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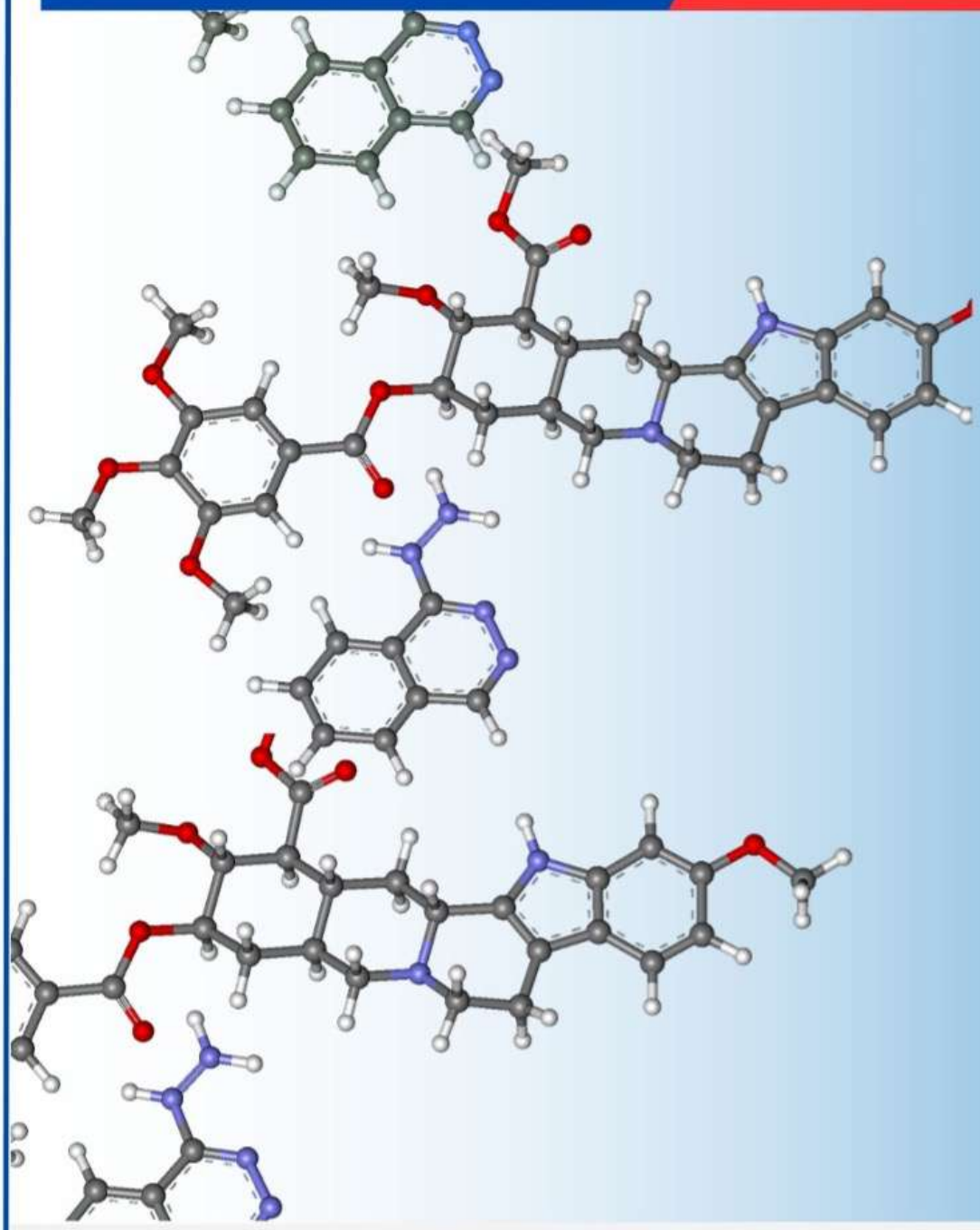

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EDITORIAL

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) 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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GRIT AND EMOTIONAL REGULATION AS PREDICTORS OF SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY IN SOUTHEAST NIGERIA

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Abstract

This study investigated the relationship between grit, emotional regulation, and academic achievement in chemistry among secondary school students in Southeast Nigeria. A sample of 450 senior secondary school students (ages 15-18) was selected using stratified random sampling from 15 schools across the five states of Southeast Nigeria. Data were collected using the Short Grit Scale (Grit-S), the Difficulties in Emotion Regulation Scale (DERS), and students' chemistry achievement test scores. Multiple regression analysis revealed that both grit ($\beta = 0.42$, $p < 0.001$) and emotional regulation ($\beta = -0.38$, $p < 0.001$) were significant predictors of chemistry achievement, jointly accounting for 43% of the variance. Gender differences were observed, with female students demonstrating higher levels of emotional regulation but no significant differences in grit levels. Socioeconomic status moderated the relationship between grit and academic performance. The findings underscore the importance of fostering non-cognitive skills alongside cognitive abilities in chemistry education, with implications for educational policy and pedagogical practice in Nigerian secondary schools.

Keywords: Grit, Emotional Regulation, Academic Achievement, Chemistry Education, Secondary School, Nigeria

1. Introduction

The persistent underperformance of secondary school students in science subjects, particularly chemistry, remains a significant challenge in Nigeria's educational system. According to the West African Examinations Council (WAEC) and National Examinations Council (NECO) statistics, pass rates in chemistry have consistently remained below 50% over the past decade (Nigerian Educational Research and Development Council [NERDC], 2023). This underperformance has raised concerns among educators, policymakers, and researchers, prompting investigations into various factors that may influence academic achievement beyond cognitive abilities.

While traditional factors such as teaching methods, curriculum content, and school resources have been extensively studied, there is growing recognition of the role of non-cognitive factors in academic success (Duckworth et al., 2007; Mega et al., 2014). Two such factors that have gained prominence in educational psychology research are grit and emotional regulation. Tang and Zhu (2023) noted that grit, a relatively newer construct, has gained prominence in the educational psychology literature, defined as a combination of passion and perseverance for long-term goals. Cheon et al. (2024) conducted two randomized controlled trials to help

teachers develop physical education students' course-specific grit-perseverance and mental toughness, published in the Journal of Sport and Exercise Psychology. Also, a comprehensive bibliometric review by Fan and Chiang (2024) analysed 121 core academic articles on L2 grit published between 2016 and 2024, showing that research evolved through three distinct stages: initial exploration, rapid growth, and diversification. On the other hand, Aldrup, Carstensen, and Klusmann (2023) published a systematic review in Educational Psychologist integrating four lines of research on teachers' emotion regulation and teaching effectiveness, analysing 68 records published between 2009 and 2023. Wang, Buric, Chang, and Gross (2023) conducted a comprehensive meta-analysis on teachers' emotion regulation and related environmental, personal, instructional, and well-being factors.

Grit, defined as "perseverance and passion for long-term goals" (Duckworth et al., 2007, p. 1087), has emerged as a significant predictor of academic success across various educational contexts. It encompasses the tendency to sustain interest and effort toward challenging long-term goals despite setbacks and failures. Emotional regulation, on the other hand, refers to the processes by which individuals monitor, evaluate, and modify their emotional reactions to accomplish their goals (Gross, 2015). Both constructs represent non-cognitive skills that may influence how students approach challenging academic subjects like chemistry.

The Nigerian educational context, particularly in the Southeast region, presents unique socio-cultural dynamics that may influence the development and expression of grit and emotional regulation skills among students. The Igbo culture, predominant in Southeast Nigeria, emphasizes educational achievement, resilience, and self-discipline (Nwoye, 2017), values that align closely with the concept of grit. However, there is limited empirical research on how these psychological constructs operate within this specific cultural context and how they relate to academic performance in science subjects.

This study aims to fill this gap by examining the relationship between grit, emotional regulation, and academic achievement in chemistry among secondary school students in Southeast Nigeria. By focusing on these non-cognitive factors, the research contributes to a more comprehensive understanding of the determinants of academic success in chemistry and provides insights that could inform educational interventions aimed at improving science education outcomes in Nigerian secondary schools.

1.1 Purpose of the Study

The primary purpose of this study is to investigate the extent to which grit and emotional regulation predict academic achievement in chemistry among secondary school students in Southeast Nigeria. Specifically, the study aims to:

1. Determine the relationship between grit and chemistry achievement among secondary school students.
2. Examine the relationship between emotional regulation and chemistry achievement among secondary school students.
3. Investigate whether grit and emotional regulation jointly predict chemistry achievement.
4. Explore potential gender differences in grit, emotional regulation, and their relationship with chemistry achievement.

5. Examine the moderating effect of socioeconomic status on the relationship between grit, emotional regulation, and chemistry achievement.

1.2 Research Questions

1. To what extent does grit predict academic achievement in chemistry among secondary school students in Southeast Nigeria?
2. To what extent does emotional regulation predict academic achievement in chemistry among secondary school students in Southeast Nigeria?
3. To what extent do grit and emotional regulation jointly predict academic achievement in chemistry among secondary school students in Southeast Nigeria?
4. Are there significant gender differences in the levels of grit, emotional regulation and academic achievement among secondary school students in Southeast Nigeria?
5. Does socioeconomic status moderate the relationship between grit, emotional regulation, and academic achievement in chemistry?

2. Literature Review

2.1 Theoretical Framework

This study is anchored in two primary theoretical frameworks: Duckworth's theory of grit (Duckworth et al., 2007) and Gross's process model of emotional regulation (Gross, 2015). Additionally, the social cognitive theory (Bandura, 1986) provides a broader framework for understanding how personal factors interact with environmental influences to shape academic behaviours and outcomes.

Duckworth's theory of grit posits that achievement of difficult goals entails not only talent but also the sustained and focused application of talent over time. Grit encompasses two key components: consistency of interest (passion) and perseverance of effort. According to this theory, individuals with high levels of grit are more likely to persist in challenging tasks and thus achieve greater success in domains requiring sustained effort, such as academic learning (Duckworth & Quinn, 2009).

Gross's process model of emotional regulation describes various strategies individuals use to manage their emotions at different points in the emotion-generative process. These strategies include situation selection, situation modification, attentional deployment, cognitive change, and response modulation. According to this model, adaptive emotional regulation involves the flexible use of these strategies to modify emotional experiences and expressions in ways that facilitate goal attainment (Gross, 2015).

Social cognitive theory (Bandura, 1986) provides a framework for understanding how personal factors (such as grit and emotional regulation skills), behavioural patterns, and environmental influences interact reciprocally to determine learning outcomes. This theory emphasizes the role of self-efficacy, self-regulation, and environmental supports in academic achievement, suggesting that students' beliefs about their capabilities, their ability to regulate learning behaviours, and the contextual factors in their learning environment collectively influence academic performance.

2.2 Grit and Academic Achievement

Research on the relationship between grit and academic achievement has yielded mixed but generally positive findings. In their seminal work, Duckworth et al. (2007) found that grit predicted educational attainment among adults and academic performance among undergraduate psychology students. Subsequent studies have demonstrated significant positive correlations between grit and various academic outcomes, including GPA (Muenks et al., 2017), retention rates (Eskreis-Winkler et al., 2014), and graduation rates (Duckworth & Quinn, 2009).

In the Nigerian context, studies examining grit in relation to academic achievement are emerging. Adegboyega (2021) found that grit significantly predicted academic achievement among university students in Southwest Nigeria, while Nwosu et al. (2022) reported positive correlations between perseverance (a component of grit) and mathematics performance among secondary school students in Anambra State. However, research specifically examining grit in relation to chemistry achievement in Nigerian secondary schools remains scarce.

The relevance of grit to chemistry education is particularly noteworthy. Chemistry, with its abstract concepts, mathematical applications, and laboratory experimentation, presents unique challenges for learners (Johnstone, 2006). Mastery of chemistry concepts often requires persistent effort through repeated practice, problem-solving, and revision—qualities that align with the perseverance aspect of grit. Additionally, developing interest and passion for chemistry despite its challenging nature reflects the consistency of interest component of grit.

2.3 Emotional Regulation and Academic Achievement

Emotional regulation has been increasingly recognized as an important factor in academic success. Research suggests that students who can effectively regulate their emotions tend to demonstrate better academic performance across various subjects (Mega et al., 2014; Valiente et al., 2012). Specifically, adaptive emotional regulation has been linked to improved attention and concentration, increased academic engagement, and reduced test anxiety (Gross & Thompson, 2007).

In the context of science education, emotional regulation may be particularly important due to the cognitive demands and potential frustrations associated with learning complex scientific concepts. Chemistry, in particular, evokes various emotions in students, from curiosity and excitement to anxiety and frustration (Alsop & Watts, 2003). Students who can effectively manage these emotions may be better positioned to engage productively with challenging chemistry content.

Studies in the Nigerian context have begun to explore the role of emotional factors in academic achievement. Ogundokun (2011) found that emotional intelligence, a construct related to emotional regulation, significantly predicted academic achievement among secondary school students in Southwest Nigeria. Similarly, Igbo et al. (2020) reported that emotional self-regulation was positively correlated with academic performance among adolescents in Eastern Nigeria. However, research specifically examining emotional regulation in relation to chemistry achievement remains limited.

2.4 Gender Differences in Grit, Emotional Regulation, and Academic Achievement

Research on gender differences in grit has produced inconsistent findings. Some studies have found no significant differences between males and females in overall grit scores (Duckworth & Quinn, 2009), while others have reported higher grit levels among females (Christensen & Knezek, 2014). In the Nigerian context, Adegboyega (2021) found no significant gender differences in grit among university students.

With regard to emotional regulation, research generally suggests that females tend to exhibit higher levels of emotional awareness and expression but may also experience greater difficulties with certain aspects of emotional regulation compared to males (Nolen-Hoeksema & Aldao, 2011). In the Nigerian context, Umaru and Umma (2015) found that female secondary school students reported higher emotional intelligence scores than their male counterparts.

Gender disparities in science achievement have been well-documented globally and in Nigeria specifically. Historically, male students have tended to outperform female students in physical sciences, including chemistry (Ezeudu & Obi, 2015). However, recent trends suggest that these gaps may be narrowing in some contexts (National Bureau of Statistics [NBS], 2023). The interplay between gender, non-cognitive factors (such as grit and emotional regulation), and chemistry achievement remains an area requiring further investigation.

2.5 Socioeconomic Status, Non-cognitive Factors, and Academic Achievement

Socioeconomic status (SES) has been consistently identified as a significant predictor of academic achievement, with students from higher SES backgrounds generally performing better academically than their lower SES counterparts (Sirin, 2005). In Nigeria, socioeconomic disparities in educational outcomes are particularly pronounced, with students from disadvantaged backgrounds facing numerous obstacles to academic success (Olanipekun et al., 2019).

Research suggests that SES may moderate the relationship between non-cognitive factors and academic achievement. For instance, Claro et al. (2016) found that while growth mindset (a construct related to grit) predicted academic achievement across all socioeconomic levels, its effect was more pronounced among students from lower SES backgrounds. Similarly, Evans and Rosenbaum (2008) found that self-regulation (which includes aspects of emotional regulation) partially mediated the relationship between SES and academic achievement.

In the Nigerian context, studies have begun to explore how SES interacts with psychological factors to influence academic outcomes. Ogunleye and Akinsola (2018) found that self-efficacy moderated the relationship between SES and chemistry achievement among secondary school students in Lagos State. However, research examining how SES might moderate the influence of grit and emotional regulation on academic outcomes in Southeast Nigeria remains limited.

While existing research provides valuable insights into the relationships between grit, emotional regulation, and academic achievement, several gaps remain, particularly in the Nigerian context:

1. Limited research on these non-cognitive factors in relation to chemistry achievement specifically.
2. Scarcity of studies focusing on secondary school students in Southeast Nigeria.

3. Insufficient attention to potential moderating factors such as gender and socioeconomic status.
4. Limited integration of cultural perspectives in understanding how grit and emotional regulation operate within the Nigerian educational context.

This study aims to address these gaps by examining the predictive relationship between grit, emotional regulation, and chemistry achievement among secondary school students in Southeast Nigeria, while also considering the potential moderating effects of gender and socioeconomic status.

3. Methodology

3.1 Research Design

This study employed a correlational research design to investigate the relationship between grit, emotional regulation, and academic achievement in chemistry. This design was appropriate for examining the predictive relationships among variables without manipulating the independent variables (Creswell & Creswell, 2018).

3.2 Population and Sample

The population for this study comprised all senior secondary school (SSS) 2 students in government-approved secondary schools across the five states of Southeast Nigeria: Abia, Anambra, Ebonyi, Enugu, and Imo. According to the most recent data from the Federal Ministry of Education (2023), this population consists of approximately 320,000 students.

A sample of 450 students (236 females and 214 males) was selected using a stratified random sampling technique. Three secondary schools were randomly selected from each of the five states, resulting in a total of 15 schools. From each school, 30 SS2 students were randomly selected to participate in the study. The selection ensured proportional representation of both genders and various socioeconomic backgrounds.

The age range of participants was 15-18 years, with a mean age of 16.4 years (SD = 0.78). The sample included students from urban (45%), semi-urban (30%), and rural (25%) schools to ensure representativeness across different educational contexts in Southeast Nigeria.

3.3 Instruments

3.3.1 Short Grit Scale (Grit-S)

Grit was measured using the Short Grit Scale (Grit-S) developed by Duckworth and Quinn (2009). This 8-item self-report measure assesses two dimensions of grit: consistency of interest (4 items) and perseverance of effort (4 items). Items are rated on a 5-point Likert scale ranging from 1 (not like me at all) to 5 (very much like me). Sample items include "I have overcome setbacks to conquer an important challenge" (perseverance) and "I often set a goal but later choose to pursue a different one" (consistency of interest, reverse-scored). The scale yields a total grit score, with higher scores indicating greater grit.

The Grit-S has demonstrated good psychometric properties across various populations. For this study, the scale was adapted to the Nigerian context following a pilot study and expert review. The Cronbach's alpha coefficient for the adapted Grit-S in this study was 0.82, indicating good internal consistency.

3.3.2 Difficulties in Emotion Regulation Scale (DERS)

Emotional regulation was measured using the Difficulties in Emotion Regulation Scale (DERS) developed by Gratz and Roemer (2004). The DERS is a 36-item self-report measure that assesses six dimensions of emotional regulation difficulties: non-acceptance of emotional responses, difficulties engaging in goal-directed behaviour, impulse control difficulties, lack of emotional awareness, limited access to emotional regulation strategies, and lack of emotional clarity.

Items are rated on a 5-point Likert scale ranging from 1 (almost never) to 5 (almost always). The scale yields a total score, with higher scores indicating greater difficulties in emotional regulation (i.e., poorer emotional regulation skills). For ease of interpretation in this study, scores were reverse-coded so that higher scores reflected better emotional regulation abilities.

The DERS has demonstrated good psychometric properties across various populations. For this study, the scale was adapted to the Nigerian context following a pilot study and expert review. The Cronbach's alpha coefficient for the adapted DERS in this study was 0.85, indicating good internal consistency.

3.3.3 Chemistry Achievement Test (CAT)

Academic achievement in chemistry was measured using a researcher-developed Chemistry Achievement Test (CAT). The CAT was a 50-item multiple-choice test covering key concepts from the SS2 chemistry curriculum as prescribed by the Nigerian Educational Research and Development Council (NERDC). The test assessed students' knowledge and understanding of concepts in physical chemistry, organic chemistry, and inorganic chemistry. The content validity of the CAT was established through expert review by five experienced chemistry teachers and two measurement and evaluation specialists. The test items were pilot-tested with a sample of 80 SS2 students who were not part of the main study. Item analysis was conducted to determine item difficulty and discrimination indices, and problematic items were revised or replaced. The Kuder-Richardson formula 20 (KR-20) reliability coefficient for the final version of the CAT was 0.86, indicating good internal consistency.

3.3.4 Socioeconomic Status Questionnaire (SESQ)

Socioeconomic status was measured using a researcher-developed Socioeconomic Status Questionnaire (SESQ). The SESQ collected information on parents' education, occupation, income bracket, housing type, and possession of household amenities. Based on these indicators, a composite SES score was computed for each participant, and participants were categorized into low, middle, and high SES groups for analysis purposes. The validity of the SESQ was established through expert review by three sociologists and two educational psychologists familiar with the Nigerian context. The test-retest reliability coefficient of the SESQ over a two-week interval was 0.89, indicating good stability.

3.4 Data Collection Procedure

Permission was sought from the State Ministries of Education and principals of the selected schools. Informed consent was obtained from parents/guardians and assent from the students themselves. Data collection was conducted during regular school hours by the researcher and

four trained research assistants. The instruments were administered in the following order: Socioeconomic Status Questionnaire, Short Grit Scale, Difficulties in Emotion Regulation Scale, and finally the Chemistry Achievement Test. The entire data collection process for each participant took approximately 90 minutes, with a short break provided between the completion of the questionnaires and the administration of the achievement test. To minimize response bias, participants were assured of the confidentiality of their responses and were informed that there were no right or wrong answers to the questionnaire items. The CAT was administered under examination conditions to ensure the validity of the achievement scores.

3.5 Data Analysis

Data were analysed using both descriptive and inferential statistics. Descriptive statistics, including means, standard deviations, and percentages, were used to summarize the demographic characteristics of the sample and the distribution of scores on the key variables.

Pearson product-moment correlation analysis was used to examine the bivariate relationships among grit, emotional regulation, and chemistry achievement. Multiple regression analysis was employed to determine the extent to which grit and emotional regulation predicted chemistry achievement, both individually and jointly.

Independent samples t-tests were conducted to examine gender differences in grit, emotional regulation, and chemistry achievement. Moderated multiple regression analysis was used to investigate whether socioeconomic status moderated the relationship between the predictor variables (grit and emotional regulation) and the outcome variable (chemistry achievement).

All statistical analyses were performed using IBM SPSS Statistics (Version 27), with a significance level of 0.05 adopted for all inferential tests.

4. Results

4.1 Descriptive Statistics

Table 1: Descriptive Statistics for Key Variables (N = 450)

Variable`	Mean	SD	Min	Max	Skewness	Kurtosis
Grit	3.42	0.68	1.75	5.00	-0.26	-0.52
Emotional Regulation (higher = better)	3.42	0.74	1.42	5.00	-0.18	-0.63
Chemistry Achievement (%)	63.45	15.12	28.00	96.00	-0.34	-0.47

Table 1 presents the descriptive statistics for the key variables in the study. The mean score for grit was 3.42 (SD = 0.68) on a 5-point scale, indicating a moderate level of grit among the participants. The mean score for emotional regulation difficulties was 2.58 (SD = 0.74), suggesting that participants experienced moderate levels of difficulty in regulating their emotions. The mean score for chemistry achievement was 63.45% (SD = 15.12), indicating moderate performance on the chemistry test.

4.2 Correlation Analysis

Table 2: Bivariate Correlations Among Key Variables (N = 450)

Variable	1	2	3
1. Grit	1.00		
2. Emotional Regulation	0.40**	1.00	
3. Chemistry Achievement	0.51**	0.48**	1.00

Note: ** $p < 0.001$

Table 2 presents the bivariate correlations among the key variables. Grit was positively correlated with chemistry achievement ($r = 0.51$, $p < 0.001$), indicating that students with higher levels of grit tended to perform better in chemistry. Emotional regulation was also positively correlated with chemistry achievement ($r = 0.48$, $p < 0.001$), suggesting that students with better emotional regulation skills (lower difficulties) tended to achieve higher scores in chemistry. A moderate positive correlation was observed between grit and emotional regulation ($r = 0.40$, $p < 0.001$), indicating that these non-cognitive factors are related but distinct constructs.

4.3 Multiple Regression Analysis

Table 3: Multiple Regression Analysis Predicting Chemistry Achievement from Grit and Emotional Regulation (N = 450)

Predictor	B	SE	B	T	P	VIF
(Constant)	12.36	3.21		3.85	< 0.001	
Grit	9.28	0.95	0.42	9.77	< 0.001	1.19
Emotional Regulation	7.73	0.88	0.38	8.78	< 0.001	1.19

Note: $R^2 = 0.43$, Adjusted $R^2 = 0.42$, $F(2, 447) = 165.42$, $p < 0.001$

Multiple regression analysis was conducted to determine the extent to which grit and emotional regulation predicted chemistry achievement. The results are presented in Table 3.

The regression model was statistically significant, $F(2, 447) = 165.42$, $p < 0.001$, with the two predictor variables jointly accounting for 43% of the variance in chemistry achievement ($R^2 = 0.43$, Adjusted $R^2 = 0.42$). Both grit ($\beta = 0.42$, $p < 0.001$) and emotional regulation ($\beta = 0.38$, $p < 0.001$) were significant predictors of chemistry achievement.

The variance inflation factor (VIF) values were well below 10, indicating no multicollinearity issues between the predictor variables.

4.4 Gender Differences

Table 4: Gender Differences in Key Variables

Variable	Males (n = 214)	Females (n = 236)	T	p	Cohen's d
	M (SD)	M (SD)			
Grit	3.46 (0.70)	3.38 (0.66)	1.26	0.209	0.12
Emotional Regulation	3.31 (0.76)	3.52 (0.70)	3.42	0.001	0.32
Chemistry Achievement	64.72 (14.98)	62.28 (15.19)	1.64	0.102	0.15

Independent samples t-tests were conducted to examine gender differences in grit, emotional regulation, and chemistry achievement. The results are presented in Table 4.

No significant gender differences were observed in grit scores, $t(448) = 1.26$, $p = 0.209$, with males ($M = 3.46$, $SD = 0.70$) and females ($M = 3.38$, $SD = 0.66$) reporting similar levels of grit. Significant gender differences were observed in emotional regulation, $t(448) = 3.42$, $p = 0.001$, with females ($M = 3.52$, $SD = 0.70$) reporting better emotional regulation skills than males ($M = 3.31$, $SD = 0.76$).With regard to chemistry achievement, no significant gender differences were observed, $t(448) = 1.64$, $p = 0.102$, although males ($M = 64.72$, $SD = 14.98$) scored slightly higher than females ($M = 62.28$, $SD = 15.19$).

4.5 Moderating Effect of Socioeconomic Status

Table 5: Moderated Multiple Regression Analysis of the Effect of SES on the Relationship Between Grit, Emotional Regulation, and Chemistry Achievement

Predictor	B	SE	β	t	P
(Constant)	20.45	3.67		5.57	< 0.001
Grit (G)	8.64	0.97	0.39	8.91	< 0.001
Emotional Regulation (ER)	7.52	0.88	0.37	8.55	< 0.001
Socioeconomic Status (SES)	3.28	0.96	0.14	3.42	0.001
G × SES	2.87	1.05	0.12	2.73	0.006
ER × SES	1.24	1.01	0.05	1.23	0.219

Note: $R^2 = 0.46$, Adjusted $R^2 = 0.45$, $F(5, 444) = 74.85$, $p < 0.001$

Moderated multiple regression analysis was conducted to examine whether socioeconomic status moderated the relationship between grit, emotional regulation, and chemistry achievement. The results are presented in Table 5.

The analysis revealed a significant interaction between grit and socioeconomic status in predicting chemistry achievement ($\beta = 0.12$, $p = 0.006$), indicating that the relationship between grit and chemistry achievement was moderated by socioeconomic status. Specifically, the relationship between grit and chemistry achievement was stronger for students from lower SES backgrounds ($\beta = 0.55$, $p < 0.001$) compared to those from higher SES backgrounds ($\beta = 0.31$, $p < 0.001$).

No significant interaction was observed between emotional regulation and socioeconomic status in predicting chemistry achievement ($\beta = 0.05$, $p = 0.219$), suggesting that the relationship between emotional regulation and chemistry achievement did not vary significantly across socioeconomic levels.

5. Discussion

The present study investigated the relationship between grit, emotional regulation, and academic achievement in chemistry among secondary school students in Southeast Nigeria. The findings revealed that both grit and emotional regulation were significant predictors of chemistry achievement, jointly accounting for 43% of the variance. These results align with previous research demonstrating the importance of non-cognitive factors in academic success

(Duckworth et al., 2007; Mega et al., 2014) and extend this line of inquiry to the specific context of chemistry education in Nigerian secondary schools.

5.1 Grit and Chemistry Achievement

The significant positive relationship between grit and chemistry achievement observed in this study ($\beta = 0.42$, $p < 0.001$) is consistent with previous research demonstrating the role of perseverance and passion in academic success (Duckworth et al., 2007; Muenks et al., 2017). This finding suggests that students who maintain consistent interest and persistent effort in their chemistry studies, despite challenges and setbacks, tend to achieve better academic outcomes.

The relevance of grit to chemistry achievement can be understood in terms of the nature of chemistry as a discipline. Chemistry learning involves mastering abstract concepts (such as atomic structure, chemical bonding, and reaction mechanisms), developing mathematical problem-solving skills, and conducting practical laboratory work (Johnstone, 2006). These demands require sustained effort and persistence through difficulties—qualities that characterize high levels of grit.

In the Nigerian context, where educational resources may be limited and class sizes large, individual differences in grit may become particularly salient. Students with high levels of grit may be better equipped to overcome the challenges posed by infrastructural deficiencies, teacher shortages, and limited access to learning materials (Olanipekun et al., 2019). By persisting through these challenges and maintaining focus on their long-term educational goals, high-grit students may gain a significant advantage in chemistry achievement.

5.2 Emotional Regulation and Chemistry Achievement

The significant positive relationship between emotional regulation and chemistry achievement observed in this study ($\beta = 0.38$, $p < 0.001$) aligns with previous research demonstrating the importance of emotional processes in academic learning (Gross & Thompson, 2007; Mega et al., 2014). This finding suggests that students who can effectively manage their emotions during the learning process tend to perform better in chemistry.

Several mechanisms may explain the link between emotional regulation and chemistry achievement. First, effective emotional regulation may help students manage anxiety and frustration associated with challenging chemistry concepts, thereby enabling better concentration and information processing (Gross, 2015). Second, emotional regulation may facilitate adaptive responses to academic setbacks, such as poor test performance or difficulty understanding new concepts, allowing students to persevere rather than disengage (Valiente et al., 2012). Third, emotional regulation may promote positive academic emotions such as curiosity and interest, which are crucial for deep engagement with chemistry content (Pekrun et al., 2017).

The cultural context of Southeast Nigeria may add another dimension to the relationship between emotional regulation and academic achievement. In traditional Igbo society, emotional restraint and self-discipline are highly valued (Nwoye, 2017). Students who have internalized these cultural values may be particularly adept at regulating their emotions in

academic contexts, giving them an advantage in navigating the emotional challenges of chemistry learning.

5.3 Gender Differences

The absence of significant gender differences in grit scores observed in this study is consistent with some previous research (Duckworth & Quinn, 2009) but contrasts with studies that have found gender differences (Christensen & Knezek, 2014). This finding suggests that in the cultural context of Southeast Nigeria, both male and female students develop similar levels of perseverance and passion for long-term goals, perhaps reflecting shared socialization practices that emphasize educational achievement.

The significant gender difference in emotional regulation, with females demonstrating better emotional regulation skills than males, aligns with previous research on gender differences in emotional competencies (Nolen-Hoeksema & Aldao, 2011). This finding may reflect gender-specific socialization practices in Nigerian society, where females are often encouraged to be more attuned to emotions and to develop skills for managing interpersonal relationships (Umaru & Umma, 2015).

The absence of significant gender differences in chemistry achievement, despite historical patterns of male advantage in physical sciences, is encouraging and may indicate progress toward greater gender equity in science education in Nigerian secondary schools. This finding aligns with recent reports of narrowing gender gaps in science achievement both globally and in Nigeria specifically (NBS, 2023).

5.4 Moderating Effect of Socioeconomic Status

The finding that socioeconomic status moderated the relationship between grit and chemistry achievement, with the relationship being stronger for students from lower SES backgrounds, has important implications for educational equity. This result suggests that grit may serve as a protective factor for socioeconomically disadvantaged students, helping them overcome resource limitations and other obstacles to academic success.

This finding is consistent with previous research suggesting that non-cognitive factors may be particularly important for students facing structural disadvantages (Claro et al., 2016). For students from lower SES backgrounds in Southeast Nigeria, who may have limited access to educational resources, private tutoring, and parental academic support, personal qualities such as perseverance and passion for long-term goals may be crucial for academic success in challenging subjects like chemistry.

The non-significant interaction between emotional regulation and socioeconomic status suggests that the benefits of effective emotional regulation for chemistry achievement are relatively consistent across socioeconomic levels. This finding indicates that emotional regulation represents a universally important skill for academic success, regardless of students' socioeconomic background.

5.5 Educational Implications

The findings of this study have several important implications for educational practice and policy in Nigerian secondary schools:

1. Curriculum Development and Implementation

The significant predictive power of grit and emotional regulation on chemistry achievement suggests that the Nigerian chemistry curriculum should be expanded beyond cognitive content to explicitly incorporate non-cognitive skill development. The Nigerian Educational Research and Development Council (NERDC) should consider revising the chemistry curriculum to include learning objectives related to perseverance, emotional awareness, and self-regulation. This holistic approach would align with the broader goals of developing well-rounded students capable of succeeding in an increasingly complex and demanding world.

Chemistry textbooks and instructional materials should include sections on study strategies, goal-setting techniques, and methods for managing academic stress and frustration. These materials should provide students with concrete tools for developing grit and emotional regulation skills within the context of chemistry learning.

2. **Teacher Training and Professional Development**

The findings underscore the need for comprehensive teacher training programs that equip chemistry teachers with knowledge and skills for fostering non-cognitive development alongside content mastery. Pre-service teacher education programs at Nigerian colleges of education and universities should incorporate courses on educational psychology, focusing on non-cognitive factors in learning and strategies for promoting these skills in the classroom.

In-service professional development programs should be organized regularly to update practicing chemistry teachers on research-based strategies for developing students' grit and emotional regulation skills. These programs should include practical workshops where teachers can learn and practice specific instructional techniques, such as:

- Implementing growth mindset interventions that help students view challenges as opportunities for learning
- Using formative assessment and constructive feedback to promote perseverance
- Teaching emotional awareness and regulation strategies explicitly
- Creating classroom environments that support risk-taking and learning from failure
- Incorporating metacognitive reflection activities that help students monitor their emotional states and learning processes

3. Pedagogical Practices in Chemistry Classrooms

Chemistry teachers should adopt instructional approaches that deliberately foster grit and emotional regulation. Several specific strategies can be implemented: for Promoting Grit, this is setting long-term chemistry learning goals with students and regularly monitor progress toward these goals, share stories of successful scientists who faced and overcame significant obstacles, emphasizing the role of perseverance, design challenging but achievable tasks that require sustained effort over time. Secondly, for Developing Emotional Regulation**,** this will be beginning chemistry lessons with brief mindfulness or breathing exercises to help students manage anxiety, teach students to identify and label emotions experienced during chemistry learning, provide explicit instruction on coping strategies for dealing with frustration when

facing difficult concepts, create a supportive classroom climate where students feel safe expressing confusion or difficulty and incorporate peer learning opportunities where students can share emotional and cognitive challenges.

4. Addressing Socioeconomic Disparities

The finding that grit has a stronger relationship with chemistry achievement for students from lower socioeconomic backgrounds highlights the importance of targeted interventions for disadvantaged students. Schools and policymakers should:

- Prioritize grit-building interventions in schools serving predominantly low-SES communities
- Provide additional support systems (such as tutoring, mentoring, and after-school programs) that help disadvantaged, students develop and maintain long-term academic goals
- Ensure equitable access to educational resources and materials that support sustained engagement with chemistry content
- Partner with community organizations and non-governmental organizations to provide scholarships, learning materials, and enrichment programs for students from low-SES backgrounds
- Implement summer bridge programs that help students from disadvantaged backgrounds develop the non-cognitive skills necessary for success in challenging science courses

5. Parental Involvement and Community Engagement

Parents and guardians play a crucial role in developing children's non-cognitive skills. Schools should: Organize parent education workshops on the importance of grit and emotional regulation for academic success, provide parents with practical strategies for fostering these skills at home, such as encouraging children to complete challenging tasks, modelling emotional regulation, and praising effort rather than innate ability, establish parent-teacher partnerships focused on supporting students' non-cognitive development.

6. Gender-Responsive Interventions

Although no significant gender differences were found in grit or chemistry achievement, the gender difference in emotional regulation suggests the need for gender-responsive interventions:

- Provide targeted emotional regulation training for male students, who demonstrated lower levels of emotional regulation skills
- Ensure that chemistry learning environments are equally supportive and engaging for both male and female students
- Challenge gender stereotypes that may influence students' emotional expression and regulation
- Provide role models of both genders who demonstrate effective emotional regulation in scientific pursuits

- Monitor gender equity in chemistry education continuously and address any emerging disparities

Recommendations:

At the broader policy level, several recommendations emerge from this study:

1. The Federal Ministry of Education and State Ministries of Education should mandate the integration of non-cognitive skill development into the national chemistry curriculum and other science curricula.
2. Establish minimum standards for teacher education programs that include training on fostering non-cognitive skills. The National Teachers' Institute (NTI) should develop specific modules on promoting grit and emotional regulation.
3. Allocate funding for the development of instructional materials, assessment tools, and intervention programs focused on non-cognitive skill development in science education.
4. Establish a national research agenda on non-cognitive factors in science education and fund longitudinal studies to track the long-term effects of interventions.
5. Invest in improving school infrastructure and resources, particularly in disadvantaged areas, to create learning environments conducive to developing perseverance and emotional regulation.
6. Revise school accountability systems to include indicators of non-cognitive skill development alongside academic achievement measures.
7. Mandate regular professional development for all chemistry teachers focused on evidence-based practices for promoting non-cognitive skills.

6. Conclusion

This study investigated the relationship between grit, emotional regulation, and academic achievement in chemistry among secondary school students in Southeast Nigeria. The findings demonstrate that both grit and emotional regulation are significant predictors of chemistry achievement, jointly accounting for 43% of the variance in student performance. These results underscore the critical importance of non-cognitive factors in science education and provide compelling evidence that academic success in chemistry depends not only on cognitive abilities but also on psychological and emotional competencies.

The study revealed that students who demonstrate perseverance, maintain consistent interest in long-term academic goals, and effectively manage their emotions during learning are better positioned to succeed in chemistry. This finding has profound implications for educational practice, suggesting that chemistry educators must adopt a more holistic approach that nurtures both cognitive and non-cognitive skills.

The moderating effect of socioeconomic status on the relationship between grit and chemistry achievement highlights the particular importance of fostering resilience and perseverance among students from disadvantaged backgrounds. For these students, grit may serve as a critical protective factor that helps them overcome structural obstacles and achieve academic

success despite limited resources. This finding points to the potential of non-cognitive interventions as a strategy for promoting educational equity in Nigerian schools.

The absence of significant gender differences in grit and chemistry achievement is encouraging and suggests progress toward gender equity in science education in Southeast Nigeria. However, the gender difference in emotional regulation indicates the need for targeted interventions to support male students in developing emotional competencies.

From a practical standpoint, this study provides a strong rationale for integrating non-cognitive skill development into chemistry education in Nigerian secondary schools. Teachers, school administrators, curriculum developers, and policymakers should work collaboratively to create learning environments and implement instructional practices that foster grit and emotional regulation alongside content mastery. This may involve revising curricula, transforming pedagogical approaches, enhancing teacher training programs, and implementing school-wide initiatives that support students' psychological and emotional development.

The findings also highlight the need for systemic changes in the Nigerian educational system. Beyond classroom-level interventions, there is a need for policy reforms that recognize the importance of non-cognitive factors in academic achievement and allocate resources accordingly. Investment in teacher professional development, development of culturally appropriate instructional materials, and establishment of student support services are essential for creating an educational ecosystem that nurtures the whole student.

This study contributes to the growing body of literature demonstrating that academic achievement is multifaceted, influenced by a complex interplay of cognitive, emotional, motivational, and contextual factors. By focusing on grit and emotional regulation in the specific context of chemistry education in Southeast Nigeria, the study extends our understanding of how non-cognitive factors operate in diverse cultural and educational settings.

Looking forward, continued research is needed to further elucidate the mechanisms through which grit and emotional regulation influence chemistry achievement and to develop and evaluate interventions that effectively promote these skills. Longitudinal studies tracking students over time would provide valuable insights into the causal pathways and long-term impacts of non-cognitive skills on educational and career outcomes.

Ultimately, the goal of chemistry education should be not only to transmit knowledge of chemical principles but also to develop resilient, emotionally intelligent individuals who can persevere through challenges, regulate their emotions effectively, and achieve their full potential. By recognizing and actively fostering non-cognitive skills such as grit and emotional regulation, educators can help students not only succeed in chemistry but also develop competencies that will serve them well throughout their academic careers and beyond.

The present study demonstrates that in the context of Nigerian secondary education, fostering grit and emotional regulation represents a promising avenue for improving chemistry achievement and, by extension, advancing the broader goals of science education. As Nigeria strives to develop its human capital and compete in an increasingly knowledge-based global economy, nurturing both the cognitive and non-cognitive capacities of its students will be essential. This study provides evidence and direction for such efforts, with implications that extend beyond chemistry classrooms to the entire educational enterprise.

In conclusion, grit and emotional regulation are not mere buzzwords but represent substantive psychological constructs with real implications for educational outcomes. Their significant predictive relationship with chemistry achievement among secondary school students in Southeast Nigeria underscores the need for a paradigm shift in how we conceptualize and approach science education. By embracing a more comprehensive view of student success—one that values perseverance, passion, and emotional competence alongside intellectual ability—we can create more effective, equitable, and humane educational systems that truly prepare students for the challenges and opportunities of the 21st century.

Limitations of the Study

1. The correlational nature of this study limits causal inferences. While grit and emotional regulation predict chemistry achievement, the directionality of these relationships cannot be definitively established. Longitudinal research is needed to examine causal pathways.
2. The use of self-report questionnaires for measuring grit and emotional regulation may be subject to social desirability bias and may not fully capture actual behavioural manifestations of these constructs. Future research could incorporate teacher ratings, parent ratings, or behavioural observations.
3. This study focused on Southeast Nigeria, and findings may not be generalizable to other regions of Nigeria with different cultural and educational contexts. Future research should examine these relationships in other Nigerian regions.
4. The study focused on SS2 students; the relationships observed may differ for students at other educational levels. Additionally, only students in government-approved schools were included, potentially excluding students in private or informal educational settings.
5. Chemistry achievement was measured using a single test, which may not fully capture students' comprehensive understanding and competence in chemistry. Future research could incorporate multiple measures of achievement, including practical laboratory skills and long-term retention of knowledge.

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