.266	0.213	0.053
r_{45}	0.216	000	0.216
r_{4}e	0.213	000	0.213
T47	0.062	000	0.062
r_{45}	0.066	000	0.066
I-56	0.317	000	0.317
r_{57}	0.203	000	0.203
r_{5}8	0.487	000	0.487
re?	0.881	000	0.881
I-68	0.054	000	0.054
r_{78}	0.287	000	0.287

Table 4: Significant Pathways through which the Predictor Variables (X1 - X8).

NORMAL EQUATION	*DIRECT PATHS*	*INDIRECT PATHS*
r13		(4)P31, P32, P34, P35
M4		(6) P41, P42, P45, P47
M5		(2)P51,P52
M6		(5)P61,P62, P63, P64, P65
r17		(5)P71, P72, P73, P74, P75
M8		(3) P81, P82, P83, P84, P85, P86, P87
r23		(8)P31,P32, P34, P35
r24		(4)P41,P42, P45, P47
r25		(2)P51,P52
r26		(5)P61,P62, P63, P64, P65
r27		(5)P71,P72, P73, P74, P75
r28	P82	(6) P81, P83, P84, P85, P86, P87
r34		(4)P41,P42, P45, P47
r35		(2)P51,P52
r36		(5)P61,P62, P63, P64, P65
r37		(5) P71, P72, P73, P74, P75
r38	P83	(6)P81, P82, P84, P85, P86
r45		(2)P51,P52
r46		(5)P61,P62, P63, P64, P65
r47		(5)P71,P72, P73, P74, P75
r45	P84	(6) P81 , P82, P83, P85, P86, P87
r56		(5)P61,P62, P63, P64, P65
r57		(5)P71, P72, P74, P75

r58		(3) P81, P82, P83, P84, P85, P86, P87
r67		(5)P71,P72, P73, P74, P75
r68	P86	(6) P81, P82, P83, P84, P85, P87
r78	P87	(6) P81, P82, P83, P84, P85, P86

What are the directions as well as the estimate of the strengths of the causal paths of the variables in the model?

The directions of the causal paths of the variables are the paths, which are (i) significant, (ii) meaningful, and (iii) have a link with the criterion variable (threshold time). The beta weights giving the estimates of strengths of the causations are shown as path coefficients from the new model of teacher factors and threshold time for typical classroom interaction patterns of integrated science teachers. The beta weights associated with the pathways (path coefficient) provide the estimates of the causal paths of the variable. From these betas, actual values of the indirect paths were determined simply by multiplying single paths.

Note: Table 4 reveals that directions to which the independent variables could predict the criterion variable are 136 in number.

What are the direct and indirect effects of independent variables (teachers' factors) on the dependent variable (threshold time)?

Out of the 136 pathways and 27 significant and meaningful pathways through which the predictor variables caused variation in the criterion variable, five are direct paths, while twenty-two is indirect. The five direct paths are associated with threshold time. These are Teachers' Attitude toward integrated science teaching (X1), cognitive style (X3), self-concept (X4) teachers' Qualifications (X7), and years of teaching experience (X8). An indirect path (a compound path) is considered significant and meaningful if the constituent single paths are significant and meaningful. Results show that of the five variables that have a direct effect on the integrated science teachers' threshold time for exhibiting their classroom interaction patterns, teachers' attitude towards integrated science teaching contributed most to their threshold time ((3 = 0.421, t = 5.642, p < 0.05); The other significant contributions to threshold time are as follows, in order of magnitude: Cognitive style (|3 =. 357, t= 4.088, p < 0.05); self-concept (p = 0.306, t = 4.881, p < 0.05); teachers' qualification ((3 =0.291, t = 4.169); and years of teaching experience (p = 0.217, t = 2.975, p < .05).

What proportions of the total effects are (i) Direct (ii) Indirect

Table 5 presents the independent variables and their effects (direct and indirect) on the dependent variable (threshold time). The table also shows the total effects and the proportions that are direct and indirect.

Table 5: Proportions of total Effects of direct and Indirect Predictors on threshold time.

Criterion Variable	Predictor Variable	Total Effect A	% B	Direct Effect C	% Effect D	Indirect Effect (a-c) E	% Effect F	G/TaX 100/(E) G	a-TaX 100/1(F)H
	X1	.032	1.7						16.3
	X2	.297	4.7	-046	2.43	11.15	14.24	9.58	7.28
	X3	.074	3.91	-012	-0.63	10.5	-28.96	2.5	76.7
X9	X4	-.027	13.0	-074	3.91	8.18	-29.13	15.4	56.0
	X5	173	9.14			10.35			11.3
	X6	.032	1.7	-145	7.7	5.47	-29.14	30.2	18.2
	X7	.021	55.3	-283	14.9		-14.64	-58.9	37.0
	X8	.018	64.3	8.2	6.41	21.3	62.1		35.6
Total %		0.48			28.3	46.1	-28.3		136.18
Proportions			43.22	53.9				68.2	

KEY:

A = Original Coefficient Ta = E total effect Tr = E reproduced Correlation

C = Path Coefficient TE = Total effect E = a - c B= TE/Ta X Tr D = /Ta x Tr F = a - b/Tax 100

G = B/Ta X 100 H = a - b/Tax 100

2 DISCUSSION

The findings of the study showed that out of the eight-variable-components of teacher characteristics hypothesized to exert causal influence on threshold time, only five: teacher's attitude towards integrated science teaching (X1), Cognitive style (X3), Self-concept (X4), Teacher's Qualification (X7), and years of teaching experience (X8), have a direct association with threshold time. Even so, teachers' attitude towards Integrated Science teaching contributed most to threshold time. Out of the 136 pathways and 27 significant and meaningful pathways through which the predictor variables caused variation in the criterion variable, five are direct paths, while twenty-two is indirect. The proportion of total effects of direct and indirect predictors on threshold time are 53.9 and 46.1 respectively.

Furthermore, the results from this study clearly show that out of the twenty-seven (27) hypothesized paths (fig. 1), sixteen significant pathways were found to have survived. These pathways were derived from the structural equations that were used to produce the most meaningful causal model of this investigation (fig. 2). The factors include Attitude towards integrated science teaching, Attitude towards integrated science, Cognitive style, Self-concept, Gender, Locus of control, Qualification, and years of teaching (experience). These factors predict the threshold time for teachers' classroom interaction in integrated science in Delta State secondary schools. From the results of the study, evidence abounds that 60.1% of the variance in the threshold time (variable 9) of the classroom interaction among the participants is accounted for by the eight predictors when taken together. The remaining 3.1.8% of the variance might be due to the influence of other factors not considered in this study. However, the present findings corroborated [6] and [25] that achievement can be said to be the outcome of instruction.

The results in Table 2 clearly show the contributions of the eight-predictor variables when taken together. These accounted for 53.9% direct effect, and 46.1% indirect components of the study. It could also be deduced from the results in Table 4, looking at the magnitude of the beta weights, that as much as five predictor variables (teachers' attitude towards integrated science teaching (X1), cognitive style (X3), self-concept (X4), teachers' qualification (X7) and years of teaching (experience) (X8)) have a direct causal effect on the threshold time of the integrated science teachers' classroom interaction. Teachers' attitude towards integrated science teaching has contributed most (76.7%) followed by cognitive style (3.91%) to threshold time. On the other hand, Teachers' attitude towards integrated science teaching and cognitive style contributed 3.1% and 76.7% of the variability in the criterion measure direct and indirect effect on the threshold time of the participants respectively. This finding is consistent with the findings reported by [29], [30], [6]. Other variables with potent effects on threshold time are Self-concept (56%, 13% variability), teachers' qualifications (37% causal and 55.3% direct and indirect variability on threshold time) and the result is in line with [3], and [6] in respect to self-concept. Also in the study, years of teaching experience as a variable is found to have both direct and indirect causal links with academic performance (35.6% causal and 64.3% variability on the criterion variable). This finding supports the works of [19] and [6], who observed that there is a significant relationship between years of experience and the threshold time of teachers in classroom interaction patterns.

3 CONCLUSION

From the findings of the study, it can be concluded that an effective teacher could plan, design, and make the environment an inviting place for nurturing and facilitating learning activities of students if he/she possesses a positive attitude towards Integrated Science teaching, the right cognitive style, the right positive self-concept, the right qualification and wealth of experience, and would help students accomplish specific tasks and activities on time. The teachers' ability to manage instructional time is key to effective teaching and learning.

4 RECOMMENDATIONS

- Based on the findings of this study, the following recommendations were made:
- Government should intensify efforts through policymakers and curriculum developers to reduce threshold time to the barest minimum through methodology courses.
- Integrated Science teachers should be exposed to the benefits/knowledge of threshold time to enhance good management of instructional time.
- Teacher preparation programme should lay great emphasis on threshold time, as a mechanism for quality control of instructional time.
- Efforts should be made to maintain and reinforce the experienced teachers so as to encourage them to put in their very best in the schools.

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