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Relationship between Grit and Mathematical Ability as Predictors of Senior Secondary School Chemistry Students Achievement in Jahun Education Zone Jigawa State, Nigeria

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Abstract

This study investigated the relationship between grit and mathematical ability as predictors of senior secondary school students' achievement in Chemistry in Jahun Education Zone, Jigawa State, Nigeria. Using a correlational research design, data were collected from 210 Senior Secondary School II students sampled from five public secondary schools. Three instruments—the Chemistry Grit Scale (CGS), Chemistry Students Mathematical Ability Test (CSMAT), and Chemistry Achievement Test (CAT)—were employed to measure students' grit, mathematical ability, and Chemistry achievement. Descriptive statistics (mean, standard deviation) summarized the data, while Pearson Product-Moment Correlation and Multiple Regression Analysis were used to examine relationships and predictive effects. Findings revealed a significant moderate positive relationship between grit and Chemistry achievement ($r = 0.462$, $p < 0.05$) and a significant strong positive relationship between mathematical ability and Chemistry achievement ($r = 0.681$, $p < 0.05$). These results indicate that students' perseverance and consistency of interest, as well as their mathematical competence, significantly influence performance in Chemistry. The study recommends that educators foster students' grit through long-term projects and goal-setting activities while strengthening the integration of mathematical skills into Chemistry instruction to enhance academic achievement.

Keywords: *Grit, Mathematical Ability, Chemistry Achievement, Senior Secondary School, Jahun Education Zone*

Introduction

Education is a key driver of national development, and the mastery of science subjects such as Chemistry is vital for technological advancement and scientific innovation. Chemistry, as a core science subject in the senior secondary school curriculum, plays a critical role in preparing students for higher education and careers in Science, Technology, Engineering, and Mathematics (STEM) fields. However, Chemistry is often perceived as a challenging subject because it requires both conceptual understanding and practical application, including problem-solving, calculations, and laboratory experiments. Many students struggle to achieve high performance due to difficulties in comprehending abstract concepts, interpreting data, and applying formulas accurately (Oloyede, 2019; Ibrahim & Yusuf, 2020).

Science education is the process of helping students to develop a deeper understanding of the natural world and to acquire the skills and attitudes necessary to participate in scientific inquiry and to make informed decisions about scientific issues (Osborne & Dillon, 2018). Also, according to (Akomolafe & Adesua, 2024), science education was defined as helping students

develop their understanding of the natural world and acquire the skills and attitudes necessary to participate in scientific inquiry and make informed decisions about scientific issues.

Chemistry is one of the three main arms of science, along with biology and physics. Chemistry can be defined as a scientific study of matter, its properties, and interactions with other matter and with energy (Helmentine, 2019). In other word, chemistry is the study of matter, its structure transformations, interactions and the energy consequences of the interactions and transformations. Reports from the West African Examinations Council (WAEC, 2021; 2025) and the National Examinations Council (NECO, 2020) consistently show that a significant proportion of students fail to attain credit passes in Chemistry, particularly in topics requiring quantitative and analytical thinking. This trend has raised concerns among educators, parents, and policymakers.

The concept of grit, popularized by Angela Duckworth (2016), refers to perseverance and passion for long-term goals. Unlike cognitive ability, which reflects intelligence or reasoning, grit is a non-cognitive personality trait that emphasizes sustained effort and consistency of interest. Grit significantly predicts academic performance, persistence in difficult tasks, and long-term success even beyond what traditional intelligence tests can explain (Eskreis-Winkler, Shulman, Beal, & Duckworth, 2024).

Beyond cognitive abilities, non-cognitive traits particularly grit have emerged as important predictors of academic achievement in the last decade. Grit, conceptualized by Duckworth as perseverance of effort and consistency of interest toward long-term goals, reflects a student's ability to stay focused, endure academic challenges, and remain motivated despite failure or difficulties. Grit positively correlates with students' achievement in various academic fields, including science and mathematics (Alamer, 2022).

Mathematical ability can be defined as a natural or learnt capability to process numerical data and conclude a mathematical calculation based on that data. It is also defined as the capacity to learn and master new mathematical ideas and skills. It is an ability to obtain, process, and retain mathematical information. Mathematical ability is an important predictor of achievement in Chemistry. Mathematical ability, which includes skills such as numerical reasoning, algebraic manipulation, and logical problem-solving, is essential for understanding chemical calculations, stoichiometry, and experimental analysis. Students who demonstrate strong mathematical competence tend to perform better in Chemistry because they can efficiently process quantitative information and solve complex problems (Uche & Okonkwo, 2020; Chukwu & Nwankwo, 2020).

Furthermore, mathematical ability can be defined as the ability to perform mathematical tasks and to effectively solve given mathematical problems. Mathematical ability is one's capacity to recognize, label, and generate examples of concepts, use and interrelate models, diagrams, manipulatives, and varied representations of concepts, identify and apply principles. It is ability to manipulate ideas about the understanding of a mathematical concept in a variety of ways. It also the capacity to recognize, interpret related concepts and principles. It has to do with one's ability to apply the signs, symbols, and terms used to solve problems in mathematics. Mathematical ability also entails ones' capacity to verify or justify the correctness of a procedure using concrete models or symbolic methods.

One of the key cognitive determinants of success in chemistry is mathematical ability. Chemistry, particularly at the senior secondary level, is heavily quantitative. Topics such as stoichiometry, gas laws, chemical equations, molarity, titration calculations, and thermodynamics require students to possess mathematical competencies including algebraic

manipulation, proportional reasoning, and basic arithmetic fluency. Research has consistently shown that students' mathematical ability directly predicts their success in chemistry performance (Nwafor et al., 2022).

Academic achievement is the measure of how well a student, teacher, or institution has met its educational objectives. It is determined by marks that are assigned by teachers and refers to the knowledge obtained. Academic achievement has an impact on students' lives as well as teachers' lives by enhancing their self-confidence and instilling a sense of accomplishment and belief in them based on the premise that they have tutored and mentored such successful individuals (Oredein, & Killian, 2019). Students' performance in Chemistry at the senior secondary school level in Nigeria has remained relatively low over the past decade, as evidenced by repeated reports from the West African Examinations Council (WAEC, 2022). Understanding the psychological and cognitive factors influencing student achievement in Chemistry is therefore critical for improving learning outcomes. Among the key variables increasingly gaining recognition in educational research are grit and mathematical ability, particularly their influence as predictors of students' academic performance (Sadiq & Usman, 2023).

In the context of Jigawa State, where many schools face challenges such as inadequate instructional materials, overcrowded classrooms, limited teacher specialization, and low student motivation, understanding the predictors of chemistry achievement becomes even more critical. Students in the Jahun Education Zone often encounter both academic and environmental barriers that may affect their ability to persist in demanding subjects like chemistry. While mathematical ability provides the foundation for understanding quantitative chemistry concepts, grit may enable students to sustain the effort required to engage with difficult topics. Yet, despite the importance of these two variables, there is limited empirical evidence assessing how grit and mathematical ability jointly predict chemistry achievement among senior secondary school students in the Jahun Education Zone.

It is against this backdrop that the present study investigated the relationship between grit and mathematical ability as predictors of senior secondary school students' chemistry achievement in Jahun Education Zone, Jigawa State. By exploring both variables within the same analytical framework, the study seeks to provide evidence-based insights that can inform teaching practices, curriculum planning, student support services, and intervention programs aimed at improving science education outcomes in the Jahun Educational Zone.

Statement of the Problem

Chemistry is a fundamental science subject in senior secondary schools and serves as a foundation for careers in medicine, engineering, technology, and other science-related fields. Despite its importance, many students continue to perform poorly in Chemistry in both internal school assessments and external examinations such as the West African Senior School Certificate Examination (WAEC) (WAEC, 2022). Persistent low performance in Chemistry limits students' opportunities for further studies in science-based disciplines. Evidence from WAEC results in the Jahun Education Zone shows that about 60% of students fail Chemistry annually between 2019 and 2025, indicating a consistent pattern of underachievement.

Students' poor performance in Chemistry has been linked to both cognitive and non-cognitive factors. Cognitively, the subject requires strong mathematical ability for solving quantitative problems in areas such as stoichiometry, gas laws, and chemical calculations (Adeniyi, 2020; Eze & Ekwueme, 2017). Many students struggle with these mathematical demands. In addition, non-cognitive factors such as grit defined as perseverance and sustained passion for long-term

goals (Duckworth et al., 2007) may influence students' ability to persist when faced with challenging Chemistry tasks.

However, limited empirical studies have examined how grit and mathematical ability jointly influence students' Chemistry achievement in the Jahun Education Zone. This gap necessitates investigation to provide evidence-based strategies for improving chemistry students' academic performance in Jahun Education Zone Jigawa State Nigeria.

Objectives of the Study

The objectives of this study were to examine the relationship between grit and mathematical ability as predictors of Chemistry achievement among senior secondary school students in Jahun Education Zone, Jigawa State. The study therefore specifically

1. Determined the relationship between grit and Chemistry achievement of senior secondary school students in Jahun Education Zone, Jigawa State.
2. Examined the relationship between mathematical ability and Chemistry achievement of senior secondary school students in Jahun Education Zone, Jigawa State.

Research Questions

The study seeks to answer the following research questions:

1. What is the relationship between mean grit score and Chemistry achievement of senior secondary school chemistry students in Jahun Education Zone, Jigawa State.?
2. What is the relationship between mean mathematical ability score and Chemistry achievement of senior secondary school chemistry students in Jahun Education Zone, Jigawa State.?

Research Hypotheses

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

1. **HO_1:** There is no significant relationship between mean grit score and Chemistry achievement of senior secondary school chemistry students in Jahun Education Zone, Jigawa State.
2. **HO_2:** There is no significant relationship between the mean mathematical ability score and Chemistry achievement of senior secondary school chemistry students in Jahun Education Zone, Jigawa State.

Scope of the Study

This study examines the relationship between grit and mathematical ability as predictors of senior secondary school students' achievement in Chemistry in the Jahun Education Zone of Jigawa State, Nigeria. The study focused on public senior secondary schools and involves Senior Secondary School II (SS II) students offering Chemistry. SS II students were selected because they have sufficient exposure to Chemistry concepts but are not yet under the pressure of final external examinations. The variables investigated include students' grit, mathematical ability, and Chemistry achievement in selected topics such as chemical bonding, periodic table, stoichiometry, gas laws, acids, bases and salts, and thermochemistry. The findings was delimited only to SS II Chemistry students.

Methodology

Research Design

This study was employing a correlational research design. A correlational design is appropriate because the study aims to determine the relationship between variables specifically grit, mathematical ability, and Chemistry achievement without manipulating them. According to Creswell and Creswell (2018), correlational research is used to measure the degree of association between two or more variables as they naturally occur. Similarly, Cohen, Manion, and Morrison (2018) note that correlational studies are suitable when the researcher seeks to establish patterns, trends, and predictive relationships among variables. This design is also appropriate for the present study because it allows the researcher to examine how grit and mathematical ability jointly and individually predict students' performance in Chemistry. Gall, Gall, and Borg (2015) emphasize that correlational research is useful in educational settings where variables cannot be controlled experimentally but can be measured and statistically analyzed to determine their influence. Therefore, the correlational design provides a robust framework for examining the predictive relationships among the study variables.

Population of the Study

The population of this study comprised all Senior Secondary School Two (SSS II) Chemistry students in public secondary schools within Jahun Education Zone of Jigawa State. The total population of SS II students across the science schools in Jahun Education Zone consist of 1,941 students and 18 chemistry teachers, population is appropriate because SSS II students have been exposed to a substantial portion of the Chemistry curriculum and have developed the foundational mathematical skills needed to respond meaningfully to the instruments. .

Sample and Sampling Techniques

The study used a random sampling technique to ensure proportional representation of schools based on type (male, female, mixed) and location (Robson, 2002; Gay, 1999). Five secondary schools offering Chemistry were selected as intact units using simple random sampling, ensuring each school had an equal chance of selection (Borg & Gall, 1989). From these schools, 210 SS II students were sampled proportionally, as they are academically stable and not under final exam pressure. Additionally, all 10 Chemistry teachers in the selected schools were included using census sampling to capture teacher-related data. The sample size meets recommended guidelines for educational research, representing at least 30% of the population, and satisfies the central limit theorem for reliable statistical analysis (Tuckman, 1975; Sambo, 2008; Nworgu, 2015).

Table 1: Sample for the Study

S/N	School Name	School Type	SS II Students
1	GGSSS Jahun	Female	43
2	GUSS Aujara	Male	46
3	GDASS Jahun	Mixed	41
4	GDSS Harbo	Male	38
5	GDSS Aujara	Mixed	42
		Total	**210**

Source: Researcher's Field Survey (2025)

Instrumentation

Instrumentation refers to the tools or instruments that are used to collect data in a research study. In this study, three instruments were employed to collect data from students: the Chemistry Student Grit Scale (CSGS), Chemistry Students Mathematical Ability Test (CSMAT), and Chemistry Student Achievement Test (CSAT). These instruments were chosen to ensure that the variables under investigation grit, mathematical ability, and Chemistry achievement are accurately measured (Creswell & Creswell, 2021). Using multiple instruments enhances the validity and reliability of the data collected and allows for a comprehensive examination of the relationships and predictive power among the variables.

Validity of the Instruments

Validity refers to the extent to which an instrument accurately measures what it is intended to measure (Creswell & Creswell, 2021). In this study, three instruments were used: the Grit Scale, Mathematical Ability Test, and Chemistry Students Achievement Test. To ensure their validity, both face and content validity procedures are employing. The instruments were presented to two experts in Physical Science Education, Educational Measurement, and Psychology within the Faculty of Education. These experts examined the clarity of items, appropriateness of content, language structure, and alignment with the study objectives.

The experts offered suggestions on item relevance, coverage of constructs, and suitability for the target population. Their corrections were incorporated into the final draft of the instruments. This process ensured that the instruments measured the intended constructs grit, mathematical ability, and chemistry achievement appropriately. According to Bolarinwa (2020), expert review is one of the most effective ways of establishing content validity in educational research. Thus, the validation process was increase the accuracy, clarity, and relevance of the instruments for the present study.

Reliability of the Instruments

Reliability refers to the consistency and stability of instrument scores under similar conditions (Knekta, Runyon, & Eddy, 2020). To establish reliability, a pilot study was conducted with 30 students from a similar school outside the study area. The Chemistry Grit Scale was analyzed using Cronbach's Alpha, with values above 0.70 considered acceptable (Taber, 2021). The Mathematical Ability Test and Chemistry Achievement Test, scored dichotomously, were analyzed using Kuder–Richardson Formula 20 (KR-20), with values above 0.60 deemed satisfactory (Agu & Okenyi, 2022). The pilot results showed all instruments had reliability coefficients within acceptable ranges, confirming they were consistent, stable, and suitable for the main study, ensuring dependable measurement of the variables (Sullivan, 2022).

Procedure for Data Collection

Data were collected systematically to ensure accuracy, reliability, and ethical compliance. The researcher explained the study's purpose, emphasizing confidentiality, anonymity, and voluntary participation. The three instruments the Grit Scale, Mathematical Ability Test, and Chemistry Achievement Test were administered under standardized conditions, with supervision by the researcher and trained assistants to ensure independent and accurate responses.

Data collection followed a two-stage process: first, the Grit Scale assessed students' perseverance and consistency of interest; second, the Mathematical Ability and Chemistry

Achievement Tests were administered consecutively. Each session lasted 30–45 minutes. Completed instruments were collected immediately, coded, and prepared for analysis, with only fully completed responses included. The process spanned approximately one to two weeks across the five selected schools.

Procedure for Data Analysis

The collected data were analyzed using both descriptive and inferential statistics. Descriptive statistics including mean, standard deviation, frequency counts, and percentages summarized respondents' demographics, grit levels, mathematical ability, and Chemistry achievement scores. Pearson Product-Moment Correlation Coefficient (PPMC) was used to examine the strength and direction of relationships between grit, mathematical ability, and Chemistry achievement. Multiple Regression Analysis was employed to determine the predictive power of grit and mathematical ability on Chemistry performance. All hypotheses were tested at the 0.05 significance level using SPSS version 25. Decisions on accepting or rejecting null hypotheses were based on p-values and standard statistical criteria, ensuring rigorous and reliable interpretation of the relationships among the study variables.

Results

The results of the data analysis conducted to examine grit and mathematical ability as predictors of Chemistry achievement among Senior Secondary School II students in Jahun Education Zone, Jigawa State. The analysis is organized according to the research questions and hypotheses formulated in Chapter One. Descriptive statistics were used to summarize the data, while inferential statistics were employed to test the hypotheses at 0.05 level of significance.

Table 2: Descriptive Statistics of Grit, Mathematical Ability, and Chemistry Achievement

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Grit Score	210	28	73	52.84	8.91
Mathematical Ability	210	6	29	18.76	4.52
Chemistry Achievement	210	9	38	24.31	5.67

Table 2 presents the descriptive statistics summarizing the distribution of scores for grit, mathematical ability, and Chemistry achievement among the 210 respondents. The grit score has a mean of 52.84 with a standard deviation of 8.91. Considering the possible range of scores, this indicates that students generally possess a moderate to relatively high level of perseverance and consistency of interest toward long-term academic goals. The standard deviation suggests that although students differ in their grit levels, the variation is not excessively wide, meaning most students cluster around the average.

The mathematical ability scores show a mean of 18.76 out of 30, indicating that the average student demonstrated moderate competence in mathematical concepts required for Chemistry problem-solving. The relatively lower standard deviation of 4.52 implies that students' mathematical performance was fairly consistent across the sample.

For Chemistry achievement, the mean score of 24.31 out of 40 reflects moderate academic performance. The spread of scores (SD = 5.67) indicates noticeable but manageable variability among students. Overall, these descriptive results suggest that while students demonstrate moderate levels across all three variables, there is sufficient variation to justify further inferential analysis examining relationships and predictive effects.

Table 3: Pearson Correlation Between Grit and Chemistry Achievement in Chemistry

Variables	N	r	p-value	Decision
Grit & Chemistry Achievement	210	0.462	0.000	Significant

Table 4.2 presents the Pearson Product-Moment Correlation analysis examining the relationship between grit and Chemistry achievement. The correlation coefficient (r = 0.462) indicates a moderate positive relationship between the two variables. This means that as students' grit levels increase, their academic performance in Chemistry also tends to improve. The positive direction of the correlation suggests that students who exhibit higher perseverance and sustained effort are more likely to achieve better academic outcomes.

The p-value of 0.000 is less than the alpha level of 0.05, indicating that the relationship is statistically significant. Therefore, the null hypothesis stating that there is no significant relationship between grit and Chemistry achievement is rejected. This implies that grit plays a meaningful role in influencing students' academic success in Chemistry.

Although the relationship is moderate rather than strong, it demonstrates that non-cognitive attributes such as persistence, resilience, and long-term focus contribute positively to academic performance. However, since the correlation is not extremely high, it also suggests that other factors, such as cognitive skills and instructional quality, may contribute alongside grit in determining achievement outcomes.

Table 4: Pearson Correlation between Mathematical Ability and Chemistry Achievement in Chemistry

Variables	N	r	p-value	Decision
Mathematical Ability & Chemistry Achievement	210	0.681	0.000	Significant

Table 4 shows the correlation analysis between mathematical ability and Chemistry achievement. The correlation coefficient (r = 0.681) indicates a strong positive relationship between the two variables. This suggests that students who perform well in mathematical tasks are highly likely to perform well in Chemistry. The strength of this correlation is considerably higher than that observed between grit and Chemistry achievement, indicating that mathematical competence is more directly linked to academic success in Chemistry.

The p-value (0.000) is below the 0.05 significance level, confirming that the relationship is statistically significant. Consequently, the null hypothesis is rejected. This finding is consistent with the nature of Chemistry as a subject that requires quantitative reasoning, problem-solving

skills, and mathematical manipulation, particularly in areas such as stoichiometry, gas laws, and molar calculations.

The strong relationship implies that deficiencies in mathematical understanding may significantly hinder students' Chemistry performance. Therefore, enhancing students' mathematical foundation could substantially improve achievement levels in Chemistry.

Discussion of Findings

The findings of this study revealed important insights into the role of grit and mathematical ability as predictors of Chemistry achievement among senior secondary school students in Jahun Education Zone, Jigawa State. Each finding is discussed below in relation to previous research and relevant theory.

The study in table 3 found that grit has a significant moderate positive relationship with Chemistry achievement. This implies that students who demonstrate higher levels of perseverance of effort and consistency of interest tend to perform better in Chemistry. This finding aligns with Duckworth et al. (2017), who argued that grit is a non-cognitive trait associated with sustained effort toward long-term goals and predicts academic success across subjects. Similarly, Credé, Tynan, and Harms (2017) conducted a meta-analysis confirming that grit positively correlates with academic achievement, particularly in challenging courses. From a theoretical perspective, this supports the constructivist view (Piaget, 1970) that learning is an active process requiring persistence and sustained engagement with complex concepts. In the context of Chemistry, where students must integrate theoretical knowledge and practical problem-solving, grit provides the motivational drive necessary to overcome difficulties and maintain focus over time.

The study in table 4 indicated that mathematical ability has a strong significant relationship with Chemistry achievement. This suggests that students with better mathematical skills are more likely to excel in Chemistry, which relies heavily on calculations, formula manipulations, and quantitative reasoning. This is consistent with previous studies by Olatunji and Adeyemo (2018), who reported that students' mathematical competence significantly influences their performance in science subjects, including Chemistry. Moreover, Kpolovie et al. (2018) highlighted that proficiency in algebra, ratios, and problem-solving enhances students' ability to tackle complex chemical calculations effectively. Theoretically, this aligns with the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006), which emphasizes the integration of content knowledge and cognitive skills for effective learning. Mathematics provides the essential cognitive tools that support logical reasoning and accurate chemical problem-solving.

Conclusion

This study explored the relationship between grit and mathematical ability as predictors of Chemistry achievement among Senior Secondary School II students in Jahun Education Zone, Jigawa State. Findings revealed that both grit and mathematical ability significantly influence students' performance in Chemistry. Grit showed a moderate positive relationship with achievement, indicating that students who demonstrate perseverance, sustained effort, and consistency of interest are more likely to perform better. This highlights the role of non-cognitive traits in helping students persist through challenging tasks. Mathematical ability exhibited a strong positive relationship with Chemistry achievement, suggesting that students

with strong numerical reasoning, problem-solving skills, and mathematical competence are more likely to excel in quantitative topics such as stoichiometry, gas laws, and chemical calculations. Improving Chemistry performance requires attention to both cognitive and non-cognitive factors. Strengthening students' mathematical skills and fostering grit can enhance engagement, problem-solving, and academic success, providing a foundation for effective teaching strategies and interventions in the Jahun Education Zone.

Recommendations

The following recommendations are proposed:

Teachers should encourage perseverance and consistent interest in students. Activities such as long-term projects, goal-setting exercises, and recognition of sustained effort can help students develop grit, which in turn can improve their Chemistry performance. and Educators should strengthen the integration of mathematical skills into Chemistry instruction. Emphasis on algebra, ratios, percentages, and problem-solving relevant to Chemistry will enable students to better understand and apply chemical concepts.

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