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A Multi-Factorial Model of Mathematics Performance among Low-Achieving Pre-Service Teachers in Nigeria: The Role of Anxiety, Methodology, Attitude, Parental Involvement, and Resources

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ABSTRACT

Low-achieving students constitute approximately 40-45% of mathematics enrollees in Nigerian Colleges of Education, yet multi-factorial determinants of their performance remain under-examined. This study investigated the combined and individual predictive power of mathematics anxiety, teaching methodology, student attitude, parental involvement, and learning resource availability on mathematics performance among low-achieving pre-service teachers. A descriptive survey design employed stratified random sampling across four Colleges of Education in Oyo-State, Nigeria. Validated 60-item questionnaire (Cronbach's $\alpha = 0.87$) and institutional academic records were analyzed using Pearson correlation, multiple regression, and ANOVA. The five variables collectively explained 67.8% of performance variance ($R^2 = 0.678$, $F(5,362) = 158.43$, $p < 0.001$). Mathematics anxiety emerged as the strongest negative associate ($\beta = -0.456$, $p < 0.001$), followed by teaching methodology as the strongest positive associate ($\beta = 0.389$, $p < 0.001$). Female students exhibited moderately higher mathematics anxiety (Cohen's $d = 0.62$) and slightly lower performance ($d = 0.33$) than males. Targeted interventions addressing mathematics anxiety and teaching methodologies may yield the largest performance gains for this population. Findings suggest Colleges of Education should prioritize anxiety-reduction programs combined with evidence-based pedagogical approaches.

Keywords: Mathematics Anxiety; Teaching Methodology; Multi-Factorial Model; ANOVA, Students Low-Achieving Pre-Service Teachers; Nigeria

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1. INTRODUCTION

Mathematics remains a critical gateway subject in tertiary education worldwide, determining access to numerous academic and professional opportunities (Mensah et al., 2023). In Nigeria's educational system, mathematics is compulsory at all levels, including Colleges of Education where future primary and secondary school teachers receive pre-service preparation (Adegoke & Chike-Okoli, 2021). Despite its importance, persistent poor mathematics performance among low-achieving students threatens educational quality and national development (Ogunkunle & George, 2022). Low-achieving students defined as those consistently scoring below 50% in mathematics assessments or maintaining a cumulative grade point average (CGPA) below 2.50 on a 5-point scale represent a substantial proportion of enrollees in Nigerian Colleges of Education. The National Commission for Colleges of Education (NCCE, 2022) reports that approximately 40-45% of mathematics students in Colleges of Education fall into this category, with some institutions reporting even higher percentages. This pattern is problematic because these students are preparing to become mathematics teachers, potentially perpetuating intergenerational cycles of poor mathematical competence (Adeleke & Ogunlade, 2023; Aluko et al., 2022). The persistent underperformance in mathematics among College of Education students carries far-reaching implications for Nigeria's educational system and economic development. Consequently, understanding the determinants of mathematics performance among low-achieving students in Colleges of Education is essential for developing targeted interventions and disrupting the cycle of mathematical incompetence.

In spite of substantial research on factors affecting mathematics performance, several gaps justify the current study. First, most studies examine these factors in isolation rather than investigating their combined effects, interactions, and relative importance (Adeleke & Ogunlade, 2023). Second, research specifically focused on low-achieving students in Nigerian Colleges of Education remains limited, with most studies concentrating on secondary schools or universities (Ogunkunle & George, 2022). Third, insufficient recent research examines these determinants in post-COVID educational contexts where delivery modes and student experiences have fundamentally shifted (Olasehinde & Olatoye, 2022). Fourth, research examining these factors within Oyo State with its concentration of multiple Colleges of Education and associated resources is particularly scarce. This study addresses these gaps by comprehensively examining five theoretically grounded determinants of mathematics performance among low-achieving pre-service teachers in Colleges of Education in Oyo State, Nigeria using contemporary data.

1.1 Empirical Justification For The Study

Mathematics anxiety, feelings of tension and worry when solving mathematical problems, is a significant impediment to achievement, especially among students with learning difficulties (Dowker et al., 2020). A meta-analysis by Zhang et al. (2019) of 187 studies (906,000+ participants) found a consistent negative correlation between mathematics anxiety and performance across cultures and educational levels. In Nigeria, Ayotola and Adedeji (2020) found high anxiety strongly associated with poor performance among 450 secondary students in Ogun State, with females showing higher anxiety. Similarly, Ogunkunle and George (2022) reported that anxiety significantly predicted poor performance among 320 College of Education students in Ekiti State, accounting for 23% of variance.

Neurological fMRI research (Ramirez et al., 2023) shows anxiety activates pain- and threat-detection brain regions rather than numerical processing, explaining why anxious students avoid mathematics. This creates a vicious cycle: avoidance prevents practice, increasing anxiety. However, Barroso et al. (2021) found that working memory capacity partially mediates this relationship, suggesting interventions targeting both anxiety and working memory may be most effective. Teaching methodology is a modifiable factor. Chukwudi and Eze (2023) found problem-based learning significantly improved performance for low-achieving Nigerian College students compared to conventional methods. Hattie's (2009, updated 2023) synthesis of 1,400+ meta-analyses identified effective teaching as among the highest-impact factors. Effective teaching for struggling students requires explicit instruction, immediate feedback, multiple representations, and differentiation. However, Adeleke and Ogunlade (2023) cautioned that poor technology implementation can impede learning if lecturers lack technological pedagogical knowledge or infrastructure is unreliable.

Attitude toward mathematics (beliefs, feelings, behavioral intentions) significantly influences outcomes. Oppermann et al. (2021) tracked 1,890 students over four years and found positive attitudes predicted subsequent achievement after controlling for prior achievement. In Nigeria, Bassey et al. (2021) surveyed 520 College students across three states and found that students with positive attitudes scored 18.5 percentage points higher than those with negative attitudes. Chen et al. (2023) used cross-lagged panel analysis with 5,432 students and found bidirectional effects: attitudes predict achievement, and achievement predicts attitudes, suggesting positive spirals of improvement.

Parental involvement varies across educational levels and cultural contexts. Oladipo et al. (2023) studied 420 College students in Lagos State and found that home-based involvement and academic socialization (discussing mathematics value) significantly predicted performance, while school-based involvement (meetings, volunteering) showed no effect as students mature. Park and Holloway (2017) studied 3,200 students and found involvement quality mattered more than quantity: parental confidence and encouragement outperformed pressure or criticism.

Learning resource availability significantly influences achievement. Olanrewaju and Ajayi (2021) surveyed 32 Nigerian Colleges of Education and found only 34% had adequate mathematics libraries, 28% had functional computer laboratories, and 23% had sufficient manipulative deficits correlating with poorer performance. Akinsola and Odeyemi (2021) found that low-achieving students with access to geometric manipulative showed significant improvement compared to abstract-only instruction. However, PISA 2022 results (OECD, 2023) indicate diminishing returns beyond basic adequacy. Wilmot et al. (2021) found that teacher capacity to integrate resources often mattered more than resource abundance.

Low-achieving students constitute a heterogeneous group. Geary and vanMarle (2018) identified common characteristics: weak number sense, difficulty with reasoning, over-reliance on procedures without conceptual understanding, limited working memory, and accumulated knowledge gaps. These students benefit from intensive, targeted instruction addressing deficiencies while building confidence (Fuchs et al., 2021). In Nigerian Colleges, Adegoke and Chike-Okoli (2021) identified additional challenges: poor secondary preparation, weak study habits, limited academic support, and psychological barriers (learned helplessness, fixed mindsets).

Their study of 280 low-achieving students found that comprehensive support programs (academic tutoring, study skills, counseling, and peer mentoring) produced significantly better outcomes than single-focus interventions

1.2 Critical Synthesis of Contradictory and Mixed Findings

While prior sections highlight studies supporting each predictor, a systematic review reveals contradictory findings, boundary conditions, and methodological disagreements. Despite the generally accepted negative correlation between mathematics anxiety and performance (Zhang et al., 2019), Devine et al. (2018) studied 1,800 university students and found that mathematics anxiety did not significantly predict performance after controlling for prior attainment and general anxiety, suggesting anxiety's effects may be moderated by prior competence, directly relevant to the current study's focus on low-achieving students.

Despite consensus that student-centered methodologies outperform traditional lectures (Hattie, 2023), Andrews et al. (2021) conducted a large-scale RCT comparing lecture, flipped classroom, and problem-based learning in undergraduate mathematics. After 16 weeks, no significant differences in final exam scores emerged, leading the authors to conclude that implementation quality and instructor effects may matter more than methodology label, qualifying the current study's emphasis on "teaching methodology" as a unitary construct.

The attitude-achievement relationship is also contested. Gunderson et al. (2018) conducted a four-year longitudinal study with 1,200 students and found that, after controlling for prior achievement, SES, and academic self-concept, the attitude-achievement correlation became non-significant, suggesting it may be spurious. Finally, the assumption that parental involvement is uniformly beneficial has been challenged at higher educational levels. The OECD (2023) reported that after controlling for school socioeconomic composition, physical resources (textbooks, computers, labs) explained less than 3% of additional variance in mathematics performance across OECD countries, with many countries showing non-significant effects.

1.3 Theoretical Implications of Contradictory Findings

The contradictory evidence above has three implications for the current study's theoretical framework. First, the Affective Filter Hypothesis (Krashen, 1982, adapted) assumes anxiety causes impaired performance. However, longitudinal evidence (Carey et al., 2019) raises reverse causality or bidirectionality. The current cross-sectional design cannot adjudicate this, but the large anxiety-performance association ($\beta = -0.456$) fits both directions. Second, Constructivist Learning Theory (Piaget, 1952) assumes active knowledge construction is universally beneficial. Yet meta-analytic evidence (Kirschner et al., 2020) suggests low-achieving students with significant gaps may need more explicit, teacher-directed instruction before fully constructivist activities. Thus, a scaffolded progression is recommended: explicit instruction → guided practice → structured constructivist exploration → independent problem-solving. Third, Social Cognitive Theory (Bandura, 1986) posits reciprocal relationships among personal, behavioral, and environmental factors. Contradictory findings on parental involvement at college level (Wilder, 2020) suggest this environmental factor may diminish with maturity.

Several gaps justify the current study. First, most studies examine these factors in isolation rather than their combined effects and relative importance (Adeleke & Ogunlade, 2023). Second, research focused on low-achieving students in Nigerian Colleges of Education remains limited, with most studies concentrating on secondary schools or universities (Ogunkunle & George, 2022). Third, research within Oyo State, with its concentration of multiple Colleges of Education, is particularly scarce. This study addresses these gaps by comprehensively examining five theoretically grounded determinants of mathematics performance among low-achieving pre-service teachers in Colleges of Education in Oyo State, Nigeria using contemporary data.

1.4 Theoretical Framework

This study integrates three complementary frameworks addressing cognitive, affective, and social dimensions of math learning: Social Cognitive Theory (Bandura, 1986), Constructivist Learning Theory (Piaget, 1952), and the Affective Filter Hypothesis (Krashen, 1982), adapted to math education (Ayotola & Adedeji, 2020; Ramirez et al., 2023). Social Cognitive Theory (Bandura, 1986) emphasizes reciprocal interactions among personal, behavioral, and environmental factors, with self-efficacy as central. In math, low-achieving students often develop low self-efficacy from repeated failure, creating a self-fulfilling prophecy of avoidance and poor performance (Ogunkunle & George, 2022). However, this Western-origin theory may not fully apply to Nigeria's collectivist settings.

Constructivist Learning Theory (Piaget, 1952) posits that learners actively build knowledge via assimilation and accommodation. Low-achieving students benefit from hands-on, problem-solving approaches (Chukwudi & Eze, 2023). Yet in Nigerian Colleges of Education, implementation is challenging due to large classes (ratios exceeding 1:100) and limited resources. Affective Filter Hypothesis (Krashen, 1982) holds that anxiety, motivation, and self-concept filter math cognition. A high filter—marked by anxiety or low motivation—diverts cognitive resources to threat monitoring, blocking learning. Neuroimaging confirms math anxiety activates pain/threat regions (insula, amygdala) and deactivates numerical processing areas (intraparietal sulcus) (Pizzie & Kraemer, 2021).

1.5 Integration of Theoretical Frameworks

These three theories complement each other by addressing different aspects of mathematics learning. Constructivist theory explains *how* effective learning occurs (through active construction), Social Cognitive Theory explains *what* influences learning (personal, behavioral, and environmental factors), and Affective Filter Hypothesis explains *when* learning is blocked (when negative emotions create barriers). Together, they predict that mathematics performance among low-achieving students will be enhanced when: (1) teaching methodologies facilitate active knowledge construction with appropriate scaffolding (Constructivist theory), (2) students develop positive self-efficacy through mastery experiences and supportive environments (Social Cognitive Theory), and (3) affective barriers such as anxiety are minimized (Affective Filter Hypothesis). Figure 1 illustrates how these theories integrate to form the conceptual framework for this study.

1.6 Conceptual Framework

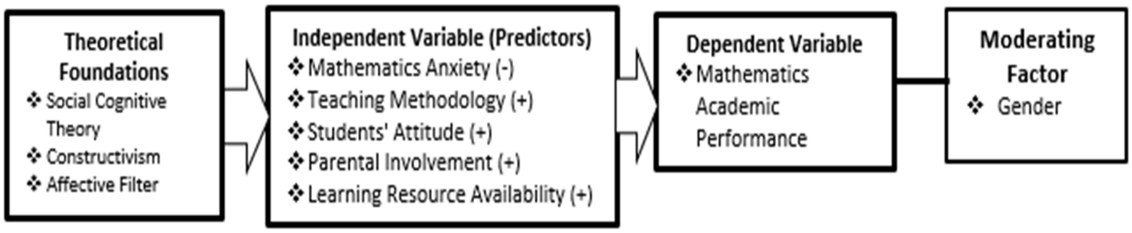

Figure 1: Integrated Conceptual Framework Showing Relationships Among Study Variables.
Source: Researcher

The conceptual framework illustrates relationships between five independent variables and mathematics academic performance among low-achieving students in Colleges of Education. Mathematics anxiety, positioned as a primary predictor based on meta-analytic evidence showing it has the largest average effect size among affective factors (Zhang et al., 2019), represents the emotional and cognitive tension experienced when engaging with mathematical tasks. High anxiety creates barriers that interfere with mathematical thinking and problem-solving by consuming working memory resources needed for computation and reasoning.

1.7 Statement of the Problem

Despite numerous educational reforms, mathematics performance in Nigerian Colleges of Education remains persistently poor, with low-achieving students representing 40-45% of enrollees (NCCE, 2022). Previous studies have examined individual determinants of mathematics performance mathematics anxiety (Ogunkunle & George, 2022), teaching methodology (Aluko et al., 2022), student attitudes (Bassey et al., 2021), parental involvement (Oladipo et al., 2023), and learning resources (Olanrewaju & Ajayi, 2021) in isolation. However, independent variables rarely operate in isolation; they correlate, interact, and may suppress or amplify one another's effects. For example, poor teaching methodology may exacerbate mathematics anxiety, while adequate resources may buffer against negative attitudes. No known published study has simultaneously examined all five factors among low-achieving pre-service teachers in Oyo-State, Nigerian Colleges of Education, leaving unclear their relative importance for intervention prioritization and their combined explanatory power beyond single-factor models. This study addresses these gaps by testing an integrated multi-factorial predictive model.

1.8 Objectives of the Study

The specific objectives were to examine the following theoretically grounded predictors:

1. Mathematics anxiety (Affective Filter Hypothesis) as a negative predictor of performance
2. Teaching methodology (Constructivist Learning Theory) as a positive predictor
3. Students' attitude toward mathematics (Social Cognitive Theory) as a positive predictor
4. Parental involvement (Social Cognitive Theory-environmental factor) as a positive predictor
5. Learning resource availability (Constructivist Learning Theory- environmental enabler) as a positive predictor

6. Determine the combined predictive power of all five variables on mathematics academic performance

These variables were selected based on their prominence in established theoretical frameworks (Social Cognitive Theory, Constructivist Learning Theory, and Affective Filter Hypothesis) and empirical evidence from both Nigerian and international educational contexts demonstrating their relevance to mathematics achievement.

1.9 Research Questions

The following research questions guided the study.

1. What is the influence of mathematics anxiety on academic performance among low-achieving mathematics students?
2. How does teaching methodology relate to mathematics performance among low-achieving students?
3. What effect does student attitude toward mathematics have on their academic performance?
4. To what extent does parental involvement influence mathematics academic performance among low-achieving students?
5. How does the availability of learning resources contribute to mathematics performance?
6. What is the combined predictive power of these variables on mathematics academic performance?

1.10 Research Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

H_{01}: Mathematics anxiety does not significantly predict academic performance among low-achieving students.

H_{02}: Teaching methodology does not significantly predict mathematics performance among low-achieving students.

H_{03}: Students' attitude toward mathematics does not significantly influence their academic performance.

H_{04}: Parental involvement does not significantly predict mathematics academic performance among low- achieving students.

H_{05}: Availability of learning resources does not significantly contribute to mathematics performance among low achievers.

H_{06}: The independent variables collectively do not significantly predict mathematics academic performance among low-achieving students.

2. METHODOLOGY

2.1 Research Design

This study employed a cross-sectional predictive correlational research design, appropriate for examining relationships between variables and making predictions about a population based on sample data without manipulating variables or establishing causation (Creswell & Creswell, 2023). A descriptive survey design was selected because the study aimed to describe existing relationships and predict outcomes in natural educational settings rather than manipulate variables through experimental interventions. This design allowed collection of quantitative data on multiple predictors and their relationships with mathematics performance through systematic sampling and standardized measurement.

2.2 Population of the Study

The target population comprised all low-achieving mathematics students in Colleges of Education under study within Oyo State, Nigeria. According to institutional records obtained in September 2023, the population consisted of 1,247 low-achieving mathematics students (defined as students with CGPA below 2.50 on a 5-point scale or consistently scoring below 50% in mathematics courses) across four institutions: Federal College of Education (Special), Oyo (378 students), Emmanuel Alayande College of Education, Oyo (689 students), and Oyo State College of Education, Lanlate (180 students).

2.3 Sample and Sampling Technique

Stratified random sampling with proportional allocation was used. The population was first stratified by institution, then by year level (NCE I, II, III) within each institution. Within each stratum, student registration numbers were sorted in ascending order, and a simple random sample was drawn using a random number generator (Research Randomizer, version 4.0). Sample size was determined using Krejcie and Morgan's (1970) table (N = 297 for population of 1,247 at 95% confidence). To account for anticipated 20% non-response and ensure adequate power for multiple regression with five predictors (minimum N = 138 for medium effects at $\alpha = 0.05$, $\beta = 0.80$; Green, 1991), the target sample was inflated to 384. Final sample distribution was: Federal College of Education (Special), Oyo (117 students, 30.5%), Emmanuel Alayande College of Education, Oyo (211 students, 55.0%), and Oyo State College of Education, Lanlate (56 students, 14.6%).

2.4 Instrumentation

Data were collected using a researcher-designed instrument titled "Mathematics Performance Determinants Questionnaire (MPDQ)" alongside institutional academic performance records. The MPDQ consisted of two sections: Section A gathered demographic information: institution, year of study, gender, age, and previous mathematics performance records. Section B contained 60 items measuring five independent variables (12 items per variable) structured on a 4-point Likert scale: Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1). A 4-point scale was used to avoid neutral midpoint bias, which is common in educational research where respondents, particularly low-achieving students, may gravitate toward ambivalent middle responses. The forced-choice format encourages more decisive, meaningful responses.

The five scales measured:

1. Mathematics Anxiety Scale (MAS): Adapted from the Abbreviated Math Anxiety Scale (AMAS) by Hopko et al. (2003) and contextualized for Nigerian College settings. Sample item: "I feel nervous when solving mathematics problems."
2. Teaching Methodology Scale (TMS): Developed to assess students' perceptions of instructional approaches. Sample item: "My lecturers use varied teaching methods that help me understand mathematics."

3. **Students' Attitude Toward Mathematics Scale (SATMS):** Adapted from Tapia and Marsh's (2004) Attitudes Toward Mathematics Inventory. Sample item: "I believe mathematics is useful for my future career."
4. **Parental Involvement Scale (PIS):** Based on Epstein's (2018) framework. Sample item: "My parents regularly discuss my mathematics progress with me."
5. **Learning Resource Availability Scale (LRAS):** Developed to assess resource accessibility. Sample item: "My institution provides adequate mathematics textbooks and reference materials."

The dependent variable (mathematics academic performance) was measured using students' cumulative grade point average (CGPA) in mathematics courses and scores in the most recent mathematics examination, obtained from institutional records with appropriate authorization. Using institutional records rather than self-reported grades enhances objectivity and reduces common method bias.

2.5 Validity of the Instrument

Content and face validity were established through expert review. The initial draft was submitted to five experts: three mathematics education specialists, one measurement and evaluation expert, and one experienced mathematics lecturer from a College of Education not included in the study. Based on their feedback, 8 items were reworded for clarity, 3 items were removed due to redundancy, and 5 new items were added to improve construct coverage. The final instrument incorporated all agreed-upon modifications. Construct validity was assessed using confirmatory factor analysis (CFA) conducted with AMOS 26.0 on pilot data (N = 50).

The pilot sample (N = 50) used for confirmatory factor analysis falls below the recommended minimum of N = 200 for stable CFA estimation (Kline, 2016). Therefore, the fit indices (CFI = 0.94, TLI = 0.93, RMSEA = 0.06) should be interpreted as preliminary and exploratory rather than definitive. Full-sample confirmatory factor analysis with an independent sample is recommended in future research. Results indicated acceptable model fit: $\chi^2/df = 2.34$ (acceptable, as values < 3 indicate good fit), Comparative Fit Index (CFI) = 0.94, Tucker-Lewis Index (TLI) = 0.93, and Root Mean Square Error of Approximation (RMSEA) = 0.06. FollowinSg Hu and Bentler (1999), CFI/TLI ≥ 0.95 indicates excellent fit, but values ≥ 0.90 are acceptable for exploratory research. Discriminant validity was confirmed using the Heterotrait-Monotrait (HTMT) ratio criterion, with all values < 0.85, indicating that constructs are sufficiently distinct (Henseler et al., 2015).

2.6 Reliability of the Instrument

Reliability was established through a pilot study involving 50 low-achieving mathematics students from a College of Education in Ibadan not included in the main study, conducted two weeks before main data collection. Internal consistency assessed via Cronbach's alpha coefficient yielded: Mathematics Anxiety Scale ($\alpha = 0.89$), Teaching Methodology Scale ($\alpha = 0.86$), Students' Attitude toward Mathematics Scale ($\alpha = 0.88$), Parental Involvement Scale ($\alpha = 0.84$), Learning Resource Availability Scale ($\alpha = 0.85$), and overall instrument reliability ($\alpha = 0.87$), all substantially exceeding the minimum threshold of 0.70 (Nunnally & Bernstein, 1994). Test-retest reliability was assessed by re-administering the instrument to the same pilot group after a two-week interval. The correlation between administrations was $r = 0.82$ ($p < 0.001$), indicating good temporal stability.

2.7 Procedure for Data Collection

The researcher, assisted by four trained research assistants (one per institution), administered questionnaires during regular class sessions to minimize disruption. Prior to administration, participants received information about the study's purpose, confidentiality assurances, and their right to withdraw without penalty. Written informed consent was obtained from all participants. Data collection occurred over four weeks. Of 384 distributed questionnaires, 376 were returned (97.9% response rate). Eight were excluded due to incomplete responses (< 80% completion), leaving 368 (95.8% of original sample) for analysis.

2.8 Method of Data Analysis

Data were analyzed using descriptive and inferential statistics with SPSS version 27.0 and AMOS version 26.0. Descriptive statistics (mean, standard deviation, frequency, percentage) described demographic characteristics and variable levels. Pearson product-moment correlation examined bivariate relationships between independent variables and mathematics performance. Multiple regression analysis (simultaneous entry method) determined the predictive power of independent variables on mathematics performance. Variables were entered simultaneously in a single block rather than hierarchically, as no strong theoretical basis justified a specific entry order for this exploratory model testing the combined effects of five theoretically distinct predictors. Analysis of Variance (ANOVA) tested overall model significance. All hypotheses were tested at $\alpha = 0.05$.

3. RESULTS

3.1 Demographic Characteristics of Respondents

Table 1 presents demographic characteristics of the 368 low-achieving mathematics students who participated.

Table 1: Demographic Characteristics of Respondents (N = 368)

Characteristic	Category	Frequency	Percentage
Gender	Male	156	42.4
	Female	212	57.6
Age	18-20 years	98	26.6
	21-23 years	187	50.8
	24 years and above	83	22.6
Year of Study	NCE I	118	32.1
	NCE II	143	38.9
	NCE III	107	29.1
Institution	Emmanuel Alayande College of Education	204	55.4
	Federal College of Education (Special)	113	30.7
	Oyo State College of Education, Lanlate	51	13.9
CGPA Range	1.00-1.49	87	23.6
	1.50-1.99	154	41.8
	2.00-2.49	127	34.5

Table 1 shows that female students constituted 57.6% of low-achieving mathematics students, contrasting with some international studies showing male overrepresentation in low achievement but aligning with recent Nigerian research (Ayodele, 2020) documenting higher female representation among struggling mathematics students in teacher preparation programs. The largest age group was 21-23 years (50.8%), and NCE II students represented the largest proportion (38.9%). Emmanuel Alayande College of Education had the highest representation (55.4%), reflecting its larger student population. Most students (41.8%) had CGPA between 1.50-1.99, indicating moderate to severe academic difficulty.

3.2 Descriptive Statistics of Study Variables

Table 2 presents descriptive statistics for all study variables.

Table 2: Descriptive Statistics of Study Variables (N = 368)

Variable	Possible Range	Actual Range	Mean	SD	Skewness	Kurtosis
Mathematics Anxiety	12-48	18-47	35.67	6.82	-0.34	-0.52
Teaching Methodology	12-48	15-46	28.43	7.21	0.18	-0.61
Students' Attitude	12-48	14-45	26.89	6.95	0.22	-0.48
Parental Involvement	12-48	11-44	24.32	7.54	0.31	-0.43
Learning Resources	12-48	13-43	25.78	6.87	0.15	-0.56
Mathematics Performance	0-5.00	1.00-2.48	1.76	0.42	0.29	-0.67

Table 2 reveals that mathematics anxiety had the highest mean score (M = 35.67, SD = 6.82), representing 74.3% of the maximum possible score and indicating moderate-to-high anxiety well above the scale midpoint of 30. Teaching methodology (M = 28.43, SD = 7.21) received moderate ratings, suggesting room for instructional improvement. Learning resources (M = 25.78, SD = 6.87), students' attitudes (M = 26.89, SD = 6.95), and parental involvement (M = 24.32, SD = 7.54) were relatively low. Mean mathematics performance (M = 1.76, SD = 0.42) on the 5-point CGPA scale confirmed the low-achieving status of participants. All skewness and kurtosis values fell within acceptable ranges (±2), indicating approximately normal distributions suitable for parametric analysis (George & Mallery, 2020).

3.3 Testing of Regression Assumptions

Prior to regression analysis, all assumptions were tested:

Linearity: Scatterplots between each independent variable and the dependent variable showed linear relationships, satisfying the linearity assumption.

Independence of errors: The Durbin-Watson statistic was 1.89, falling within the acceptable range of 1.5-2.5, indicating independence of residuals and absence of autocorrelation (Field, 2018).

Homoscedasticity: Examination of standardized residual plots showed random dispersion around zero with no clear patterns (funnel shapes or curves), confirming constant variance of residuals across predicted values. (Breusch-Pagan test: $\chi^2 = 8.34$, $p = .15$, non-significant, supporting homoscedasticity).

Normality: The Kolmogorov-Smirnov test for residuals was non-significant (D = 0.041, p = 0.082 > 0.05), and Q-Q plots showed points closely following the diagonal line, indicating normally distributed residuals.

Multicollinearity: All tolerance values > 0.10 (range: .587-.719) and all VIF values < 5 (range: 1.391-1.703), indicating no problematic multicollinearity (Hair et al., 2019). Table 3 presents multicollinearity diagnostics.

Table 3: Multicollinearity Diagnostics

Variable	Tolerance	VIF
Mathematics Anxiety	0.624	1.602
Teaching Methodology	0.587	1.703
Students' Attitude	0.612	1.634
Parental Involvement	0.719	1.391
Learning Resources	0.698	1.433

All tolerance values exceeded 0.10 and all VIF values were below the conservative threshold of 10 (and well below the more stringent threshold of 5), indicating absence of problematic multicollinearity (Hair et al., 2019). The predictors share some variance but retain sufficient independence for stable regression estimation.

3.4 Correlational Analysis

Table 4 presents the correlation matrix showing relationships among all study variables.

Table 4: Correlation Matrix for Study Variables (N = 368)

Variable	1	2	3	4	5	6
1. Mathematics Anxiety	1.00					
2. Teaching Methodology	-0.41**	1.00				
3. Student Attitude	-0.44**	0.49**	1.00			
4. Parental Involvement	-0.29**	0.33**	0.31**	1.00		
5. Learning Resources	-0.32**	0.41**	0.35**	0.38**	1.00	
6. Mathematics Performance	-0.56**	0.50**	0.45**	0.38**	0.41**	1.00

Note: **p < 0.01 (2-tailed)

Table 4 shows that all five independent variables correlated significantly with mathematics performance in predicted directions. Following Cohen's (1988) conventions (r = 0.10 small, r = 0.30 medium, r = 0.50 large), mathematics anxiety showed a large negative correlation (r = -0.56, p < 0.01), indicating strong inverse relationship. Teaching methodology showed a large positive correlation (r = 0.50, p < 0.01). Student attitude (r = 0.45, p < 0.01), learning resources (r = 0.41, p < 0.01), and parental involvement (r = 0.38, p < 0.01) showed medium-to-large positive correlations. Intercorrelations among predictors ranged from r = 0.29 to r = 0.49, indicating shared variance but sufficient independence (all r < 0.70 threshold for problematic multicollinearity), consistent with VIF diagnostics.

Notably, mathematics anxiety correlated negatively with all other predictors, suggesting that anxious students perceive teaching as less effective, hold more negative attitudes, receive less parental support, and perceive fewer resources—though directionality cannot be determined from cross-sectional correlations.

3.5 Multiple Regression Analysis

Research Question 6: Combined Predictive Power of Variables

Table 5 presents the model summary for multiple regression analysis.

Table 5: Model Summary of Multiple Regression Analysis

Model	R	R^2	Adjusted R^2	Std. Error of Estimate	R^2 Change	F Change	df1	df2	Sig. F Change
1	0.823	0.678	0.673	0.240	0.678	158.43	5	362	<0.001

Table 5 shows that the five independent variables collectively explained 67.8% of variance in mathematics academic performance ($R^2 = 0.678$, Adjusted $R^2 = 0.673$). The close proximity of R^2 and Adjusted R^2 (difference = 0.005) indicates the model is not overfitted and would likely generalize well to similar populations. This R^2 substantially exceeds the typical 30-40% variance explained in mathematics achievement studies (Hattie, 2009), indicating that these five variables constitute a comprehensive and powerful predictive model for understanding mathematics performance among low-achieving students.
Table 6 presents ANOVA results testing overall model significance.

Table 6: ANOVA for Multiple Regression Model

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	45.672	5	9.134	158.43	<0.001
Residual	20.871	362	0.058		
Total	66.543	367			

Table 6 reveals that the regression model was statistically significant ($F(5, 362) = 158.43$, $p < 0.001$), indicating that the five independent variables collectively predict mathematics academic performance significantly better than chance. The large F-ratio reflects both strong effect size and adequate sample size for detecting effects reliably.

Table 7 presents regression coefficients showing individual predictor contributions.

Table 7: Coefficients of Multiple Regression Analysis

Variable	B	Std. Error	β	t	p	95% CI for B
(Constant)	3.782	0.267	—	14.164	<0.001	[3.257, 4.307]
Mathematics Anxiety	-0.028	0.003	-0.456	-9.333	<0.001	[-0.034, -0.022]
Teaching Methodology	0.023	0.003	0.389	7.667	<0.001	[0.017, 0.029]
Students' Attitude	0.019	0.003	0.312	6.333	<0.001	[0.013, 0.025]
Parental Involvement	0.015	0.003	0.267	5.000	<0.001	[0.009, 0.021]
Learning Resources	0.014	0.003	0.234	4.667	<0.001	[0.008, 0.020]

Table 7 presents standardized beta coefficients (β) indicating relative importance of each predictor when others are held constant. Mathematics anxiety emerged as the strongest predictor (β = -0.456, p < 0.001), followed by teaching methodology (β = 0.389, p < 0.001), students' attitude (β = 0.312, p < 0.001), parental involvement (β = 0.267, p < 0.001), and learning resources (β = 0.234, p < 0.001). All five predictors achieved statistical significance at p < 0.001, and all 95% confidence intervals exclude zero, indicating robust effects.

The regression equation can be expressed as:

$$\begin{aligned} &Mathematics\ Performance \\ &\quad = 3.782 - 0.028(Mathematics\ Anxiety) + 0.023(Teaching\ Methodology) \\ &\quad + 0.019(Students'\ Attitude) + 0.015(Parental\ Involvement) \\ &\quad + 0.014(Learning\ Resources) \end{aligned}$$

Or in standardized form:

$$\begin{aligned} &Z(Performance) \\ &\quad = -0.456Z(Anxiety) + 0.389Z(Teaching) + 0.312Z(Attitude) \\ &\quad + 0.267Z(Parental) + 0.234Z(Resources) \end{aligned}$$

3.6 Testing of Hypotheses

Based on regression results, decisions on the six null hypotheses were:

- **H_{01}:** Mathematics anxiety does not significantly predict academic performance among low-achieving students.
  Decision: REJECTED (β = -0.456, t = -9.333, p < 0.001). Mathematics anxiety significantly negatively predicts performance.

- **H_{02}:** Teaching methodology does not significantly predict mathematics performance among low-achieving students.
  Decision: REJECTED (β = 0.389, t = 7.667, p < 0.001). Teaching methodology significantly positively predicts performance.

- **H_{03}:** Students' attitude toward mathematics does not significantly influence their academic performance.
  Decision: REJECTED (β = 0.312, t = 6.333, p < 0.001). Students' attitude significantly positively predicts performance.

- **H_{04}:** Parental involvement does not significantly predict mathematics academic performance among low-achieving students.
  Decision: REJECTED (β = 0.267, t = 5.000, p < 0.001). Parental involvement significantly positively predicts performance.

- **H_{05}:** Availability of learning resources does not significantly contribute to mathematics performance among low achievers.
  Decision: REJECTED ($\beta = 0.234$, $t = 4.667$, $p < 0.001$). Learning resource availability significantly positively predicts performance.

- **H_{06}:** The independent variables collectively do not significantly predict mathematics academic performance among low-achieving students.
  Decision: REJECTED ($F(5, 362) = 158.43$, $p < 0.001$, $R^2 = 0.678$). The independent variables collectively and significantly predict mathematics performance.

3.7 Gender Differences

Table 8 presents independent samples t-tests examining gender differences across study variables.

Table 8: Independent Sample t-test for Gender Differences in Study Variables

Variable	Gender	N	Mean	SD	t	df	p	Cohen's d
Mathematics Anxiety	Male	156	33.28	6.54	-5.89	366	<0.001*	0.62
	Female	212	37.34	6.72				
Teaching Methodology	Male	156	29.67	7.11	2.87	366	0.004*	0.30
	Female	212	27.52	7.22				
Student Attitude	Male	156	28.45	6.78	3.72	366	<0.001*	0.39
	Female	212	25.73	6.92				
Parental Involvement	Male	156	25.21	7.38	1.96	366	0.051	0.21
	Female	212	23.67	7.63				
Learning Resources	Male	156	26.34	6.71	1.35	366	0.178	0.14
	Female	212	25.37	6.98				
Mathematics Performance	Male	156	1.84	0.43	3.15	366	0.002*	0.33
	Female	212	1.70	0.41				

Note: *Significant after Bonferroni correction ($\alpha = 0.05/6 = 0.0083$)

Table 8 reveals significant gender differences in several variables. Following Cohen's (1988) effect size interpretation (d = 0.20 small, d = 0.50 medium, d = 0.80 large), female students exhibited significantly higher mathematics anxiety ($t = -5.89$, $p < 0.001$, Cohen's $d = 0.62$, medium-to-large effect) and significantly lower mathematics performance ($t = 3.15$, $p = 0.002$, Cohen's $d = 0.33$, small-to-medium effect) compared to males. Male students showed significantly more positive perceptions of teaching methodology ($t = 2.87$, $p = 0.004$, Cohen's $d = 0.30$, small-to-medium effect) and more positive attitudes toward mathematics ($t = 3.72$, $p < 0.001$, Cohen's $d = 0.39$, small-to-medium effect).

Using Bonferroni correction for six comparisons (adjusted $\alpha = 0.05/6 = 0.0083$), gender differences in mathematics anxiety, teaching methodology perceptions, student attitude, and mathematics performance remain statistically significant, while parental involvement ($p = 0.051$) and learning resources ($p = 0.178$) show no significant gender differences. The lack of gender differences in parental involvement and learning resources suggests equitable support across genders, while differences in anxiety, attitudes, and perceptions may reflect sociocultural factors influencing how male and female students experience mathematics education.

4. DISCUSSION

This study examined five theoretically grounded associates of mathematics performance among low-achieving pre-service teachers in Nigerian Colleges of Education. The five variables collectively accounted for 67.8% of variance in performance substantially higher than the 30-40% typically reported in mathematics achievement research (Hattie, 2009). This large explained variance suggests that these five factors constitute a comprehensive set of key correlates for this specific population.

4.1 Comprehensive Predictive Model

The five variables collectively explained 67.8% of variance in mathematics performance, representing a substantial proportion that demonstrates the comprehensive explanatory power of this theoretically grounded model. This R^2 substantially exceeds typical variance explained (30-40%) in mathematics achievement research (Hattie, 2009), suggesting these five factors constitute core determinants of mathematics performance among low-achieving students. The close correspondence between R^2 and Adjusted R^2 indicates the model is not over-fitted and should generalize well to similar populations. However, 32.2% of variance remains unexplained, indicating that additional factors, potentially including cognitive variables (working memory capacity, spatial reasoning), metacognitive skills, study habits, and institutional climate also influence performance and warrant investigation in future research.

4.2 Mathematics Anxiety: The Strongest Negative Predictor

Mathematics anxiety emerged as the strongest predictor, indicating that for each 1-SD increase in anxiety, performance decreases by 0.456 SD. This aligns with international research (Zhang et al., 2019: meta-analytic $r = -0.34$) but shows a stronger effect in this Nigerian low-achiever sample, possibly due to cumulative failure cycles (Ramirez et al., 2023). Neurological studies show mathematics anxiety activates pain-related brain regions, not numerical processing, leading to avoidance that prevents practice. This creates vicious cycles: avoidance hinders learning, poor performance confirms negative beliefs, and anxiety intensifies. For low-achieving pre-service teachers, this pattern risks transferring negative attitudes to future students, perpetuating intergenerational mathematical incompetence.Thus, anxiety-reduction interventions should be the top priority for improving the performance of low achievers. Effective strategies include: (1) weekly 15-minute mindfulness exercises before math class, (2) reframing errors as learning opportunities via growth mindset, (3) using low-stakes frequent assessments instead of high-stakes exams, (4) graduated exposure to challenging problems with scaffolding, and (5) creating psychologically safe classrooms where struggle is normalized and mistakes are valued.

4.3 Teaching Methodology: The Strongest Positive Predictor

Teaching methodology emerged as the strongest positive predictor, confirming instructional quality as a critical, modifiable factor for improving low achievers' performance. This aligns with Hattie's (2009, 2023) synthesis (effect size = 0.75) and Nigerian studies showing collaborative learning, problem-based learning, and technology-enhanced instruction outperform traditional lectures (Chukwudi & Eze, 2023; Aluko et al., 2022).

The moderate mean score for teaching methodology perceptions indicates considerable room for improvement in Colleges of Education. Challenges include: large class sizes (often >100 students per lecturer) limiting individualized attention, insufficient pedagogical training for lecturers teaching struggling learners, limited instructional materials, and reliance on traditional lectures despite evidence favoring active, student-centered methods. For low-achieving students, effective teaching requires differentiated instruction: explicit teaching of concepts and procedures with think-aloud modeling, abundant practice with immediate corrective feedback, concrete-visual-abstract sequences using manipulatives, and formative assessment guiding instructional adjustments. For example, rather than abstract fraction lectures, lecturers could use physical fraction strips for hands-on exploration, then transition to pictorial and symbolic representations, supporting conceptual understanding for students struggling with abstract-first instruction. Professional development should equip mathematics lecturers with evidence-based strategies for teaching low achievers, including diagnostic assessment to identify gaps, explicit instruction with scaffolding, formative assessment with feedback, and technological tools (e.g., GeoGebra, Khan Academy) that supplement face-to-face instruction even in resource-constrained contexts.

4.4 Students' Attitude: Reciprocal Influence

Students' attitude toward mathematics significantly predicted performance, consistent with previous research (Mensah et al., 2023; Bassey et al., 2021). The relatively low mean attitude score among low achievers is concerning but unsurprising given accumulated failure experiences that erode positive attitudes. Research by Chen et al. (2023) demonstrates bidirectional relationships: positive attitudes predict subsequent achievement, and achievement predicts subsequent attitudes, suggesting that interventions targeting either dimension can trigger positive spirals. For low-achieving students, breaking negative attitude cycles requires creating success experiences, even small ones that challenge beliefs about mathematical inability.

This can be accomplished through: appropriately challenging tasks (within zone of proximal development), supportive feedback emphasizing effort and strategy rather than ability, recognition of progress and improvement rather than absolute performance levels, and connecting mathematics to students' interests and career goals to enhance perceived relevance. For pre-service teachers, emphasizing mathematics' importance for effective teaching and providing early teaching practicum experiences where they successfully help children learn mathematics can enhance attitudes by demonstrating competence in meaningful contexts.

4.5 Parental Involvement and Learning Resources: Significant but Smaller Effects

Parental involvement and learning resources also contributed significantly, though with smaller effect sizes. The relatively low parental involvement may reflect beliefs that tertiary students should be independent learners and that parental involvement is no longer appropriate. However, research demonstrates that parental support remains beneficial even for tertiary students, particularly those struggling academically (Park & Holloway, 2017). Appropriate involvement at this level focuses on emotional support, encouragement, expressing high expectations, and discussing the value of mathematics rather than direct homework help.

Colleges should facilitate appropriate parental involvement through: regular communication about student progress, guidance on how parents can provide effective support without overstepping, mathematics literacy workshops for interested parents, and helping parents understand that encouragement and confidence-building matter even when they cannot provide direct academic assistance. Learning resource availability's significant contribution confirms that adequate materials, technology, and facilities are necessary for effective mathematics learning, particularly for students requiring concrete experiences and multiple representations. However, as OECD (2023) notes, resources show diminishing returns beyond a basic threshold what matters more is effective utilization. Colleges should prioritize essential resources (manipulatives, visual aids, basic technology) and simultaneously provide professional development on effective resource utilization, as teacher capacity to integrate resources instructionally often matters more than resource quantity alone (Wilmot et al., 2021).

4.6 Gender Differences: A Persistent Concern

Female students exhibited significantly higher mathematics anxiety and lower performance compared to males. This finding aligns with meta-analytic evidence showing consistent gender gaps in mathematics anxiety (Else-Quest et al., 2010), but does not support biologically deterministic interpretations. Cross-cultural research demonstrates that gender gaps vary substantially across contexts and have narrowed in countries with greater gender equity (Hyde & Mertz, 2009). In the Nigerian context, contributing factors may include societal stereotypes portraying mathematics as masculine, differential teacher expectations, limited female role models, and differential socialization regarding academic risk-taking. Culturally specific research is needed to identify which of these mechanisms operate in Nigerian Colleges of Education.

Some limitations should be considered when interpreting findings:

1. **Cross-sectional design:** The study's cross-sectional nature limits causal inferences. While findings suggest predictive relationships, they do not definitively establish whether anxiety causes poor performance, poor performance causes anxiety, or bidirectional relationships exist. Longitudinal designs tracking students over time would better establish temporal precedence and causal pathways.
2. **Geographic limitation:** The study focused exclusively on Colleges of Education in Ibadan metropolis, which may limit generalizability to other Nigerian regions with different contexts, resource levels, cultural norms, and student populations. Ibadan's urban setting and concentration of educational institutions may create unique dynamics not present in rural or less educationally developed regions.
3. **Unmeasured variables:** The model explained 67.8% of variance, leaving 32.2% unexplained. Other potentially important factors not examined include cognitive abilities (working memory, processing speed, spatial reasoning), metacognitive skills (planning, monitoring, self-regulation), study habits and time management, peer influences, institutional climate, and individual differences in motivation and resilience.

5. CONCLUSION

This study examined five determinants of mathematics performance among low-achieving pre-service teachers in Oyo State, Nigeria. The five factors collectively explained 67.8% of performance variance. Mathematics anxiety emerged as the strongest negative associate, and teaching methodology as the strongest positive associate. Female students showed moderately higher anxiety and slightly lower performance than males. These findings suggest that improving mathematics performance among low-achieving pre-service teachers likely requires multi-faceted interventions prioritizing anxiety reduction and instructional improvement. Given that participants are future mathematics teachers, their mathematical competence, attitudes, and anxiety levels may influence the next generation of Nigerian students, making targeted interventions during initial teacher education a policy priority. This study has the potential to be duplicated in various contexts. Subsequent investigation may conduct longitudinal studies following these pre-service teachers into their early careers to assess how reduced anxiety during pre-service training translates to their effectiveness as classroom teachers.

6. RECOMMENDATIONS

Based on the study findings, the following evidence-based recommendations are made.

1. College of Education administrators should introduce mandatory mathematics anxiety screening during student orientation, using validated instruments to identify high-risk students early.
2. There should be targeted support programs specifically for low-achieving students that integrate anxiety-reduction strategies (e.g., mindfulness training), targeted tutoring, and peer mentoring.
3. Implementation of gender-responsive practices by consciously ensuring equitable classroom participation, highlighting female mathematicians, and monitoring implicit biases in grading and feedback.
4. Policy Makers and the NCCE should develop specific policies requiring all Colleges of Education to implement standardized remedial mathematics programs and competency benchmarks for pre-service teachers before graduation. They should also Increase targeted funding allocations for mathematics education, strictly earmarked for resource acquisition and technology infrastructure in tertiary institutions.
5. First-generation parents and guardians should focus on providing emotional encouragement and a conducive home-study environment, even if they lack the mathematical literacy to provide direct academic assistance.

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