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Student and Teacher Related Variables as Determinants of Secondary School Students Academic Achievement in Chemistry

FRANCIS A. ABUSEJI

ABSTRAK

Kajian ini membina dan menguji sebuah model untuk menyediakan penjelasan secara kausal pencapaian kimia di kalangan pelajar sekolah menengah dari aspek pemboleh ubah-pemboleh ubah pelajar – jantina, tabiat pembelajaran, kebolehan matematik dan pemboleh ubah guru. Sebuah rekaan ex-post facto diadaptasi untuk kajian ini. Populasinya pula terdiri dari seluruh pelajar sekolah menengah tahun dua (SSII) dan guru mereka di Epe dan kawasan kerajaan tempatan Ibeju-Lekki di wilayah Lagos, Nigeria. Enam dan empat buah sekolah telah digunakan di dalam kedua-dua kawasan kerajaan tempatan itu. Sebanyak empat set instrumen atau alat digunakan; ianya adalah (i) Soalan Berkaitan Maklumat Peribadi Guru (PDQT), (ii) Kajian Inventori Tingkahlaku (SHI), (iii) Ujian Keupayaan Matematik (MAT), (iv) Ujian Pencapaian Kimia (CAT). Keputusan yang diperolehi menunjukkan bahawa 7.60% kepelbagaian kejayaan pelajar dalam mata pelajaran Kimia (X_8) telah diambil kira oleh kesemua tujuh pemboleh ubah penentu apabila dinilai bersama. Ia juga menunjukkan bahawa hanya pemboleh ubah – usia guru (X_1), jantina guru (X_2), kelayakan (X_3) dan pengalaman (X_4) mempunyai kesan secara langsung terhadap keupayaan pelajar dalam mata pelajaran Kimia (X_8). Cadangan berdasarkan kepentingan pemboleh ubah turut dikemukakan.

ABSTRACT

The study constructed and tested a model for providing a causal explanation of secondary school achievements in chemistry in terms of student variables – gender, study habit, mathematical ability and teacher's variables – gender, age, qualification and years of experience. An ex-post facto design was adopted for the study. The population was made up of all senior secondary school year two (SSII) students and their teachers in Epe and Ibeju-Lekki local government areas of Lagos state, Nigeria. However, six and four schools were used in the two local government areas respectively. Four sets of instrument were used; these were, (i) Personal Data Questionnaire for Teachers (PDQT) (ii) Study Habit Inventory (SHI) (iii) Mathematical Ability Test (MAT) and (iv) Chemistry Achievement Test (CAT). The results showed that 7.60% of the variability in students' achievement in chemistry (X_8) was accounted for by all the seven



predictor variables when taken together. It was also revealed that only four of the variables-teacher age (X_1), teacher gender (X_2), qualification (X_3) and experience (X_4) had direct causal effect on student's achievement in chemistry (X_8). Recommendations based on the importance of these variables were then highlighted.

INTRODUCTION

Effective science teaching is the gateway to attainment of scientific and technological greatness. Science and chemistry teaching can only be effective when students are willing and the teacher make use of appropriate methods and resources in teaching the students. Modern science teaching and learning stress student's participation in the learning process through exposure to diverse learning experiences (Baikie 2000). The learning of chemistry on the part of the learner depends on the way it is presented and the way he actively interacts with the learning experiences presented to him. With the current explosion in scientific knowledge, much demand is placed on both the teachers and learners in the whole process of teaching and learning of science. The job of a teacher is to impart knowledge into the students such that they acquire desirable skills, abilities, knowledge and other competencies, which would help them in their later life. To achieve this, the teacher should be well versed in their teaching subjects and be ready to teach within the level of their students. Onwuakpa and Nweke (2000) in their contribution, advised that science teachers in general and chemistry teachers in particular should give assignments, projects and tests to their students and discuss the results of these with them. This is because knowledge of student's performance in tests and assignments helps to identify their areas of weakness and strength. Bajah (1999) gave the importance of science teacher as follows:

No matter how well our thoughts about science have been developed and documented, no matter how realistic we think our objectives are, the success of our science programmes depends to a great extent on the classroom teacher. It is he in the final analysis, who translates our thoughts into action ... pg. 43 – 49.

Observation has shown that in spite of the various innovations introduced into our science teaching in general and chemistry in particular, the performance of students still remains low. This is buttressed by the poor performance of students in chemistry in the West African Senior School Certificate Examinations [WAEC] (Adejumobi & Ivowi 1992; Adeyegbe 1992; Ezeudu 1995). Friedman (2000) also supported the idea that achievement in science is low and he attributed the reason for this among other things, to the teaching of chemistry by neither teachers with a major nor minor in the subject. Several other reasons have been advanced for the under – achievement in chemistry and other science subjects. Agusiobo (1998) posited that the poor capital investment in terms of provision

of science resources contributed to student's low level of academic performance. Okafor (1996) reported that 5% of the post – primary schools in Lagos State had no laboratory; schools with laboratories were ill equipped with human and material resources. These factors, which are not peculiar to Lagos State alone, are likely to affect student's achievement in chemistry.

Similarly, Ogbonnia (1999) and Onwu (1993) showed that students generally have difficulty in understanding the physical chemistry aspect of the senior secondary school chemistry curriculum and this, perhaps, accounts for their consistent poor achievement in the subject in the senior school certificate examination. The situation has also been blamed on teacher's persistent use of traditional teaching methods, which have been found ineffective in science pedagogy (Nworgu 1997).

Harbor–Peters (1994) in his study on gender interaction on achievement discovered that there was a marked difference between the performance of male and female students. Joseph (1996) and Oke (1995) affirmed that boys performed better than girls in science. However, Tang (1989) found that gender difference is in favour of female pupils. Similarly, Toh's (1993) comparison of performance in three practical problem-solving tasks indicated that girls distinctly preferred contents familiarity and outperformed boys in several processes/ skills when familiar with contents. This result therefore contradicted the general belief that boys performed better than girls in science related disciplines. On the other hand, Lagowski (1994) determined the effect of gender on problem solving abilities in introductory chemistry. The result showed no gender differences in some cognitive items.

The importance of mathematics in the studying and understanding of science has long been recognized worldwide. Salau (2000) points out that there exists an impregnable link between mathematics and other science subjects. The teaching of practical aspect of chemistry can hardly be achieved without the knowledge of mathematics. One of the findings of Daniel as quoted in Osokoya (1999) was that self-ratings of mathematical ability is a significant predictor of achievement in introductory college chemistry. The research finding suggests that there is a set of minimum mathematical skill necessary for passing chemistry.

Also, the studies carried out by Naiz (1993) and Simsek (1993) seemed to lend credence to the efficacy of mathematical ability groupings on learning outcomes. The most important highlight of these studies is that the high ability subjects out – performed their low ability counterparts.

On teacher's gender and achievement, Okoruwa (1999) found that teacher's gender had significant effect on achievement mean scores of pupils in science; male teachers were more effective than their female counterparts. In addition, he found that there was no significant difference in the achievement of pupils taught by teachers of different age group. Bilesanmi (1999) reported that the finding on the effect of gender of science teachers on performance of students outside Nigeria was ambivalent. It was shown that in Chile, England, Federal

Republic of Germany, Japan and Sweden where there was a greater proportion of male teachers of science in schools, the level of performance was higher. On the other hand, the same trend was found in Australia and Italy where there were more female teachers in schools.

On teacher's qualification, Darling – Hammond (2000) found that teacher quality characteristics such as, certification status and degree in subject to be taught are very significant and positively correlated with subject outcomes in science and mathematics.

Ingersoll (1999) found out in a study that 63% chemistry, physics, earth and space science instructors do not have certification in the subjects and this results in the poor performance of students. Greenwald, Hedges and Laine (1996) asserted that achievement positively correlated with teacher's qualification. However, Osokoya (1999), Oladele (1991) and Igwe (1990) found little or no significant relationship between teacher qualification and achievement.

Hansen (1988) posited that teachers who have spent more time studying and teaching are more effective overall and they develop higher order thinking skills for meeting the needs of diverse students and hence increasing their performance. Bilesanmi (1999) in her study found that teacher experience has the second most effective causal effect on students' achievement. Okoruwa (1999) found that teachers' teaching experience had significant effect on students' achievement in science. Also, Fetler (1999) investigated the relationship between measures of teachers' experience and student achievement in science and mathematics. He found that teaching experience as measured by years of service correlated positively with student test results.

THE PROBLEM

The three pivots in a teaching-learning situation are the teacher, student and the learning environment. It is in order to find out the relationships among some of the connected variables and student's achievement that the study construct and test a model for providing a causal explanation of secondary school achievements in chemistry in terms of student variables – gender, study habit, mathematical ability and teacher variables – gender, age, qualification and year of experience.

RESEARCH QUESTIONS

Based on the stated problem, the study attempts to provide answers to the following questions:

1. What is the most meaningful causal model for students' achievement in chemistry?

2. What are the directions as well as estimate of the strengths of the causal path (path coefficients) of the various variables in the model?
3. What are the direct and indirect effects of the independent variables on achievement in chemistry?
4. What are the composite and relative contributions of the seven independent variables ($X_1 - X_7$) to the prediction of students' academic achievement X_8 ?

SIGNIFICANCE OF THE STUDY

The study would throw more light into the causal relationships among the student and teacher related variables under investigation and achievement of students in chemistry. The outcome of the study is therefore expected to assist all stakeholders in the teaching of chemistry particularly at the senior secondary school level, to fashion out appropriate strategies that would enhance the teaching and learning of the subject.

UNDERLYING THEORETICAL FRAMEWORK

The focus of the study is hinged on teacher and student; therefore, theories that have to do with the characteristics of both of them as they affect learning would be applicable. Students are at the center of learning because it is the believe of the authors that teacher cannot control learning, which is the prerogative of the student. He can only control his teaching. This claim supports constructivist's view that learners are actively engaged in making meaning and in the construction of ideas. And this could be said to be affected by variables that have to do with them; these include, gender, study habit and mathematical ability that are considered in the study.

The theories of Piaget [1973], Ausubel [1970] and Gagne [1970] would therefore provide theoretical basis for the study.

METHODOLOGY

An ex – post facto research design was adopted for the study. The population for the study was made up of all senior secondary school year two (SSSII) students and their teachers in Epe and Ibeju – Lekki Local Government Areas of Lagos State. Six and four schools were used in Epe and Ibeju – Lekki local government respectively. The ten sampled schools were the only ones that met the criteria, which were:

1. The school must have covered all the course contents in their scheme from SSS 1 up to the second term of the SSS 2.



2. The male and female chemistry teachers must have taught the students in the senior secondary school one (SSS 1).

The low number of schools was due to the recent mass transfer of teachers within the state. In all, two hundred and one senior secondary school two (SSS 2) chemistry students were used in the selected schools. The teacher sample consisted of all the male and female chemistry teachers from the selected schools. Four sets of instrument were used which were, (i) Personal Data Questionnaire for Teachers (PDQT) (ii) Study Habit Inventory (SHI) (iii) Mathematical Ability Test (MAT), and (iv) Chemistry Achievement Test (CAT).

The PDQT was a seven-item instrument used to seek information on teachers' age, gender, qualification and years of experience in teaching chemistry. The SHI was a 20-item test designed to determine the study habit of chemistry students. The Mathematical Ability Test and the Chemistry Achievement Test were 20 items multiple choice tests with four alternatives, one correct answer and three distractors to sample students' quantitative attitude and level of cognitive achievement respectively. All the instruments were validated and their reliability determined before they were used. The above instruments were used for the collection of the data needed for this study. The administration and collection of all the necessary information were done during the normal class hours. Two statistical procedures were employed to analyse the data. These were the multiple regression analysis and path analysis.

The hypothesized model was initially designed based on the three factors for generating a hypothesized causal model identified by Blalock (1964), Duncan (1966), Bryant and Doran (1977) which were, temporal order, research findings and theoretical grounds. This causal model is presented in Figure 1.

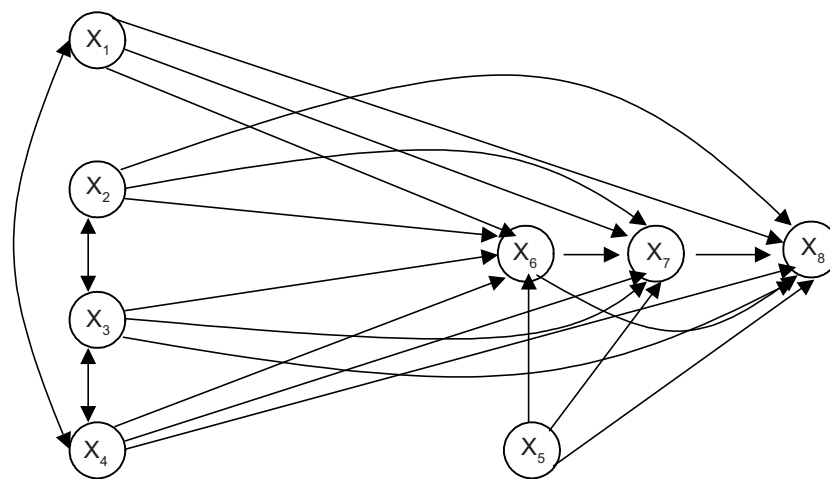
To identify the important paths, the investigators employed the techniques of path analysis theorem (Wolfe 1977) to construct the resultant structural equations. Hence, the effect of the seven-(7) predictor variables ($X_1 - X_7$) on achievement of students in secondary school chemistry (X_8) was predicted using structural equations which are shown below. In all, the investigator came up with a set of three structural equations after exploring all the hypothetical linkages in Figure 1.

$$X_6 = P_1X_1 + P_2X_2 + P_3X_3 + P_4X_4 + P_5X_5 \dots \dots \dots \text{equ. 2.1}$$

$$X_7 = P_1X_1 + P_2X_2 + P_3X_3 + P_4X_4 + P_5X_5 + P_6X_6 \dots \dots \dots \text{equ. 2.2}$$

$$X_8 = P_1X_1 + P_2X_2 + P_3X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 \dots \dots \dots \text{equ. 2.3}$$

Three-regression analysis was run in order to compare the values of the path coefficients (associated beta weights) for the hypothesized causal model.



- KEY**
- X₁ - Teacher's age
 - X₂ - Teacher's gender
 - X₃ - Teacher's qualification
 - X₄ - Teacher's experience
 - X₅ - Student's gender
 - X₆ - Student's study habit
 - X₇ - Student's mathematical ability
 - X₈ - Academic achievement

FIGURE 1. Hypothesized causal model

RESULTS

ANSWERING OF RESEARCH QUESTIONS

RESEARCH QUESTION ONE

What is the most meaningful causal model (involving teacher and student variables) for students' achievement in secondary school chemistry?

R = .329 implies positive multiple correlation among all the seven independent variables and the dependent variable. Adjusted R² of 0.076 implies that 7.60% of

TABLE 1. Composite effect of the independent variables X_i (I=1,2,3 ...7) on the dependent variable (X₈)

R	R ²	Adjusted R ²	Standardized Error of the Estimate
.329	.109	.076	2.5595

the total variation in students' achievement was accounted for by the seven independent variables. The remaining 92.40% was either due to error or factors not considered in the study.

TABLE 2. Path coefficient and their levels of significance

Paths	Standardized Path Coefficient
P ₁₆	0.200 *
P ₁₇	-0.116*
P ₁₈	-0.289 *
P ₂₆	0.249 *
P ₂₇	-0.131 *
P ₂₈	-0.064 *
P ₃₆	-0.164 *
P ₃₇	-0.017
P ₃₈	0.287 *
P ₄₆	0.078 *
P ₄₇	-0.007
P ₄₈	-0.227 *
P ₅₆	0.089 *
P ₅₇	-0.130 *
P ₅₈	-0.043
P ₆₇	0.068 *
P ₆₈	-0.047
P ₇₈	0.001

* Significant at $p < 0.05$ level

From the above table, it is obvious that thirteen from eighteen hypothesized paths are significant at 0.05 level.

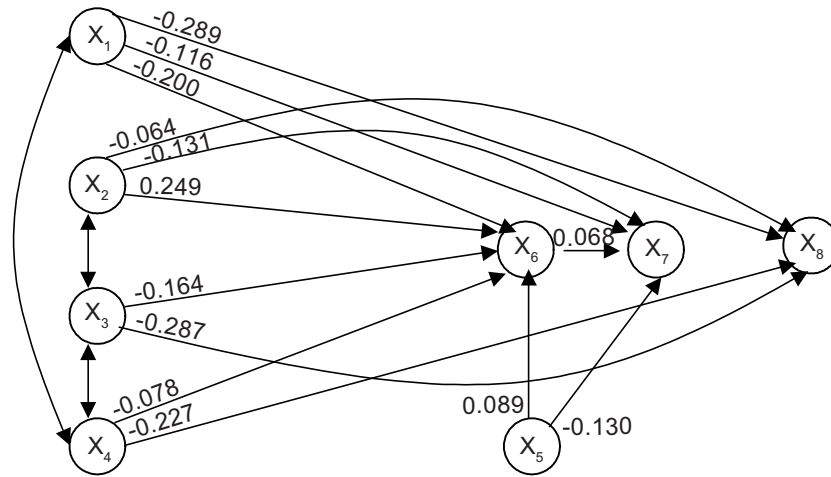
The above figure shows the most meaningful causal model (involving teacher age, gender, qualification and experience, student ability) in predicting students' achievement in chemistry.

RESEARCH QUESTION TWO

What are the direction and estimate of the strength of the causal paths (path coefficients) of the variables in the model?

The direction of causal paths of the variables are the paths which are: (i) significant, (ii) meaningful and (iii) have a link with the criterion variables (X_8). These paths are four and they are all direct as shown in Table 3.

The path coefficients (beta weights of the paths) indicating the estimates of strengths of the causation are shown in Figure 3 as the coefficients from the meaningful causal model.



KEY

- X₁ - Teacher's age
- X₂ - Teacher's gender
- X₃ - Teacher's qualification
- X₄ - Teacher's experience
- X₅ - Student's gender
- X₆ - Student's study habit
- X₇ - Student's mathematical ability
- X₈ - Academic achievement

FIGURE 2. Structural equations

TABLE 3. Significant paths through which X_i (I=1,2,3..7) caused variation in dependent variable X₈ (p<0.05)

	Direct Paths	Indirect Path
R ₁₈	P ₈₁ (- 0. 289)	—
R ₂₈	P ₈₂ (- 0. 064)	—
R ₃₈	P ₈₃ (0. 287)	—
R ₄₈	P ₈₄ (- 0. 227)	—
R ₅₈	—	—
R ₆₈	—	—
R ₇₈	—	—

RESEARCH QUESTION THREE

What are the direct and indirect effects of the variables on achievement in secondary school chemistry?

The significant paths through which the predictors caused variation in students' achievement in chemistry are shown in Table 3. Out of the paths through which all the predictors caused variations in the dependent variable, only four are direct.

RESEARCH QUESTION FOUR

What proportion (%) of the total effects are (i) direct and (ii) indirect?

Table 4 presents the independent variables and their effects (direct and indirect) on the dependent variable (achievement in secondary school chemistry). The table also shows the total effect and the proportion of it that are direct and indirect.

TABLE 4. Proportions of the total effects of the predictors that are direct and indirect

Criterion	Predictor variable 1 - 7	Total effect (a) r		Direct effect (b) p		Indirect effect (a - b)		%
			% (c)		% (d)		% (E)	
Variable 8	1	-0.242	3.76	-0.289	4.40	0.047	-0.72	49.34
	2	0.147	-2.24	-0.064	0.97	0.221	-3.37	-29.40
	3	-0.041	0.62	0.287	-4.37	-0.033	5.00	8.14
	4	-0.235	3.58	-0.227	3.46	-0.008	0.12	46.98
	5	-0.070	1.07	-0.043	0.65	-0.027	0.41	14.04
	6	-0.070	1.07	-0.47	0.65	-0.027	0.41	14.04
	7	0.016	-0.24	0.001	-0.02	0.0515	2.23	3.15
Total		-0.499	7.60	-0.382	5.82	-0.117	1.78	100.00

$$\text{Note: } c = \left(\frac{a}{Ta} \right) \times 7.60\%$$

$$d = \left(\frac{b}{Ta} \right) \times 7.60\%$$

$$E = \left(\frac{a-b}{Ta} \right) \times 7.60\%$$

From table, 5.82% of the total effects are direct while 1.78% are indirect.

DISCUSSION

The eighteen pathways hypothesized in the model shown in Figure 1 were reproduced to thirteen significant pathways in Figure 3. The result showed that 7.60% of the variability in students' achievement in chemistry (X_8) was accounted for by all the seven-predictor variables when taken together. Again, since the magnitude of beta weights was assumed to be directly proportional to the degree of the effects of the influencing variables, it could be seen from table 3 that only four variables i.e. teacher age (X_1), teacher gender (X_2), qualification (X_3) and experience (X_4) have direct causal effect on students' achievement in chemistry (X_8).

Teacher's Age has significant causal effect on students' achievement in chemistry. The direct effect accounted for 4.40%, which is the highest of the total effect of all the seven independent variables, on students' achievement in chemistry. The indirect effect accounted for -0.72% of the total effect. Thus, teacher's age (X_1) accounted for 3.08% of the total effect of students' achievement in chemistry. These findings run contrary to the works of Adeniji (1999) and Okoruwa (1999), who reported that, age of the teacher alone cannot influence academic achievement. Teacher's qualification has the second most potent causal effect on student's achievement in chemistry. Its direct and indirect effect accounted for -4.37%, and 5.00% of the total effect of the seven variables, on the criterion variable respectively. Thus, altogether, teacher's qualification accounted for 0.63% of the total effect of the seven independent variables, on students' achievement in chemistry. This finding is consistent with the findings of Darling – Hammond (2000), Sparks (2000), Osokoya (1999) and Sanders & Rivers (1996) who found separately that, teacher's qualification significantly and positively correlated with student learning outcomes in science. This showed that teacher's qualification is a significant predictor of students' achievement in chemistry. This is because a teacher with higher qualification in a given subject is most likely to ask higher level cognitively based questions; thus helping the students to learn and perform better (Sanders & Rivers 1996). The most meaningful causal model in fig. 3 also supports this viewpoint. However, the finding is contrary to the work of Adeniji (1999), Isonio & Cooperman (1992) and Igwe (1990) who found no significant relationship between teacher's qualification and academic achievement.

Teacher's experience has significant causal effect on students' achievement. The direct and indirect effects accounted for 3.40% and 0.12% of the total effects respectively. Altogether, teacher experience (X_4) accounted for 3.58% of the total effect of the seven independent variables on students' achievement in secondary school chemistry. Teacher's experience was also found to significantly



affect study habit. This finding supports the works of Bilesanmi (1999), Fetler (1999), Osokoya (1999) and Okoruwa (1999) who had independently showed that teacher experience predicts students' academic achievement. The reason for this could be explained in the opinion of Hansen (1988) that teachers who have spent more time studying and teaching are more effective. However, this finding is contrary to the work of Adeniji (1999) who found that teacher's length of teaching and administrative experience were not related to students' achievement in science.

Teacher's gender has direct effect on students' achievement in chemistry. The direct effect accounted for 0.97% of the total effect of all the seven independent variables on student's achievement in chemistry whereas its indirect effect accounted for - 3.37% of the total effect. Altogether, teacher's gender accounted for - 2.40% of the total effect of the seven independent variables on students' achievement in secondary school chemistry. This finding corroborates the works of Okoruwa (1999), Orosan (1992), Reap (1992) and Smith (1992) who found that gender could predict academic achievement. This finding contradicts the works of Adeniji (1999), Onocha (1985) and Miller (1984) who found that gender alone has no effect on academic achievement but could act in conjunction with other variables to affect learning outcomes.

Furthermore, the study revealed that other variables like student gender (X_5), study habit (X_6) and mathematical ability (X_7) had no direct or indirect effect on academic achievement in chemistry. Some scholars found student gender to significantly affect achievement in favour of boys (Joseph 1996; Oke, 1995; Erinosh, 1994; Yoloye, 1994) while some were in favour of girls (Toh 1993; Tang 1989). Others like, Lagowski (1994) and Onocha (1985) did not see any relationship between student gender and academic achievement. The results of this study did not imply that student gender, study habit and mathematical ability do not influence achievement at all but in the presence of important factors like teacher age, qualification, experience and teacher gender, their effects would be so low that they are not likely to be statistically significant.

This study has provided the most meaningful causal model involving seven independent variables and students' achievement in secondary school chemistry. It has also indicated the direction as well as the estimates of the strengths of the causal paths. In all, the results from the study have indicated that the seven-predictor variables when taken together, accounted for 7.60% of the variability in achievement in chemistry. The result further indicated that four out of the seven variables have only direct causal linkages while the remaining three have no direct or indirect linkages.

CONCLUSION

The study revealed that students' achievement was directly affected by four teacher variables. Teachers play an important role in the teaching – learning



process. It is hoped that chemistry teachers will take advantage of this to improve the quality of their chemistry teaching and hence, the achievement of students in chemistry. Similarly, it is expected that government will take note of these important variables and encourage teachers to perform their duties creditably.

RECOMMENDATIONS

Based on the findings, the following recommendations are made:

1. Teacher training programme should emphasize and re – emphasize the teacher variables that could actively affect students' achievement in chemistry.
2. In-service training should be provided for chemistry teachers.
3. Government should continue to motivate teachers to stay on their job.
4. Teachers should be encouraged and motivated to acquire higher qualifications.
5. Government should review the existing criteria for employing chemistry teachers such that those teacher variables that could positively and directly affect students' achievement are considered.
6. Workshops, seminars and conferences should be organized for chemistry teachers to enable them prepare and develop themselves towards improving the achievement of their students.

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