

MATHEMATICS ANXIETY AS A CORRELATE OF SENIOR SECONDARY STUDENTS' ACHIEVEMENT IN CHEMISTRY

Chinweike, Jane Ndubumma¹, Eucharia Ifeoma Emeji, Anulika Mary Okeke, Anthonia C. Orga, & Ezema, Precious Chidiebere

Department of Science Education (Mathematics Education)
Faculty of Education, University of Nigeria, Nsukka

Abstract

This study investigated the relationship between mathematics anxiety and students' achievement in chemistry in Nsukka Local Government Area of Enugu State. Two research questions and two research questions guided the study. A correlational research design was adopted. The population consisted of one thousand and eighty seven (1087) (542 males and 545 females) Senior Secondary School Two (SSII) students in Nsukka Local Government area of Enugu State. The sample size of 292 SSII made up of 143 male and 149 female participants was selected using Taro Yamane formula. Purposive sampling technique was used to sample six (6) co-educational schools. The instruments used for data collection were Mathematics Anxiety Rating Scale (MARS) and Chemistry Achievement Tests (CAT). MARS was adapted while CAT was developed by the researcher. Pearson correlation and multiple regression analyses were used for data analysis. The reliability index of 0.793 and 0.85 were obtained for MARS and CAT respectively. Pearson correlation and multiple regression analyses were used for data analysis. The findings revealed a significant negative relationship between mathematics anxiety and students' achievement in chemistry. The study also showed that gender significantly moderated this relationship, as females and males reacted differently to mathematics-related tasks in chemistry. Based on the findings, it was recommended among others that teachers should adopt anxiety-reducing instructional strategies while teaching.

Keywords: Mathematics anxiety, students' achievement, chemistry

Introduction

Academic success in science subjects is closely linked to students' mastery of mathematics, yet many learners experience difficulties that hinder their achievement. Mathematics anxiety, a psychological barrier characterized by feelings of tension, fear, or helplessness when engaging with mathematical tasks, has emerged as a significant factor influencing students' achievement not only in mathematics but also in related disciplines such as chemistry (Ramirez et al., 2021; Mutlu, 2021). Mathematics anxiety is the level of emotional distress and apprehension a student experiences when performing mathematical tasks. Mathematics anxiety has been widely conceptualized as an emotional and cognitive response that negatively affects students' engagement and achievement in tasks requiring quantitative reasoning (Owusu et al., 2021; Luttenberger et al., 2020). It manifests as avoidance behaviors, reduced confidence, and impaired working memory, particularly in situations involving complex calculations or multi-step problem-solving (Maloney et al., 2017; Namkung et al., 2022). Physically, it may result in symptoms such as sweating, increased heart rate, or nausea when confronted with mathematics problems (Dowker et al., 2016).

For the purpose of this study, mathematics anxiety is operationally defined as the level of emotional distress and apprehension a student experiences when performing mathematical tasks, including those embedded within chemistry problem-solving, such as mole calculations, titrations, or gas law computations. High levels of mathematics anxiety

can lead to decreased participation in quantitative activities, poor comprehension of scientific concepts, and poor academic achievement, potentially limiting students' opportunities in STEM-related fields.

Chemistry, as a core science subject in secondary education, demands both conceptual understanding and mathematical proficiency. It plays a central role in preparing students for careers in health sciences, engineering, environmental science, and other technical disciplines. Success in chemistry requires the application of algebra, ratios, proportions, and data analysis to understand chemical phenomena and solve practical problems (Namkung et al., 2022). Core topics such as chemical equations, stoichiometry, thermodynamics, gas laws, and solution chemistry rely heavily on accurate numerical reasoning. Consequently, students with high mathematics anxiety may struggle with these quantitative components, despite having the ability to grasp theoretical or experimental aspects of the subject. Mathematics anxiety reduces students' confidence, limiting their engagement in calculation-based tasks, and negatively affecting overall achievement in chemistry.

Academic achievement refers to the level of knowledge, skills, and competencies a student acquires in a given subject or across subjects. It is measured through continuous assessments, assignments, tests, and examinations that determine how well a student has mastered the content taught (Umar, 2021). Academic achievement is influenced by several factors including intelligence, learning environment, teacher quality, study habits, motivation, socio-economic background, and psychological variables such as anxiety and self-concept (Santrock, 2021). Because schooling is a social experience, gender often interacts with these factors to create variations in achievement among students (Eddy & Easton-Brooks, 2011).

Gender is shaped by cultural, psychological, and societal influences. Gender is an important socio-cultural variable that helps to explain differences in behaviour, interest, and achievement among students within the school system (UNESCO, 2020). Unlike biological sex, which refers to the physical differences between males and females, gender focuses on the socially constructed roles, expectations, and behaviours that a society considers appropriate for boys and girls (World Health Organization, 2021). These gender expectations influence how students think, how they learn, and how they approach academic tasks, including their confidence in subjects such as mathematics and chemistry (Eccles & Wigfield, 2020). In many societies, including Nigeria, boys and girls are socialized differently, and these differences play a significant role in academic patterns observed in the classroom (Okeke, 2019).

Empirical studies highlight a consistent negative relationship between mathematics anxiety and academic achievement in quantitative disciplines. Research indicates that learners with high mathematics anxiety perform poorly on tasks requiring complex calculations, such as those common in chemistry, while their achievement on concept-only questions may remain unaffected (Maloney et al., 2017; Namkung et al., 2022). Moreover, gendered stereotypes, peer comparisons, and family expectations can influence students' anxiety levels and self-concept, with some evidence suggesting that female students report higher mathematics anxiety, although achievement gaps often diminish when instructional quality is controlled (Mutlu, 2021; Luttenberger et al., 2020).

Given the integral role of mathematics in chemistry and the challenges posed by mathematics anxiety, there is a clear need to examine how these emotional factors affect students' achievement. Understanding the interplay between mathematics anxiety and chemistry achievement can inform instructional strategies, targeted interventions, and resource allocation, ultimately helping students in Nsukka Local Government Area

achieve better outcomes in chemistry and strengthen their readiness for STEM-related pursuits. This study, therefore, seeks to investigate the relationship between mathematics anxiety and students' achievement in chemistry, providing insights that could enhance both teaching and learning in secondary science education. In specific terms, the study addressed the following issues;

1. What's the relationship between mathematics anxiety and academic achievement in chemistry among senior secondary school students in Nsukka Local Government Area?
2. What's the relationship between mathematics anxiety and academic achievement in chemistry among senior secondary school students as moderated by gender?

Method

The study adopted a correlational survey research design. According to Creswell and Creswell (2018), a correlational design is used to determine the degree of relationship between two or more variables without manipulating them. This design is appropriate because it allows the researcher to investigate and describe the existing relationship between two variables mathematics anxiety (independent variable) and students' achievement in chemistry (dependent variable) without manipulating or altering the environment in which the students learn. The population for this study consisted of one thousand and eighty seven (1087) senior secondary school two (SS2) chemistry students (542 males and 545 females) of thirty (30) public schools in Nsukka local government area (LGA) of Enugu State. The participants were SS2 Chemistry students selected using Taro Yamane formula. The participants were 292 (143male and 149 female) in number from six coeducational schools from the thirty (30) public secondary schools in Nsukka local government area using purposive sampling technique. The instruments used for data collection were Mathematics Anxiety Rating Scale (MARS) and a Chemistry Achievement Test (CAT). The MARS is a structured self-report questionnaire was adapted from the Students' Mathematics Anxiety Scales (SMAS) and revised to suit the context of secondary school students in Nigeria. It gathers demographic information, including gender, age, and school name, as well as items assessing students' emotional and psychological responses to mathematical tasks, particularly in the context of chemistry. The questionnaire contains 15 items structured on a four-point Likert scale, ranging from Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The numerical values attached to the respond options are 4, 3, 2 and 1 respectively. The total score obtained from the MARS reflects each student's level of mathematics anxiety, with scores between 46 - 60 indicating high anxiety scores between 31- 45 indicating moderate anxiety, and scores between 15 and 30 indicating low anxiety. CAT contains 25 items and was constructed by the researchers with the use of test blueprint. The test covers SS2 chemistry topics such as the mole concept and stoichiometry, gas laws and calculations, concentration and dilution, and energy changes and equations. Each correct response carries one mark, giving a total score of 25.

These instruments were face validated by three experts from University of Nigeria Nsukka, one from chemistry unit, one from Mathematics unit, and one from Measurements and Evaluation, all from Department of Science Education. The experts validated the instruments with respect to the clarity of the items statement and whether the items are in line with the purpose of the study. A pilot test was conducted on twenty five (25) SSII students of public secondary school located outside the population of the study. The reliability of the MARS was ascertained using Cronbach Alpha and CAT was established using Kuder-Richardson 20 (K-R₂₀), at 0.841 and 0.93 MARS and CAT respectively. Correlation coefficient (r) was used to answer the research questions while

the hypotheses were tested using ANOVA (in the regression output) and the associated p-value for interaction obtained from moderation analysis all at 0.05 level of significance and Statistical Package for Social Sciences (SPSS) was used for analysis. The benchmark for considering the statistical outcomes is as follows 0.00 to 0.19 is very weak relationship, 0.20 to 0.39 is weak (low relationship), 0.40 to 0.59 is moderate relationship, 0.60 to 0.79 is strong relationship and 0.80 to 1.00 is very strong relationship. The regression analysis was considered appropriate in order to determine the strength and direction of the relationship between mathematics anxiety and achievement in chemistry.

Results

Research Question One: What is the relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students?

Table 1: Pearson's Product Moment Correlation of the Mathematics anxiety and academic achievement in Chemistry

		Mathematics Anxiety	Chemistry Achievement
Mathematics Anxiety	Pearson	1	-.432
	Correlation		
	Sig. (2-tailed)		.002
	N	292	292
Chemistry Achievement	Pearson	-.432	1
	Correlation		
	Sig. (2-tailed)	.002	

Table 1 presented the Pearson's Product Moment Correlation of the Mathematics anxiety and academic achievement in chemistry among senior secondary school students. The correlation analysis revealed a moderate negative relationship between Mathematics anxiety and academic achievement in Chemistry among senior secondary school students (Correlation Coefficient $R = -0.432$, $p = 0.002$). This indicates that as Mathematics anxiety increases, academic achievement in chemistry tends to decrease.

Hypothesis One: There is no significant relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students.

The results of the correlation analysis in Table 1 shows the probability associated with the calculated value of $R (-0.432)$ is 0.002. The associated p-value is less than the level of significance p-value (0.05). Therefore, the null hypothesis that no significant relationship exists between Mathematics anxiety and academic achievement in chemistry among senior secondary school students is rejected. Conclusively, there is a significant negative relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students.

Research Question Two: What is the relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students as moderated by gender?

Table 2: Regression Model Summary of the Relationships among the Dependent Independent and Moderating (gender) Variables

Gender	R	R Square	Adjusted R Square
--------	---	----------	-------------------

Male	0.058 ^a	0.003	-0.004
Female	0.107 ^a	0.011	0.005

The result in Table 2 shows the relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students as moderated by gender. The results revealed an R value of 0.058 for male students and R value of 0.107 for female students. This implies that there are positive relationship between male and female students' Mathematics anxiety and academic achievement in Chemistry. The results further reveals that male students had a R square of 0.003 (0.3%) indicating the amount of variation in the academic achievement of Chemistry students accounted for by their male students' Mathematics anxiety. On the other hand, female students had a R square of 0.011 (1.1%) indicating the amount of variation in the academic achievement of Chemistry students accounted for by their female students' Mathematics anxiety. The proportion of variation in students' academic achievement of Chemistry attributed to Mathematics anxiety is higher for female Chemistry students than their male counterpart.

Hypothesis Two: There is no significant relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students as moderated by gender.

Table 3: Hayes Process of relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students as moderated by gender

Model Summary

R	R-sq	MSE	F	Df1	Df2	P
0.1376	0.0189	52.2177	1.8522	3.0000	288.0000	0.0379

Table 3 displays the Hayes processes for the relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students as moderated by gender. The result shows $F(3, 288) = 1.8522$ and the associated p-value of 0.0379. The associated is less than the level of significance (0.05). Therefore, the null hypothesis which stated that there is no significant relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students as moderated by gender is rejected. Hence, the inference drawn is that there exist a significant relationship between Mathematics anxiety and academic achievement in chemistry among senior secondary school students as moderated by gender.

Discussion of Findings

The study revealed a moderate negative correlation between mathematics anxiety and students' achievement in chemistry. This finding aligns with previous research by Ashcraft and Faust (1994), Beilock and Maloney (2015), and Dowker et al. (2016), which established that mathematics anxiety interferes with working memory, reduces confidence, and impairs performance in numerically demanding tasks. In the context of chemistry, where calculations are central to topics such as stoichiometry, gas laws, and molarity, students with high levels of mathematics anxiety are likely to struggle with problem-solving and conceptual understanding. Therefore, the negative impact of mathematics anxiety observed in this study confirms that emotional and cognitive barriers significantly affect chemistry performance among senior secondary students.

The analysis showed that gender significantly moderates the relationship between mathematics anxiety and chemistry achievement. Specifically, while mathematics anxiety negatively predicted achievement, gender influenced the strength of this relationship. This finding supports the work of Hyde (2014) and Voyer and Voyer (2014), which suggest that gender-related factors, such as societal expectations, classroom interactions, and

confidence levels, can amplify or mitigate the effects of mathematics anxiety. In practice, male and female students may experience and respond to mathematics anxiety differently, which affects how they approach chemistry problem-solving. The study highlights the need for gender-sensitive interventions to support students in overcoming anxiety and improving performance.

Conclusions

Based on the findings of this study, the following conclusions are drawn: Mathematics anxiety negatively affects students' achievement in chemistry, confirming that emotional and cognitive barriers significantly influence performance in numerically intensive subjects. Gender plays a moderating role in the relationship between mathematics anxiety and chemistry achievement, suggesting that male and female students experience and respond to mathematics anxiety differently.

Recommendations

Based on the finding of the Study, the following recommendation is made:

1. Teachers should adopt teaching strategies that minimize mathematics anxiety, such as using step-by-step problem-solving approaches, providing regular solving approaches, providing regular practice opportunities, and offering positive reinforcement to build students' confidence in handling numerical tasks.
2. Teacher should create a supportive classroom environment where mistakes are treated as learning opportunities can also help reduce fear and apprehension towards mathematical calculations in chemistry.
3. School administrators and policymakers should prioritize interventions that address gender disparities in science education.

REFERENCE

- Akanazu, I. C., & Okoli, F. C. (2019). Test anxiety and secondary school students' achievement in chemistry in Imo State, Nigeria. *Nigerian Journal of Educational Research*, 21(1), 65–78.
- Ashcraft, M. H., & Faust, M. W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. *Cognition and Emotion*, 8(2), 97–125.
- Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, 130(2), 224–237.
- Ashcraft, M. H., & Ridley, K. S. (2005). Math anxiety and its cognitive consequences: A tutorial review. In J. I. D. Campbell (Ed.), *Handbook of Mathematical Cognition* (pp. 315–327). Psychology Press.
- Beilock, S. L., & Maloney, E. A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences*, 2(1), 4–12.
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
- Dowker, A., Bennett, K., & Smith, L. (2016). Attitudes to mathematics and mathematical attainment: A longitudinal study of primary school children. *Journal of Educational Psychology*, 108(3), 364–378.
- Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology*, 7, 508.
- Eccles, J. S., & Wigfield, A. (2020). *Motivation to succeed: The role of gender and social context*. Routledge.

- Eddy, J. M., & Easton-Brooks, D. (2011). Gender differences in academic achievement: The role of socialization and learning environment. *Journal of Educational Research*, 104(2), 145–153.
- Hyde, J. S. (2014). Gender similarities and differences. *Annual Review of Psychology*, 65, 373–398.
- Luttenberger, S., Wimmer, S., & Paechter, M. (2020). Spotlight on math anxiety. *Frontiers in Psychology*, 11, 1–14.
- Maloney, E. A., Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2017). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological Science*, 28(9), 1–12.
- Mutlu, A. (2021). The impact of mathematics anxiety on academic achievement in STEM subjects: A review. *Education and Science*, 46(205), 45–62.
- Namkung, J. M., Peng, P., & Lin, X. (2022). The relationship between mathematics anxiety and science achievement: A meta-analysis. *Educational Psychology Review*, 34, 1–33.
- Owusu, E. O., Adjei, F. E., & Osei, P. A. (2021). Mathematics anxiety and academic achievement of senior high school students in science subjects. *International Journal of Education and Practice*, 9(3), 212–224.
- Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2021). Math anxiety, working memory, and math achievement in early childhood. *Journal of Experimental Child Psychology*, 196, 104915.
- Santrock, J. W. (2021). *Educational psychology* (7th ed.). McGraw-Hill Education.
- Umar, A. (2021). Academic achievement and socio-cognitive factors among secondary school students. *Journal of Educational Studies*, 45(2), 55–68.
- UNESCO. (2020). *Gender and education: Inclusive policies and practices*. UNESCO Publishing.
- World Health Organization. (2021). *Gender, equity, and human rights in education*. WHO Press.
- Voyer, D., & Voyer, S. D. (2014). Gender differences in scholastic achievement: A meta-analysis. *Psychological Bulletin*, 140(4), 1174–1204.