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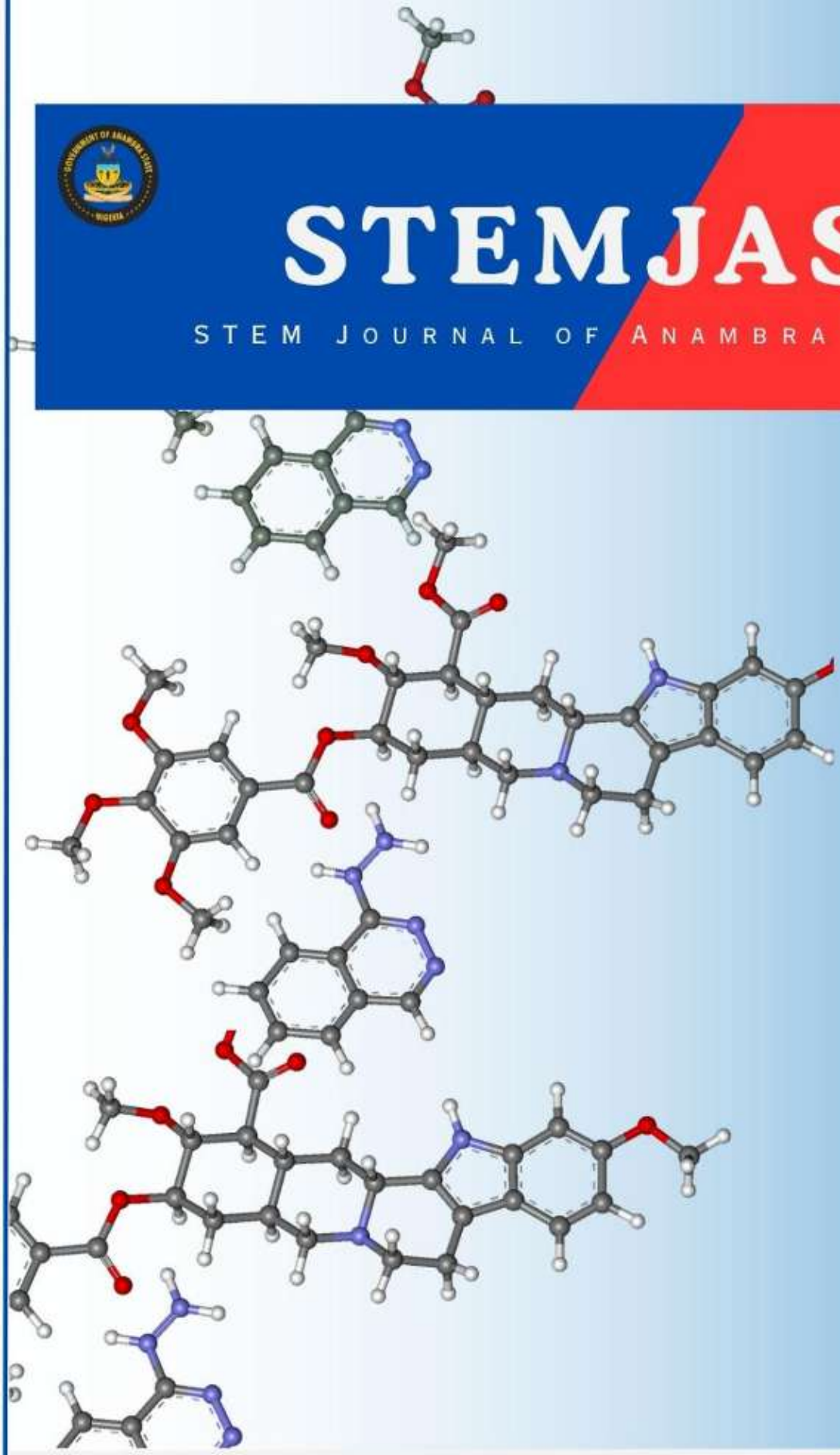

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EDITORIAL

STEM Journal of Anambra STAN (STEMJAS) is a publication of **Science Teachers Association of Nigeria, Anambra State Chapter.** STEMJAS is developed to disseminate information on Science, Technology, Engineering and Mathematics (STEM) Education to teachers, teacher-trainers, researchers and other interested persons. Articles that are of relevance to STEM education are published in this journal. We are grateful to the contributors and hope that our readers will enjoy reading these contributions.

Prof. Ebele C. Okigbo
Editor-in-Chief

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EFFECTS OF MOTIVATION TYPE AND TEST ANXIETY ON STUDENTS' ACADEMIC PERFORMANCE IN CHEMISTRY

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Abstract

This study investigated the effects of motivation type (intrinsic vs. extrinsic) and test anxiety on the academic performance of senior secondary school students in chemistry. A descriptive survey research design was employed, with a stratified random sample of 386 chemistry students drawn from public secondary schools in Anambra State, Nigeria. Data were collected using three validated instruments: the Academic Motivation Scale–Chemistry Version (AMS-CV), the Westside Test Anxiety Scale (WTAS), and the Chemistry Achievement Test (CAT). Reliability coefficients of 0.84, 0.81, and 0.87 were obtained, respectively, using Cronbach's alpha. Multiple regression and one-way ANOVA were used for data analysis. Results revealed that intrinsic motivation was a significant positive predictor of chemistry academic performance ($\beta = 0.47$, $p < .001$), while high test anxiety was a significant negative predictor ($\beta = -0.39$, $p < .001$). Extrinsic motivation demonstrated a moderate positive relationship with performance but was not statistically significant ($\beta = 0.12$, $p = .063$). A significant interaction effect between motivation type and test anxiety level was also observed. Students with high intrinsic motivation and low test anxiety recorded the highest mean chemistry scores ($M = 74.3$, $SD = 8.6$). These findings underscore the importance of fostering intrinsic motivation and implementing anxiety-reduction interventions in chemistry classrooms. Implications for curriculum design, teacher training, and school counseling are discussed.

Keywords: Intrinsic Motivation, Extrinsic Motivation, Test Anxiety, Academic Performance, Chemistry Education, Self-Determination Theory, Secondary School Students

1. Introduction

Chemistry is widely regarded as a foundational science discipline that underpins advances in medicine, agriculture, engineering, and environmental sustainability. Despite its centrality to scientific literacy, chemistry consistently records some of the lowest academic achievement scores among secondary school students globally (Nakamura et al., 2022; Obinna & Eze, 2023). In Nigeria specifically, the West African Examinations Council (WAEC) annual reports have

repeatedly documented mass failure rates in chemistry, with fewer than 50% of candidates earning credit-level passes in several consecutive years (WAEC, 2023). Understanding the psychological and motivational factors that contribute to this persistent under performance is, therefore, both a scholarly imperative and a policy priority.

Among the most extensively studied psychological factors in academic achievement research are motivation and anxiety. Motivation, defined as the internal processes that initiate, guide, and sustain goal-directed behaviour has been identified as one of the strongest predictors of academic performance across subjects and educational levels (Ryan & Deci, 2020; Schunk & DiBenedetto, 2021). Within the Self-Determination Theory (SDT) framework articulated by Ryan and Deci (2000, 2020), motivation exists on a continuum ranging from amotivation to extrinsic motivation and, at the highest level, intrinsic motivation. Intrinsically motivated learners engage with learning activities out of inherent interest, curiosity, and enjoyment, whereas extrinsically motivated learners are driven by external rewards, grades, or social pressures.

Test anxiety, on the other hand, refers to a situation-specific trait characterized by worry, cognitive interference, and somatic arousal during evaluative situations (Zeidner, 2021). High levels of test anxiety have been linked to reduced working memory capacity, impaired retrieval of learned information, and diminished test performance (Fernandez et al., 2022; Putwain et al., 2021). In chemistry, a subject that demands both conceptual understanding and problem-solving fluency, test anxiety may be particularly debilitating, as students must simultaneously recall chemical principles, apply algorithmic procedures, and interpret data under time pressure.

Despite substantial literature on motivation and anxiety individually, relatively few studies have examined their combined and interactive effects on chemistry performance, particularly within the Nigerian secondary school context. Most existing Nigerian studies have focused on instructional strategies (Obi & Nwosu, 2021) or gender differences in chemistry achievement (Adeyemi et al., 2022), without systematically integrating motivational and anxiety variables. This study addresses that gap by investigating: (a) the differential effects of intrinsic and extrinsic motivation types on chemistry academic performance; (b) the effect of test anxiety level on chemistry academic performance; and (c) the interaction effect between motivation type and test anxiety on chemistry academic performance.

The findings of this study are expected to inform teachers, curriculum planners, school counselors, and policymakers in designing more effective chemistry learning environments that are both motivationally supportive and anxiety-sensitive.

Statement of the Problem

The persistent poor performance of Nigerian secondary school students in chemistry has been documented across multiple national and international assessments (WAEC, 2023; Trends in International Mathematics and Science Study [TIMSS], 2023). While infrastructure deficits and curriculum challenges have received policy attention, the psychological dimensions of this problem particularly the roles of motivation type and test anxiety remain inadequately studied in the Nigerian context. This study, therefore, sought to provide empirical data on how these psychological variables interact to influence chemistry academic performance.

Purpose of the Study

The specific objectives of this study were to:

1. Determine the effect of motivation type (intrinsic vs. extrinsic) on the academic performance of senior secondary school students in chemistry.
2. Assess the effect of test anxiety level (low, moderate, high) on academic performance in chemistry.
3. Examine the interaction effect between motivation type and test anxiety level on chemistry academic performance.

Hypotheses

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

- HO_1: There is no significant difference in the chemistry academic performance of students based on motivation type.
- HO_2: There is no significant difference in the chemistry academic performance of students based on test anxiety level.
- HO_3: There is no significant interaction effect between motivation type and test anxiety level on chemistry academic performance.

Literature Review

Self-Determination Theory and Motivation Types

Self-Determination Theory (SDT), as articulated by Ryan and Deci (2000) and subsequently expanded (Ryan & Deci, 2017, 2020), provides the most widely cited theoretical framework for understanding human motivation in educational contexts. SDT posits that motivation exists on an internalization continuum encompassing: (a) amotivation, the absence of intentional regulation; (b) external regulation behaviour driven by rewards and punishments; (c) introjected regulation behaviour guided by self-imposed pressure and ego involvement; (d) identified regulation behaviour aligned with personally endorsed values; (e) integrated regulation behaviour fully

assimilated with one's sense of self; and (f) intrinsic motivation behaviour emanating from inherent interest and satisfaction. The first two forms constitute what is broadly termed extrinsic motivation in educational measurement, while the latter forms are proximal to intrinsic motivation.

A substantial body of empirical evidence supports SDT's predictions. Vansteenkiste et al. (2020) conducted a multi-cohort longitudinal study across four European countries and confirmed that autonomous (intrinsic) motivation was consistently and positively associated with academic achievement, persistence, and conceptual learning, while controlled (extrinsic) motivation showed null or negative associations with deep learning outcomes. Similarly, Rogowska et al. (2020) found that intrinsic academic motivation significantly predicted grade point averages among Polish university students ($r = 0.43$, $p < .001$), whereas extrinsic motivation showed a weak, non-significant correlation.

In the science education domain specifically, Bong et al. (2021) demonstrated that intrinsic motivation predicted science achievement beyond the effects of prior achievement, gender, and socioeconomic status among middle-school students in South Korea. Notably, the authors found that the relationship was stronger in chemistry and biology than in physics, suggesting subject-specific motivational dynamics. More recently, Fadlelmula et al. (2023) confirmed that students with higher levels of self-determined motivation in chemistry showed superior performance on both near-transfer and far-transfer chemistry problem-solving tasks.

Test Anxiety: Conceptualization and Academic Consequences

Test anxiety is a well-documented psychological construct characterized by two primary components: (a) worry, which is cognitive concerns about the consequences of failure; and (b) emotionality, which is physiological and affective arousal in response to evaluative threat (Liebert & Morris, 1967; Zeidner, 2021). Contemporary models, including the Cognitive Interference Model (Sarason, 1988) and the Attentional Control Theory (Eysenck et al., 2007), posit that test anxiety consumes attentional and working memory resources, thereby reducing the cognitive bandwidth available for task-relevant processing.

Meta-analytic evidence consistently confirms a moderate negative relationship between test anxiety and academic performance. Von der Embse et al. (2018) conducted a comprehensive meta-analysis of 238 studies ($N = 221{,}500$) and reported a mean corrected correlation of $r = -0.22$ between test anxiety and academic achievement, with stronger effects observed in STEM subjects. Putwain et al. (2021) extended these findings by showing that the negative impact of test anxiety was partially mediated by reductions in academic self-efficacy and effort regulation. Fernandez et al. (2022) further demonstrated that high-anxiety students showed significantly impaired performance on assessments requiring multi-step chemical calculations, a common component of chemistry examinations relative to low-anxiety peers.

In the Nigerian educational context, Okeke and Nwoye (2022) reported that 61.4% of senior secondary students in Anambra State experienced moderate to high levels of test anxiety before chemistry examinations. Similarly, Abubakar and Siddiqui (2020) found that test anxiety significantly predicted performance in secondary school chemistry in northern Nigerian states, accounting for 18.3% of variance in examination scores after controlling for gender and school type.

Interaction Between Motivation and Test Anxiety

Although motivation and test anxiety are often studied in isolation, growing evidence suggests that they interact in complex ways to determine academic outcomes. Pekrun's Control-Value Theory (CVT; Pekrun, 2006; Pekrun & Perry, 2014) provides a useful framework for understanding this interaction: the theory posits that students' subjective control over academic outcomes and the value they attach to those outcomes jointly determine the academic emotions including anxiety that they experience. Under CVT, intrinsically motivated students, who attach high value to learning itself and believe in their capacity to achieve, are expected to experience less debilitating anxiety because failure is less threatening to their core identity.

Empirical support for this interactive relationship is accumulating. Putwain and Symes (2018) found that autonomous motivation buffered the negative effects of test anxiety on GCSE mathematics performance in a sample of 612 British adolescents. Similarly, Huang et al. (2021) reported a significant motivation-by-anxiety interaction in a Chinese high school sample, such that the negative effect of test anxiety on science performance was significantly attenuated among students with high intrinsic motivation. Contrariwise, extrinsically motivated students showed amplified anxiety effects, possibly because external reward structures heighten performance pressure.

These interactive effects remain under explored in the chemistry-specific literature and within sub-Saharan African educational contexts, where unique cultural, socioeconomic, and structural factors such as high-stakes examination cultures (Oghuma et al., 2022) and teacher-centred pedagogies (Eze & Amadi, 2023) may moderate the relationships differently from Western samples.

Chemistry-Specific Considerations

Chemistry presents unique cognitive and affective challenges that distinguish it from other science subjects. Students must navigate multiple representational levels—the macroscopic (observable phenomena), submicroscopic (molecular and atomic interpretations), and symbolic (chemical formulae and equations)—simultaneously (Johnstone, 2010; Upahi et al., 2020). This tri-level demand is cognitively taxing and may exacerbate anxiety, particularly during high-stakes examinations. Furthermore, the abstract nature of many chemistry concepts (atomic theory, mole

concept, electrochemistry) has been identified as a source of particular difficulty for Nigerian students (Obi & Nwosu, 2021).

Recent studies have shown that motivational variables may be especially important in chemistry relative to other sciences. Salta and Koulougliotis (2020) found that intrinsic motivation accounted for a larger proportion of variance in chemistry achievement ($R^2 = 0.29$) than in physics achievement ($R^2 = 0.19$) in a Greek secondary school sample. The authors attributed this to chemistry's greater requirement for sustained voluntary engagement with abstract concepts outside formal instruction time. These findings suggest that chemistry may be a particularly critical domain in which to investigate motivational and anxiety effects.

Theoretical Framework

This study is anchored on two complementary theoretical frameworks: Ryan and Deci's (2000, 2020) Self-Determination Theory (SDT) and Pekrun's (2006) Control-Value Theory (CVT) of academic emotions.

SDT provides the conceptual basis for operationalizing motivation types. According to SDT's Basic Psychological Needs Theory sub-theory, optimal motivation (approaching intrinsic motivation) is fostered when the basic psychological needs for autonomy, competence, and relatedness are satisfied within the learning environment. Conversely, need-thwarting environments characterized by excessive control, performance pressure, and social comparison promote extrinsic or amotivated stances and are predicted to be associated with poorer learning outcomes.

CVT complements SDT by specifying the conditions under which academic anxiety arises and its mechanisms of influence on performance. The theory predicts that students who lack subjective control over academic outcomes and who assign high value to those outcomes are most vulnerable to anxiety. Crucially, CVT specifies that autonomous motivation (aligned with SDT's intrinsic regulation) is associated with high control appraisals, whereas controlled motivation (aligned with extrinsic regulation) fosters low control and high performance pressure, thereby elevating anxiety.

The integration of these two theories generates testable predictions: (a) intrinsically motivated students should outperform extrinsically motivated students in chemistry; (b) high test anxiety should impair chemistry performance; and (c) motivation type should moderate the anxiety-performance relationship, with intrinsic motivation buffering the detrimental effects of test anxiety. Figure 1 depicts the hypothesised conceptual model guiding this study.

[Figure 1: Hypothesised Conceptual Model of Motivation Type, Test Anxiety, and Chemistry Academic Performance]

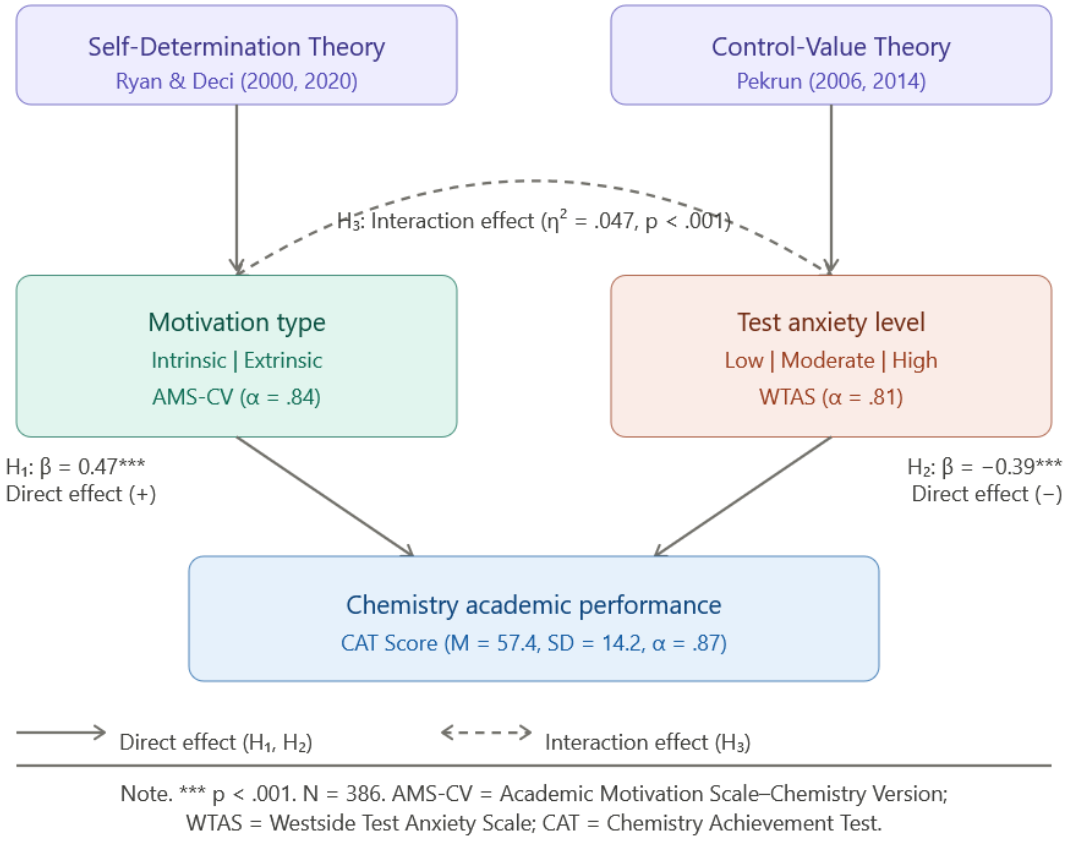

Figure 1. Conceptual framework illustrating the direct and interactive effects of motivation type and test anxiety on chemistry academic performance, grounded in SDT (Ryan & Deci, 2020) and CVT (Pekrun, 2006).

Methodology

Research Design

A descriptive survey research design was employed. Survey designs are appropriate when researchers seek to describe the characteristics of a population or examine relationships among variables without manipulating them (Creswell & Creswell, 2023). This design was selected because the study aimed to collect data on students' naturally occurring motivational orientations and anxiety levels and examine their relationships with chemistry achievement.

Population and Sampling

The target population comprised all Senior Secondary School 2 (SSS 2) chemistry students in public secondary schools in Anambra State, Nigeria. SSS 2 students were selected because they have completed at least one full year of senior secondary chemistry instruction and have sat multiple chemistry examinations, making them appropriate for assessing achievement and anxiety patterns. The Post Primary School Service Commission of Anambra State (2023) records indicated a total population of approximately 12,840 SSS 2 chemistry students across 214 public secondary schools.

Stratified random sampling was employed to ensure proportional representation across the three senatorial districts of Anambra State (Anambra North, Anambra South, and Anambra Central). From each stratum, schools were randomly selected using a table of random numbers, and students were then randomly selected within each school. The sample size of 386 was determined using Taro Yamane's (1967) formula at a 95% confidence level and 5% margin of error, with an additional 10% added to account for attrition.

Instrumentation

Academic Motivation Scale–Chemistry Version (AMS-CV)

The AMS-CV was adapted from the original Academic Motivation Scale (Vallerand et al., 1992) and customized for chemistry education. The instrument comprised 21 items rated on a 7-point Likert scale (1 = Does Not Correspond at All to 7 = Corresponds Exactly). Items were organized into three sub-scales: Intrinsic Motivation (7 items, e.g., 'Because I experience pleasure and satisfaction while learning new things in chemistry'), Extrinsic Motivation (7 items, e.g., 'Because I want to have a good chemistry grade'), and Amotivation (7 items). For this study, only the intrinsic and extrinsic sub-scales were used. Face and content validity were established through expert review by three chemistry education specialists and two educational psychologists. Cronbach's alpha reliability was 0.84 for the intrinsic sub-scale and 0.79 for the extrinsic sub-scale.

Westside Test Anxiety Scale (WTAS)

The Westside Test Anxiety Scale (Driscoll, 2007), a 10-item self-report instrument, was used to measure test anxiety. Students rated their agreement with items on a 5-point Likert scale (1 = Never to 5 = Always). Example items include 'I freeze up on important tests' and 'Even when I study well, I feel very anxious about the test.' Total scores ranged from 10 to 50, with established cut-off scores: low anxiety (10–25), moderate anxiety (26–35), and high anxiety (36–50). The WTAS has demonstrated strong psychometric properties across diverse populations (Driscoll, 2007; Steinmayr et al., 2020). In the present sample, the Cronbach's alpha reliability coefficient was 0.81.

Chemistry Achievement Test (CAT)

The CAT was a researcher-developed 50-item multiple-choice test covering the SSS 2 chemistry curriculum (Federal Ministry of Education, 2022), including topics such as mole concept, acids and bases, electrochemistry, rates of reaction, and organic chemistry. Each correct response was awarded 2 marks, giving a total possible score of 100. The test was validated using a table of specifications aligned with the chemistry curriculum objectives at knowledge, comprehension, application, and analysis levels following Bloom's taxonomy (Krathwohl, 2002). Item analysis yielded a mean facility index of 0.52 and a mean discrimination index of 0.41, indicating items of moderate difficulty with good discriminating power. Kuder-Richardson formula 20 (KR-20) reliability was 0.87.

Data Collection Procedure

Ethical approval was obtained prior to data collection. Letters of permission were obtained from the Post Primary School Service Commission Awka and the principals of participating schools. Informed written consent was obtained from parents/guardians, and verbal assent was obtained from student participants. To minimise social desirability bias, participants were assured of anonymity and the non-evaluative nature of the instruments. The CAT was administered first to avoid anchoring effects, followed by the AMS-CV and the WTAS. Data collection was conducted between September and November 2024.

Data Analysis

Descriptive statistics (means, standard deviations, frequencies) were computed for all major variables. Students were classified into motivation type groups based on their dominant sub-scale score on the AMS-CV: those scoring higher on the intrinsic sub-scale were classified as intrinsically motivated, and those scoring higher on the extrinsic sub-scale were classified as extrinsically motivated. Students with equal scores (n = 14, 3.6%) were excluded from motivation-type group comparisons. Test anxiety was operationalized as a three-level categorical variable (low, moderate, high) using WTAS cut-off scores. A 2 (Motivation Type: Intrinsic vs. Extrinsic) × 3 (Test Anxiety Level: Low vs. Moderate vs. High) (2X3) factorial ANOVA was conducted to test for main and interaction effects. Post-hoc comparisons were performed using Tukey's HSD test. Multiple regression analysis was used to examine the predictive relationships between continuous motivation and anxiety scores and chemistry performance. All analyses were conducted using IBM SPSS Statistics, Version 28 (IBM Corp., 2022). The significance level was set at $\alpha = .05$.

Results

Descriptive Statistics

Table 1: Descriptive Statistics for Study Variables (*N = 386)*

Variable	n (%)	M	SD	Min	Max
Intrinsic Motivation (AMS-CV)	227 (58.8%)	5.21	0.84	2.14	7.00
Extrinsic Motivation (AMS-CV)	145 (37.6%)	4.67	0.91	1.86	7.00
Test Anxiety - Low (WTAS)	93 (24.1%)	19.3	3.8	10	25
Test Anxiety - Moderate (WTAS)	178 (46.1%)	30.7	2.9	26	35
Test Anxiety - High (WTAS)	115 (29.8%)	41.2	4.1	36	50
Chemistry Achievement (CAT)	386 (100%)	57.4	14.2	18	94

Note. AMS-CV = Academic Motivation Scale–Chemistry Version; WTAS = Westside Test Anxiety Scale; CAT = Chemistry Achievement Test; M = Mean; SD = Standard Deviation.

Table 1 presents the descriptive statistics for the key study variables. Of the 386 participants, 227 (58.8%) were classified as intrinsically motivated and 145 (37.6%) as extrinsically motivated. Using WTAS cut-off scores, 93 students (24.1%) were classified as low-anxiety, 178 (46.1%) as moderate-anxiety, and 115 (29.8%) as high-anxiety. The overall mean CAT score was 57.4 (SD = 14.2) out of 100, indicating a below-average performance consistent with national trends.

Hypothesis Testing

HO_1: Motivation Type and Chemistry Performance

Table 2: *One-Way ANOVA: Effect of Motivation Type on Chemistry Achievement*

Source	SS	df	MS	F	p	η^2
Between Groups	9,847.3	1	9,847.3	48.62	< .001	0.116
Within Groups	74,972.1	370	202.6			
Total	84,819.4	371				

A one-way ANOVA revealed a statistically significant difference in CAT scores between intrinsically and extrinsically motivated students, $F(1, 370) = 48.62$, $p < .001$, $\eta^2 = 0.116$. Intrinsically motivated students (M = 64.8, SD = 12.1) significantly outperformed extrinsically motivated students (M = 51.3, SD = 13.9). Accordingly, HO1 was rejected.

HO_2: Test Anxiety Level and Chemistry Performance

A one-way ANOVA demonstrated a significant main effect of test anxiety level on CAT scores, $F(2, 383) = 61.47$, $p < .001$, $\eta^2 = 0.243$. Post-hoc Tukey's HSD comparisons indicated that all pairwise group differences were statistically significant (all $p < .01$). Low-anxiety students (M =

70.2, SD = 11.3) significantly outperformed moderate-anxiety students (M = 57.9, SD = 12.4) and high-anxiety students (M = 43.6, SD = 11.8). HO_2 was rejected.

Table 3: *Mean CAT Scores by Test Anxiety Level with Post-Hoc Comparisons*

Anxiety Level	n	M	SD	Mean Diff. (Low)	Mean Diff. (Mod.)
Low	93	70.2	11.3	—	—
Moderate	178	57.9	12.4	12.3**	—
High	115	43.6	11.8	26.6**	14.3**

*Note. ** $p < .01$ (Tukey's HSD post-hoc comparisons).*

HO_3: Interaction Effect of Motivation Type × Test Anxiety Level

A 2 × 3 factorial ANOVA revealed a statistically significant interaction between motivation type and test anxiety level, $F(2, 366) = 8.94$, $p < .001$, $\eta^2 = 0.047$. This indicates that the effect of motivation type on chemistry performance varied as a function of test anxiety level. As illustrated in Table 4, the performance gap between intrinsically and extrinsically motivated students was widest among high-anxiety students ($\Delta = 18.4$ points) compared to low-anxiety students ($\Delta = 8.7$ points). HO_3 was rejected.

Table 4: *Mean CAT Scores by Motivation Type × Test Anxiety Level (Factorial ANOVA Cell Means)*

Test Anxiety Level	Intrinsic M (SD)	Extrinsic M (SD)	Difference (Δ)
Low	74.3 (8.6)	65.6 (10.2)	8.7
Moderate	62.1 (11.1)	51.4 (12.8)	10.7
High	49.7 (10.4)	31.3 (9.9)	18.4
Overall	64.8 (12.1)	51.3 (13.9)	13.5

Multiple Regression Analysis

A hierarchical multiple regression analysis was conducted to examine the relative contributions of intrinsic motivation score (continuous), extrinsic motivation score (continuous), and test anxiety score (continuous) to chemistry performance. The overall model was statistically significant, $F(3, 382) = 74.31$, $p < .001$, $R^2 = 0.369$, indicating that the three predictor variables collectively accounted for 36.9% of the variance in CAT scores. As shown in Table 5, intrinsic motivation was the strongest significant predictor ($\beta = 0.47$, $p < .001$), followed by test anxiety ($\beta = -0.39$, $p <$

.001). Extrinsic motivation did not emerge as a statistically significant predictor (β = 0.12, p = .063).

Table 5: *Multiple Regression Analysis: Predictors of Chemistry Academic Performance*

Predictor	B	SE B	β	t	p	95% CI
(Constant)	43.21	4.18		10.34	< .001	[34.99, 51.43]
Intrinsic Motivation	8.76	1.03	0.47	8.50	< .001	[6.73, 10.79]
Test Anxiety Score	−0.89	0.13	−0.39	−6.85	< .001	[−1.15, −0.63]
Extrinsic Motivation	2.14	1.15	0.12	1.86	.063	[−0.12, 4.40]

Note. R^2 = .369; Adjusted R^2 = .364; F(3, 382) = 74.31, p < .001. CI = Confidence Interval.

Discussion

Effect of Motivation Type on Chemistry Performance

The finding that intrinsically motivated students significantly outperformed their extrinsically motivated counterparts in chemistry (M difference = 13.5 points) corroborates the predictions of SDT (Ryan & Deci, 2020) and aligns with a substantial body of empirical evidence. Intrinsically motivated students are more likely to employ deep-learning strategies, persist through conceptual difficulties, and seek to understand rather than merely memorize chemical principles—dispositions that are particularly advantageous in chemistry, where surface-level knowledge rapidly becomes insufficient (Bong et al., 2021; Salta & Koulougliotis, 2020).

The non-significant effect of extrinsic motivation in the regression analysis (β = 0.12, p = .063) is noteworthy. While extrinsic motivation showed a moderate positive zero-order correlation with performance, it did not independently predict chemistry achievement after controlling for intrinsic motivation and test anxiety. This pattern is consistent with Vansteenkiste et al.'s (2020) finding that controlled motivation predicts performance primarily through surface learning strategies that are inadequate for conceptually demanding subjects. In the chemistry context specifically, Fadlelmula et al. (2023) similarly reported that extrinsically motivated students showed inferior performance on application-level chemistry tasks even when their factual recall was comparable to intrinsically motivated peers.

These findings carry important instructional implications. Chemistry teachers who rely primarily on grade-based incentives and punitive assessment practices may inadvertently shift students toward controlled motivational orientations. Classroom practices that support student autonomy such as offering choice in laboratory investigations, using meaningful real-world chemical

contexts, and providing informational (rather than controlling) feedback are theoretically expected and empirically supported to foster intrinsic motivation (Reeve, 2022).

Effect of Test Anxiety on Chemistry Performance

The significant negative effect of test anxiety on chemistry performance ($\beta = -0.39$, $p < .001$) is consistent with the findings of Von der Embse et al. (2018) and Putwain et al. (2021). The large effect sizes observed across anxiety groups ($\eta^2 = 0.243$) suggest that test anxiety is not merely a minor nuisance but a substantive barrier to chemistry achievement. The finding that high-anxiety students scored an average of 26.6 points lower than low-anxiety students represents a practically significant performance gap equivalent to more than two letter-grade distinctions in most Nigerian grading systems.

From an Attentional Control Theory perspective, the high cognitive demand of chemistry examinations which require students to simultaneously retrieve factual knowledge, execute multi-step calculations, and interpret experimental data makes anxiety particularly destructive in this subject. Worry and cognitive interference associated with high anxiety displace chemistry-relevant processing from working memory, producing the marked performance decrements observed in this study. These findings dovetail with Fernandez et al.'s (2022) experimental demonstration that multi-step chemical problem-solving is disproportionately sensitive to anxiety-induced working memory disruptions.

The prevalence of high test anxiety in this sample (29.8%) is alarming and may partly reflect the high-stakes examination culture prevalent in Nigerian secondary schools, where chemistry results are gate-keeping credentials for tertiary science admission. Oghuma et al. (2022) have argued that the singular reliance on terminal examinations in Nigerian secondary science education creates a performance-oriented achievement climate that is theoretically expected to elevate anxiety. Systemic reforms that incorporate formative assessment, portfolio evaluation, and continuous assessment practices may help reduce the anxiety burden on students.

Interaction Between Motivation Type and Test Anxiety

The significant interaction effect ($\eta^2 = 0.047$, $p < .001$) reveals that intrinsic motivation served as a protective buffer against test anxiety, particularly at high anxiety levels. The performance gap between intrinsically and extrinsically motivated students was nearly twice as large among high-anxiety students ($\Delta = 18.4$) as among low-anxiety students ($\Delta = 8.7$). This pattern suggests that intrinsic motivation provides cognitive and affective resources that partially counteract the debilitating effects of test anxiety—a finding consistent with Putwain and Symes (2018) and Huang et al. (2021).

A possible explanation within the CVT framework is that intrinsically motivated students, who appraise chemistry tasks as inherently interesting, experience better task-focused attention even under anxious conditions. Their stronger sense of competence and personal relevance may support the re-appraisal of evaluative situations as challenges rather than threats which is a process linked to reduced anxiety reactivity (Pekrun et al., 2023). Extrinsically motivated students, in contrast, may lack these protective appraisals; their performance is contingent on external validation, making examination failure more ego-threatening and anxiety more incapacitating.

These interaction findings have dual implications. First, anxiety-reduction interventions alone may be insufficient for extrinsically motivated students if motivational orientations are not simultaneously addressed. Second, efforts to cultivate intrinsic motivation in chemistry may have the ancillary benefit of reducing the adverse academic consequences of test anxiety even without directly targeting anxiety itself.

Conclusion

This study provided empirical evidence that motivation type and test anxiety are significant and interactive determinants of secondary school students' academic performance in chemistry. Intrinsic motivation emerged as the strongest positive predictor of chemistry achievement, while test anxiety was the strongest negative predictor. The interaction analyses revealed that intrinsic motivation served as a buffer against the performance-impairing effects of test anxiety, with the most pronounced differences observed among high-anxiety students. These findings underscore the importance of addressing both motivational and anxiety-related factors simultaneously in chemistry education research, practice, and policy.

Recommendations

Based on the findings of this study, the following recommendations are offered:

1. Chemistry teachers should employ autonomy-supportive instructional practices including contextualized learning, student choice in laboratory designs, and informational feedback to foster intrinsic motivation and reduce dependence on external concentration.
2. School counselors should implement evidence-based test anxiety interventions (e.g., cognitive restructuring, mindfulness-based stress reduction, systematic desensitization) as part of a routine pre-examination support programme for chemistry students.
3. The Nigerian secondary school curriculum and examination boards should consider diversifying assessment modalities beyond terminal examinations to include continuous assessment, practical portfolios, and project-based evaluation, thereby reducing the anxiety burden associated with high-stakes testing.

4. Chemistry teacher education programme should incorporate training on motivational climate, SDT-informed classroom management, and recognition of and response to anxiety in students.

5. Future research should examine whether the motivation-anxiety interaction effects generalize across other science subjects (physics, biology) and to private schools, which may operate under different achievement climates.

Limitations of the Study

This study has several limitations that should be noted. First, the survey design precludes causal inferences; the observed relationships are correlational and may be influenced by unmeasured confounding variables such as teacher quality, instructional method, socioeconomic background, and prior chemistry achievement. Second, the study was limited to public secondary schools in Anambra State, Nigeria, restricting generalization to private schools and other geopolitical zones. Third, the self-report nature of the motivational and anxiety measures is susceptible to social desirability and response biases, notwithstanding the anonymity assurances provided. Fourth, the classification of motivation type as a binary variable (intrinsic vs. extrinsic) simplifies the motivational continuum proposed by SDT and may obscure the roles of identified and introjected regulation. Future studies should use continuous motivation profiles or latent profile analysis to capture motivational heterogeneity more accurately.

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