

Teacher Expertise and Secondary School Students' Academic Achievement in Biology in Calabar Municipality Local Government Area, Cross River State, Nigeria

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Abstract

This study examined the extent to which secondary school students' perceptions of their biology teachers' subject content mastery, classroom management skills and communication skills predict students' academic achievement in biology in Calabar Municipality Local Government Area (LGA), Cross River State, Nigeria. A descriptive survey design with a predictive orientation was adopted. The population comprised 5,436 Senior Secondary Two (SS2) Biology students in public secondary schools; a multi-stage sampling technique yielded a sample of 180 students from six schools. Data were collected with the Teacher Expertise Questionnaire (TEQ; 15 items, four-point scale) and a 40-item Biology Achievement Test (BAT), and

were analysed with mean and standard deviation and standard multiple linear regression, with variance inflation factors (VIF) used to assess multicollinearity. Students rated all three dimensions favourably. Jointly, the dimensions significantly predicted achievement, and each made a significant unique contribution: communication skills ($\beta = .40$), subject content mastery ($\beta = .39$) and classroom management skills ($\beta = .25$). Because the design is cross-sectional and non-experimental, the results indicate statistical prediction, not causation. It is recommended, among others, that professional development for biology teachers address all three dimensions and that multilevel and longitudinal studies be undertaken to test these associations further.

Keywords: Teacher Expertise, Subject Content Mastery, Classroom Management, Communication Skills, Biology Achievement

Introduction

Biology holds a central place in the science curriculum of Nigerian secondary schools. It is a foundation for careers in medicine, agriculture, biotechnology and other health-related fields, and a credit pass in the subject is commonly required for admission into science-based tertiary programmes. The quality of instruction that students receive in biology classrooms depends substantially on the expertise that the teacher brings to the classroom.

Teacher expertise is broadly conceived as the set of qualities, knowledge and skills that distinguish highly effective teachers from their less effective colleagues, and it covers both what a teacher knows and how that knowledge is translated into classroom practice (Anderson & Taner, 2023). Within this broad construct, three dimensions are frequently examined in relation to instructional effectiveness: mastery of subject matter, skill in managing the classroom, and clarity of communication with learners. Evidence on how these dimensions relate to achievement is not uniform across settings. Kumo et al. (2025), studying senior secondary schools in North Central Nigeria, reported that pedagogical content knowledge was associated with achievement, whereas classroom management and communication skills showed weaker or inverse associations. Such mixed findings underline the need for context-specific investigation.

In Cross River State, and in Calabar Municipality LGA in particular, concerns about students' performance in biology have persisted despite periodic curriculum reviews, the provision of instructional materials and teacher training interventions. Eno (2022) examined teachers' qualification, teaching experience and attitude in relation to biology achievement in Calabar Municipality. That study did not examine the more instructionally proximate dimensions of teacher expertise (subject content mastery, classroom management and communication skills), which bear more directly on day-to-day classroom practice. Whether these three dimensions are related to students' measured achievement in biology in Calabar Municipality LGA has therefore not been established empirically.

Against this background, it is necessary to investigate how well each dimension, and the three dimensions together, predict students' biology achievement when achievement is measured with a test and not with the same perception items. The findings may be useful to biology teachers, school administrators, curriculum planners and teacher-training institutions in designing targeted in-service programmes, and they add to the literature on teacher expertise and achievement in Nigeria.

Objectives of the Study

The general objective of this study is to determine the extent to which teacher expertise predicts secondary school students' academic achievement in Biology in Calabar Municipality LGA. Specifically, the study seeks to:

- i. determine the extent to which teachers' subject content mastery predicts students' academic achievement in Biology.
- ii. determine the extent to which teachers' classroom management skills predict students' academic achievement in Biology.
- iii. determine the extent to which teachers' communication skills predict students' academic achievement in Biology
- iv. determine the extent to which the three dimensions of teacher expertise jointly predict students' academic achievement in Biology.

Research Questions

In line with these objectives, the study is guided by the following research questions:

- i. To what extent does teachers' subject content mastery predict students' academic achievement in Biology in Calabar Municipality LGA?
- ii. To what extent do teachers' classroom management skills predict students' academic achievement in Biology in Calabar Municipality LGA?
- iii. To what extent do teachers' communication skills predict students' academic achievement in Biology in Calabar Municipality LGA?
- iv. To what extent do the three dimensions of teacher expertise jointly predict students' academic achievement in Biology in Calabar Municipality LGA?

Research Hypotheses

The following null hypotheses were tested at the .05 level of significance:

- i. Teachers' subject content mastery, classroom management skills and communication skills do not jointly predict students' academic achievement in Biology in Calabar Municipality LGA.
- ii. Teachers' subject content mastery does not significantly predict students' academic achievement in Biology when the other two dimensions are held constant.
- iii. Teachers' classroom management skills do not significantly predict students' academic achievement in Biology when the other two dimensions are held constant.
- iv. Teachers' communication skills do not significantly predict students' academic achievement in Biology when the other two dimensions are held constant.

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Literature Review

Conceptual Review

Teacher Expertise

Teacher expertise refers to the qualities, knowledge and skills that distinguish highly effective teachers from their less effective colleagues, and it covers both what a teacher knows and how that knowledge is translated into classroom practice (Anderson & Taner, 2023). In this study it is examined through three dimensions, subject content mastery, classroom management skills and communication skills, as perceived by students.

Subject Content Mastery

A teacher's command of the subject is widely regarded as a foundational component of teacher expertise (Anderson & Taner, 2023). In this study, subject content mastery refers to the teacher's ability to explain difficult concepts clearly, demonstrate accurate knowledge of the topics taught, connect biology concepts to real-life applications, answer students' questions confidently and correctly, and cover the curriculum thoroughly.

Classroom Management Skills

Classroom management refers broadly to the strategies a teacher uses to maintain order, sustain engagement and organise instructional time. In this study it covers maintaining discipline and order, managing lesson time, organising activities that keep students engaged, handling disruptive behaviour promptly and fairly, and creating a conducive learning environment.

Communication Skills

Communication skills concern the clarity and quality of the teacher's verbal and non-verbal exchange with learners, including speaking, listening, attitude, gestures and facial expressions (Obilor, 2020). In this study they cover speaking clearly and audibly, using simple language, listening attentively to students' contributions, using appropriate non-verbal cues, and encouraging questions and class discussion.

Students' Academic Achievement in Biology

In this study, students' academic achievement in biology is the score obtained on a 40-item multiple-choice Biology Achievement Test covering SS2 topics, converted to a percentage. Achievement is therefore measured independently of the perception items used to assess teacher expertise.

Theoretical Review

The study is anchored on Bandura's (1986) Social Cognitive Theory, which holds that learning occurs in a social context and is shaped by the reciprocal interaction of personal, behavioural and environmental factors (reciprocal determinism). A central construct is self-efficacy, the belief in one's capability to organise and carry out the actions required to attain given outcomes. Applied to the classroom, the theory suggests that a teacher's expertise forms part of the social environment from which students draw cues about their own capability to learn the subject. A teacher who explains biology concepts clearly and confidently offers the mastery and vicarious experiences that Bandura identified as sources of self-efficacy. A well-managed classroom may reduce distraction and anxiety, and encouraging communication supplies verbal persuasion, another source of self-efficacy.

On this view, teachers' subject content mastery, classroom management skills and communication skills would be expected to be positively associated with students' achievement. The present study measures these dimensions and achievement only. It does not measure self-efficacy, so the mechanisms proposed by the theory are not tested directly.

Empirical Review

Subject content mastery and students' achievement

In Nigeria, Onipede et al. (2025) investigated teacher pedagogical content knowledge and practical skills competence as determinants of students' biology performance and reported that both were significant determinants. Eno (2022), working in Calabar Municipality, reported that teachers' qualification and teaching experience were associated with students' biology achievement, although qualification is only an indirect indicator of content mastery. Abidoye and Omotayo (2023) reported a significant relationship between biology laboratory practical work and senior secondary students' performance in Ilorin East LGA, Kwara State.

Taken together, these studies point to a positive pattern, but none measured subject content mastery, classroom management and communication skills together in one study.

Classroom management skills and students' achievement

Chinedu and Chinwendu (2020) reported a significant relationship between effective classroom management and biology performance in Anambra West LGA, Anambra State. Ebimiere et al. (2020) linked classroom management practices to academic performance in public secondary schools in Rivers State. Adedigba and Sulaiman (2020) found that teachers' classroom management style significantly predicted both pupils' motivation for learning and academic achievement among primary school pupils in Kwara State. Not all findings point in the same direction: Kumo et al. (2025) reported an inverse relationship between classroom management and achievement in North Central Nigeria. Findings on this dimension may therefore depend on context and measurement.

Communication skills and students' achievement

Obilor (2020) reported that teachers' speaking, listening, attitude, gestures and facial expressions were related to students' academic performance. Adeleke et al. (2021) reported a significant relationship between teachers' communication skills and their classroom effectiveness, and Akudo (2020) linked teachers' effective communication to students' motivation for learning in Anambra State. Kumo et al. (2025) reported a weak and non-significant relationship between communication skills and achievement in their North Central Nigeria sample, so evidence on this dimension is also not uniform.

The reviewed literature links teacher characteristics to students' achievement, but three gaps remain. First, findings on classroom management and communication skills are mixed (Kumo et al., 2025), which suggests that the relationships depend on context and on how the variables are measured. Second, the only study identified in Calabar Municipality (Eno, 2022) examined teacher qualification, experience and attitude and not the instructionally proximate dimensions of expertise. Third, no study identified by the authors has examined subject content mastery, classroom management skills and communication skills together in one regression model as predictors of biology achievement in Calabar Municipality LGA. This study addresses these gaps by measuring the three dimensions with

a single instrument, measuring achievement with a separate test, and modelling the three dimensions jointly in the study area.

Methodology

The study adopted a descriptive survey design with a predictive orientation. This design is appropriate for examining how well teachers' subject content mastery, classroom management skills and communication skills (predictor variables) predict students' academic achievement in biology (criterion variable), without any manipulation of the variables, and it supports the multiple linear regression analysis needed to answer the research questions. The study was conducted in Calabar Municipality Local Government Area (LGA), one of the 18 LGAs of Cross River State, Nigeria. Together with the Calabar South Local Government Area, it forms the city of Calabar, the capital of Cross River State. The LGA had a population of about 180,000 persons according to the 2024 Population and Housing Census (National Population Commission [NPC], 2024). Biology is offered as a core science subject at the senior secondary school level in public secondary schools in the LGA.

The population of the study comprised all 5,436 Senior Secondary Two (SS2) students offering biology in public secondary schools in Calabar Municipality LGA. The enrolment figure was obtained from the official statistical records of the Cross River State Post-Primary Education Board for the 2025/2026 academic session. The population figure represents the total number of SS2 Biology students in the public secondary schools included in the study and was used as the basis for determining the sample size.

The minimum sample size was determined with the Taro Yamane (1967) formula at a 95% confidence level (5% margin of error):

$$n = N / [1 + N(e)^2] = 5,436 / [1 + 5,436(0.05)^2] = 5,436 / 14.59 \approx 373$$

The formula therefore gives a minimum of 373 students. A multi-stage sampling technique was used. At the first stage, six schools were selected by simple random sampling (balloting) from the public secondary schools offering biology in the LGA. At the second stage, 30 SS2 biology students were selected from each school by simple random sampling, giving 180 students. The achieved sample is therefore smaller than the Taro Yamane minimum; solving

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the same formula for e shows that a sample of 180 from a population of 5,436 corresponds to a margin of error of about 7.3% at the 95% confidence level. The sample is adequate for a three-predictor regression by the conventional rule of $n \geq 50 + 8m = 74$ (Tabachnick & Fidell, 2019), but the reduced precision for population-level estimates is acknowledged as a limitation.

Two instruments were used. The Teacher Expertise Questionnaire (TEQ) was researcher-developed and had two sections: Section A collected demographic information, and Section B contained 15 items on a four-point scale (Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1), organised into three five-item subscales measuring teachers' subject content mastery, classroom management skills and communication skills as perceived by students. The items are shown in Tables 3 to 5 and in the Appendix. The Biology Achievement Test (BAT) was a 40-item multiple-choice test covering SS2 Biology topics; scores were converted to percentages.

Face and content validity of both instruments were established by experts in science education and in measurement and evaluation, whose corrections were incorporated. The reliability of the TEQ was estimated in a pilot test with 30 SS2 Biology students outside the study area, using Cronbach's alpha, which gave coefficients of .81 (subject content mastery), .79 (classroom management) and .83 (communication skills). The reliability of the BAT was estimated with the Kuder–Richardson formula 20 (KR-20), which gave .77. All coefficients exceeded the conventional .70 threshold. In the main sample, Cronbach's alpha was .96, .97 and .95 for the three subscales, respectively.

The researcher, assisted by trained research assistants, administered the TEQ and the BAT to the sampled students in their schools with the permission of school authorities. The instruments were administered and retrieved on the same day.

Method of Data Analysis

Data were analysed with descriptive and inferential statistics. Mean and standard deviation were used to describe students' item-level agreement. Multiple linear regression was the only inferential technique used to test prediction. Standard (simultaneous-entry) regression, in which biology achievement was regressed on the three subscale mean scores, answered all four research questions: the partial regression coefficients (B , β) and their t -tests, each holding the other two predictors constant, answered Research Questions 1 to 3 and tested

H_{02} to H_{04} , while the model summary (R , R^2) and the overall F -test answered Research Question 4 and tested H_{01} . A correlation matrix of the variables was inspected only as a preliminary screen of predictor overlap; it was not used to test any hypothesis. Variance inflation factors (VIF) and tolerance were computed to check multicollinearity among the three predictors before the regression coefficients were interpreted ($VIF < 5$ and tolerance $> .20$ were taken as acceptable; Hair et al., 2019). Independence of residuals was checked with the Durbin–Watson statistic, and normality of residuals with the Shapiro–Wilk test. Analyses were performed using IBM SPSS Statistics, Version 26, and the output is supplied as supplementary material (Data Availability).

Decision rule for mean and standard deviation: a mean ≥ 2.50 indicates a positive response (agreement) and a mean < 2.50 a negative response (disagreement); a standard deviation ≤ 1.0 indicates consistent responses, and > 1.0 widely dispersed responses. Decision rule for hypotheses: $p \leq .05$, reject the null hypothesis; $p > .05$, accept the null hypothesis.

Results and Discussion

Data Presentation and Analysis of Results

Table 1: Descriptive Statistics and Reliability of the Study Variables (N = 180)

Variable	M	SD	Min	Max	Cronbach's α
Subject content mastery	3.56	0.53	2.00	4.00	.96
Classroom management skills	3.47	0.58	2.00	4.00	.97
Communication skills	3.62	0.49	2.00	4.00	.95
Biology achievement (%)	58.53	12.38	20.00	90.00	—

Note. Teacher expertise subscales are means on a 1–4 scale; Biology achievement is a percentage score. α = Cronbach's alpha in the main sample.

Table 2: Correlation Matrix of the Study Variables (N = 180)

Variable	1	2	3	4
1. Subject content mastery	1			

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Variable	1	2	3	4
2. Classroom management skills	.20**	1		
3. Communication skills	.27***	.34***	1	
4. Biology achievement (%)	.55***	.46***	.59***	1

Note. Zero-order correlations are shown only as a preliminary screen of predictor overlap and not used to test hypotheses. $p < .01$; $*p < .001$ (two-tailed).

Table 2 is a preliminary screen only. Correlations among the three predictors are low to moderate ($r = .20$ to $.34$), which suggests that they overlap only modestly and that all three can be entered together in the regression model.

Students' ratings of teacher expertise

Tables 3 to 5 present students' item-level ratings of their biology teachers. These descriptive results show how students perceived each dimension; the prediction of achievement is addressed in the regression analysis that follows.

Table 3: Mean Response and Standard Deviation of Subject Content Mastery

Item ("My Biology teacher ...")	Mean	SD
Explains difficult concepts clearly using relevant examples	3.57	0.56
Demonstrates deep and accurate knowledge of topics taught	3.62	0.52
Connects Biology concepts to real-life applications	3.51	0.59
Answers students' questions confidently and correctly	3.54	0.61
Covers the curriculum content thoroughly before examinations	3.58	0.55
Cumulative mean	3.56	0.53

The cumulative mean of 3.56 (SD = 0.53) indicates that students agree that their Biology teachers explain concepts clearly, show accurate knowledge, link Biology to real life, answer questions confidently and cover the curriculum. All standard deviations are below 1.0, indicating consistent responses.

Table 4: Mean Response and Standard Deviation of Classroom Management Skills

Item ("My Biology teacher ...")	Mean	SD
Maintains discipline and order during lessons	3.39	0.68
Manages time effectively during lessons	3.46	0.61
Organises classroom activities that keep students engaged	3.52	0.59
Handles disruptive behaviour promptly and fairly	3.48	0.60
Creates a conducive learning environment	3.48	0.58
Cumulative mean	3.47	0.58

The cumulative mean of 3.47 (SD = 0.58) indicates that students agree that their teachers maintain discipline, manage time, keep students engaged, handle disruptions and create a conducive environment. Classroom management received the lowest of the three subscale ratings, although all standard deviations are below 1.0.

Table 5: Mean Response and Standard Deviation of Communication Skills

Item ("My Biology teacher ...")	Mean	SD
Speaks clearly and audibly during lessons	3.68	0.50
Uses simple language that is easy to understand	3.64	0.52
Listens attentively to students' contributions	3.57	0.57
Uses appropriate non-verbal cues to reinforce teaching	3.56	0.55

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Item ("My Biology teacher ...")	Mean	SD
Encourages questions and class discussions	3.64	0.52
Cumulative mean	3.62	0.49

The cumulative mean of 3.62 (SD = 0.49) indicates strong agreement that teachers communicate clearly, use simple language, listen, use appropriate non-verbal cues and encourage discussion. Communication skills received the highest rating. Because the subscale means are close to the top of the four-point scale, the ratings have a limited range (Section 5.2).

Multiple linear regression analysis

Tables 6 to 9 present the standard multiple linear regression of biology achievement on the three dimensions of teacher expertise.

Table 6: Model Summary

R	R ²	Adjusted R ²	Std. error of estimate	Durbin–Watson
.749	.562	.554	8.26	1.88

The model summary shows a multiple correlation of $R = .749$ for the three dimensions taken together as predictors of Biology achievement. The R^2 of .562 indicates that 56.2% of the variance in achievement is jointly explained by the three dimensions, a large effect by Cohen's (1988) benchmarks ($f^2 = 1.28$).

Table 7: ANOVA

Model	Sum of squares	df	Mean square	F	Sig.
Regression	15,400.06	3	5,133.35	75.15	< .001

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Model	Sum of squares	df	Mean square	F	Sig.
Residual	12,022.30	176	68.31		
Total	27,422.36	179			

Note. Dependent variable: Biology achievement (%). Predictors: (Constant), subject content mastery, classroom management skills, communication skills.

Table 8: Regression Coefficients

Variable	B	Std. error	Std. β	t	Sig.	95% CI for B
(Constant)	-28.78	5.85		-4.92	< .001	[-40.33, -17.24]
Subject content mastery	9.07	1.22	.39	7.44	< .001	[6.67, 11.48]
Classroom management skills	5.32	1.15	.25	4.63	< .001	[3.05, 7.59]
Communication skills	10.09	1.38	.40	7.30	< .001	[7.36, 12.82]

Note. Dependent variable: Biology achievement (%). B = unstandardised coefficient; CI = confidence interval.

Table 9: Multicollinearity Diagnostics (Variance Inflation Factors)

Predictor	Tolerance	VIF
Subject content mastery	.91	1.10
Classroom management skills	.87	1.15
Communication skills	.84	1.19

All VIF values (1.10 to 1.19) fall well below the conventional threshold of 5, and tolerance values (.84 to .91) are well above .20, so multicollinearity among the three predictors is not

a concern. The Durbin–Watson statistic was 1.88, and residuals did not depart significantly from normality (Shapiro–Wilk $W = .993$, $p = .537$). The prediction equation was Achievement = $-28.78 + 9.07$ (subject content mastery) + 5.32 (classroom management) + 10.09 (communication skills). The ANOVA result, $F(3, 176) = 75.15$, $p < .001$, confirms that the three dimensions jointly predict achievement significantly.

Research Question One: To what extent does teachers' subject content mastery predict students' academic achievement in biology in Calabar Municipality LGA?

Table 8 shows that, with the other two dimensions held constant, subject content mastery was a positive and significant predictor of biology achievement ($B = 9.07$, $\beta = .39$, $t(176) = 7.44$, $p < .001$). Each one-point increase in the subject content mastery rating was associated with a predicted increase of about 9.07 percentage points in achievement. It uniquely accounted for 13.8% of the variance in achievement (squared semi-partial correlation = .138).

Research Question Two: To what extent do teachers' classroom management skills predict students' academic achievement in biology in Calabar Municipality LGA?

Table 8 shows that classroom management skills were a positive and significant predictor of biology achievement ($B = 5.32$, $\beta = .25$, $t(176) = 4.63$, $p < .001$), with a predicted increase of about 5.32 percentage points per one-point increase in the rating. They uniquely accounted for 5.3% of the variance in achievement (squared semi-partial correlation = .053).

Research Question Three: To what extent do teachers' communication skills predict students' academic achievement in biology in Calabar Municipality LGA?

Table 8 shows that communication skills were a positive and significant predictor of biology achievement ($B = 10.09$, $\beta = .40$, $t(176) = 7.30$, $p < .001$), with a predicted increase of about 10.09 percentage points per one-point increase in the rating. They uniquely accounted for 13.3% of the variance in achievement (squared semi-partial correlation = .133).

Research Question Four: To what extent do the three dimensions of teacher expertise jointly predict students' academic achievement in biology in Calabar Municipality LGA?

Table 6 shows that the three dimensions jointly explain 56.2% of the variance in biology achievement ($R = .749$, $R^2 = .562$, adjusted $R^2 = .554$), a large effect by Cohen's (1988) benchmarks ($f^2 = 1.28$). Table 7 shows that the model is statistically significant, $F(3, 176) = 75.15$, $p < .001$.

Hypothesis One: Teachers' subject content mastery, classroom management skills and communication skills do not jointly predict students' academic achievement in Biology in Calabar Municipality LGA.

Table 7 shows that the model is significant, $F(3, 176) = 75.15$, $p < .001$, with $R^2 = .562$. The null hypothesis is rejected: the three dimensions of teacher expertise jointly predict students' academic achievement in biology.

Hypothesis Two: Teachers' subject content mastery does not significantly predict students' academic achievement in biology when the other two dimensions are held constant.

Table 8 shows a positive and significant unique effect of subject content mastery on achievement ($B = 9.07$, $\beta = .39$, $t(176) = 7.44$, $p < .001$), with a squared semi-partial correlation of .138 (13.8% of the variance). The null hypothesis is rejected.

Hypothesis Three: Teachers' classroom management skills do not significantly predict students' academic achievement in biology when the other two dimensions are held constant.

Table 8 shows a positive and significant unique effect of classroom management skills on achievement ($B = 5.32$, $\beta = .25$, $t(176) = 4.63$, $p < .001$), with a squared semi-partial correlation of .053 (5.3% of the variance). The null hypothesis is rejected.

Hypothesis Four: Teachers' communication skills do not significantly predict students' academic achievement in biology when the other two dimensions are held constant.

Table 8 shows a positive and significant unique effect of communication skills on achievement ($B = 10.09$, $\beta = .40$, $t(176) = 7.30$, $p < .001$), with a squared semi-partial correlation of .133 (13.3% of the variance). The null hypothesis is rejected.

Discussion

Objective one sought to determine the extent to which teachers' subject content mastery predicts students' biology achievement. The finding shows that subject content mastery was a significant positive predictor ($\beta = .39$) when the other two dimensions were controlled. This is consistent with Onipede et al. (2025), who reported pedagogical content knowledge as a significant determinant of biology performance, and with Eno (2022), who reported that teacher qualification and experience were associated with biology achievement in Calabar Municipality.

Objective two sought to determine the extent to which classroom management skills predict achievement. Classroom management skills were a significant positive predictor ($\beta = .25$), consistent with Chinedu and Chinwendu (2020), Ebimiere et al. (2020) and Adedigba and Sulaiman (2020). This differs from the inverse relationship reported by Kumo et al. (2025); possible reasons include differences in subject, instruments, school context and analytic approach, but this study cannot test them.

Objective three sought to determine the extent to which communication skills predict achievement. Communication skills were a significant positive predictor ($\beta = .40$), consistent with Obilor (2020) and with Adeleke et al. (2021) and Akudo (2020), whose studies concerned teacher effectiveness and student motivation, respectively. This differs from the non-significant relationship reported by Kumo et al. (2025).

Objective four sought to determine how well the three dimensions jointly predict achievement. Together they accounted for more than half of the variance in biology achievement ($R^2 = .56$), and each retained a significant unique contribution when the other two were controlled. This pattern is in the direction expected from Social Cognitive Theory. It cannot, however, show that teacher expertise produces higher achievement, because the study did not measure self-efficacy and did not manipulate or track teacher expertise over time. Communication skills ($\beta = .40$) and subject content mastery ($\beta = .39$) had similar standardised weights, and both were larger than that of classroom management ($\beta = .25$). The difference between the first two was not tested formally and is small relative to the confidence intervals in Table 8, so the study does not support a firm ranking of those two. It does suggest that classroom management made a smaller unique contribution than the other two dimensions.

Conclusion

Teachers' subject content mastery, classroom management skills and communication skills, as perceived by students, jointly and individually predicted secondary school students' academic achievement in biology in Calabar Municipality LGA and together were associated with about 56% of its variance. Communication skills and subject content mastery showed the largest standardised coefficients, followed by classroom management skills. These conclusions concern statistical prediction in a cross-sectional sample and should be read together with the limitations below.

Limitations of the Study

Several limitations should be considered when interpreting the findings.

- i. **Design and causal inference:** The design is cross-sectional and non-experimental. The results show statistical prediction only; they cannot show that teacher expertise causes differences in achievement. Reverse and third-variable explanations remain possible; for example, students who already achieve highly may rate their teachers more favourably.
- ii. **Measurement:** Teacher expertise was measured through students' perceptions and not through direct observation, teacher self-report or objective content tests. Student ratings may be affected by halo effects and by students' own performance. Ratings were also clustered near the top of the four-point scale (means 3.47–3.62), which restricts variance and may attenuate or distort the coefficients.
- iii. **Instruments:** The TEQ and BAT were researcher-developed. Validity rested on expert judgement, and no factor-analytic evidence is reported. The BAT reliability ($KR-20 = .77$) is acceptable but modest, and the very high main-sample alpha values for the five-item subscales (.95 to .97) suggest that some items may be redundant.
- iv. **Sample size:** The sample of 180 students is smaller than the minimum of 373 given by the Taro Yamane formula for a population of 5,436 at a 5% margin of error; the achieved margin of error is about 7.3%. Estimates should therefore be regarded as less precise than the nominal 5% level implies.

- v. **Non-independence of observations:** Students were nested in six schools (30 per school), and students in the same school were likely rating the same teacher(s). Ordinary least squares regression assumes independent observations, so standard errors may be understated and p-values too small. A multilevel model was not fitted because the number of schools (six) is too small for stable estimation.
- vi. **Omitted variables:** Prior achievement, students' socio-economic background, gender, class size, school resources, and teacher qualification and experience were not controlled, so part of the reported associations may reflect these factors.
- vii. **Generalisability:** The sample came from six public schools in one LGA and a single class level (SS2). The findings may not generalise to private schools, other LGAs, other subjects or other class levels.

Recommendations

Based on the findings, the following recommendations are made:

- i. School authorities should organise regular subject-specific in-service training to strengthen biology teachers' command of curriculum content.
- ii. Continuing professional development for biology teachers should give deliberate attention to verbal and non-verbal communication skills.
- iii. Teacher-training institutions should strengthen the classroom management component of pre-service biology teacher education.
- iv. Supervisory and quality-assurance visits should include an assessment of these three dimensions, with feedback used to guide targeted support.
- v. Future studies should use multilevel designs with more schools and LGAs, add classroom observation and teacher-level measures of content knowledge, include prior achievement as a covariate, and use longitudinal or quasi-experimental designs to test whether improving teacher expertise is followed by gains in achievement.

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Appendix

Appendix 1: Teacher Expertise Questionnaire (TEQ), Section B

Instruction: Please indicate your level of agreement or disagreement with each statement about your Biology teacher (SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree).

S/N	ITEMS	SA	A	D	SD
	My Biology teacher ...				
1	Explains difficult concepts clearly using relevant examples				
2	Demonstrates deep and accurate knowledge of topics taught				
3	Connects Biology concepts to real-life applications				
4	Answers students' questions confidently and correctly				
5	Covers the curriculum content thoroughly before examinations				
	Classroom management skills				
6	Maintains discipline and order during lessons				
7	Manages time effectively during lessons				
8	Organises classroom activities that keep students engaged				
9	Handles disruptive behaviour promptly and fairly				
10	Creates a conducive learning environment				
	Communication skills				
11	Speaks clearly and audibly during lessons				
12	Uses simple language that is easy to understand				
13	Listens attentively to students' contributions				
14	Uses appropriate non-verbal cues to reinforce teaching				
15	Encourages questions and class discussions				

Appendix 2: Statistical Output Tables: Teacher Expertise and Biology Achievement (N = 180)

1. Reliability Statistics (main sample)

Scale	Items	Cronbach's alpha
Subject content mastery	5	.96
Classroom management skills	5	.97
Communication skills	5	.95

Pilot-test values (n = 30): .81, .79, .83; BAT KR-20 = .77.

2. Descriptive Statistics

Variable	N	Mean	Std. deviation	Minimum	Maximum
Subject content mastery	180	3.56	0.53	2.00	4.00
Classroom management skills	180	3.47	0.58	2.00	4.00
Communication skills	180	3.62	0.49	2.00	4.00
Biology achievement (%)	180	58.53	12.38	20.00	90.00

3. Item Statistics

Item ("My Biology teacher ...")	Mean	Std. deviation
SCM1 Explains difficult concepts clearly using relevant examples	3.57	0.56
SCM2 Demonstrates deep and accurate knowledge of topics taught	3.62	0.52
SCM3 Connects Biology concepts to real-life applications	3.51	0.59

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Item ("My Biology teacher ...")	Mean	Std. deviation
SCM4 Answers students' questions confidently and correctly	3.54	0.61
SCM5 Covers the curriculum content thoroughly before examinations	3.58	0.55
CMS1 Maintains discipline and order during lessons	3.39	0.68
CMS2 Manages time effectively during lessons	3.46	0.61
CMS3 Organises classroom activities that keep students engaged	3.52	0.59
CMS4 Handles disruptive behaviour promptly and fairly	3.48	0.60
CMS5 Creates a conducive learning environment	3.48	0.58
COM1 Speaks clearly and audibly during lessons	3.68	0.50
COM2 Uses simple language that is easy to understand	3.64	0.52
COM3 Listens attentively to students' contributions	3.57	0.57
COM4 Uses appropriate non-verbal cues to reinforce teaching	3.56	0.55
COM5 Encourages questions and class discussions	3.64	0.52

4. Correlations (preliminary screen only; two-tailed)

Variable	1	2	3	4
1. Subject content mastery	1			
2. Classroom management skills	.20**	1		
3. Communication skills	.27***	.34***	1	
4. Biology achievement (%)	.55***	.46***	.59***	1

** $p < .01$; *** $p < .001$. $N = 180$.

5. Regression: Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
.749	.562	.554	8.26	1.88

Predictors: (Constant), Communication skills, Classroom management skills, Subject content mastery. Dependent variable: Biology achievement (%).

6. Regression: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	15,400.06	3	5,133.35	75.15	< .001
Residual	12,022.30	176	68.31		
Total	27,422.36	179			

7. Regression: Coefficients

Model	B	Std. Error	Beta	t	Sig.	95% CI Lower	95% CI Upper
(Constant)	-28.78	5.85		-4.92	< .001	-40.33	-17.24
Subject content mastery	9.07	1.22	.39	7.44	< .001	6.67	11.48
Classroom management skills	5.32	1.15	.25	4.63	< .001	3.05	7.59
Communication skills	10.09	1.38	.40	7.30	< .001	7.36	12.82

Squared semi-partial correlations (unique variance): subject content mastery .138; classroom management .053; communication .133.

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8. Collinearity Statistics

Predictor	Tolerance	VIF
Subject content mastery	.91	1.10
Classroom management skills	.87	1.15
Communication skills	.84	1.19

9. Residual Diagnostics

Test	Statistic	Sig.
Durbin-Watson	1.88	
Shapiro-Wilk (standardised residuals)	W = .993	p = .537

10. Taro Yamane Sample-Size Check

Quantity	Value	Note
Population (N)	5,436	[NPC], 2024.
Required n at e = 0.05	373	$5,436 / [1 + 5,436(0.05)^2]$
Achieved n	180	6 schools x 30 students
Achieved margin of error	about 7.3%	$\sqrt{(N - n) / (N \times n)}$