

Quantitative Reasoning Ability as Predictor of Mathematics Achievement Among Primary School Pupils

Evarista Aghama ALEGIEUNO¹, Amen Valentine UYIGUE²
*Department of Educational Evaluation and Counselling Psychology,
Faculty of Education, University of Benin,
Benin City, Edo State, Nigeria.
evarista.alegieuno@uniben.edu / valentine.uyigue@uniben.edu*

Abstract

This study investigated Quantitative Reasoning Ability as a predictor of Mathematics achievement and how the relationship between both variables varied by sex in public primary schools in Edo South Senatorial District of Edo State Nigeria. Correlational survey research design was adopted. The study population was 14,947 pupils, while a sample of 375 was selected using the Simple Random and Proportionate Stratified Sampling Techniques. Instruments used for data collection were a 15-item Quantitative Reasoning Ability Test (QRAT) and a 30-item Mathematics Achievement Test (MAT), both were presumed to have been validated by experts in the State Universal Basic Education Board (SUBEB). The reliability of the QRAT and MAT was established through test-retest method, yielding coefficients of 0.96 and .98 respectively. Data analysis was conducted using the mean, standard deviation, linear regression, and correlational statistics at 0.05 alpha level of significance. Findings revealed that pupils' academic achievement in quantitative reasoning and Mathematics were high and Quantitative Reasoning significantly predicted Mathematics achievement. Additionally, there was a significant sex-based difference in the strength of the relationship between academic achievement in quantitative reasoning and Mathematics achievement. It was recommended among others that, educators should emphasize the development of quantitative reasoning skill to enhance Mathematics achievement and attention should be given to addressing the sex difference observed in the relationship.

Keywords: *Quantitative Reasoning, Mathematics Achievement, Primary Education, Predictive Analysis. EdoBEST.*

INTRODUCTION

Primary school is the first stage of formal education, laying the essential foundation for a child's intellectual, social, and emotional development. In Nigeria, this level of education typically accommodates children aged 6-12 years. According to (FRN, 2018) in the National Policy on Education, the aim of primary education is to prepare pupils for further educational advancement and to equip them with foundational skills. At the end of this stage, pupils take the Primary School Certificate Examination (PSCE), organized by each states Ministry of Education. This examination plays a vital role in certification and determines eligibility for upper basic education. The Edo state government through her Edo Basic Sector Transformation (EdoBEST) initiative has created a template for the implementation of a basic education reform in Nigeria. Olamide (2022) in a publication in the punch newspaper quoted Joseph-Raji a world bank Senior Economist as saying “EdoBEST has addressed myriads of challenges that faced the basic education sector in Edo State prior to its launch in 2018.

During this phase, pupils are expected to acquire permanent literacy, numeracy, and communication skills tailored to their developmental levels. In today's Nigeria, there is an increasing emphasis on Mathematics education due to its significance in scientific and technological development. Mathematics is not only central to science and technology but also forms the bedrock of logical reasoning. Mathematics is defined as the study of quantity, structure, space, and change. Mathematics helps in pattern recognition, logical deduction, and problem-solving, and it aids empirical sciences in understanding natural phenomena (Brainly, 2022). Recognizing its importance, the Nigerian government has made Mathematics a compulsory subject in the curriculum at both primary and secondary levels of her educational system.

The primary school Mathematics curriculum includes five major content areas: numbers and numeration, basic operations, measurement and geometry, everyday statistics, and algebraic processes. Mastery of these concepts is expected to promote strong performance in internal and external examinations. A critical factor influencing Mathematics performance in pupils is quantitative reasoning ability. Quantitative reasoning refers to the ability to understand, analyse, and interpret numerical and mathematical information to solve real-world problems. It includes several cognitive skills such as numerical operations, pattern recognition, data analysis, logical reasoning, and mathematical modelling. These abilities enable pupils to think critically and draw valid conclusions based on data, rather than guesswork.

Research has shown a growing interest in developing cognitive skills in children, particularly those that underlie mathematical thinking. Nogues (2021) emphasized the importance of building numerical cognition in early learners, especially those at risk of developing Mathematics learning difficulties. The acquisition of Quantitative reasoning is central to this development, as it fosters the kind of deep learning necessary for pupils to succeed academically and make informed decisions in everyday life. Philosophically, Plato's theory of recollection, suggest that learning involves uncovering and developing innate knowledge through reasoning, this aligns with Mathematics education, which emphasizes understanding over memorization.

According to Smith (2022), Mathematics learning is designed to enhance reasoning and problem-solving skills by encouraging pupils to apply mathematical concepts and justify their solutions. The National Policy on Education also emphasizes the importance of nurturing reasoning abilities in pupils, particularly in the realm of quantitative thinking. Quantitative reasoning is a core component of cognitive development and is essential for tackling mathematical tasks effectively. For primary school pupils, these foundational abilities play a major role in shaping their

understanding and confidence in Mathematics. Quantitative reasoning is closely tied to several cognitive domains such as attention, memory, and processing speed. Attention the ability to stay focused and avoids distractions is especially crucial in solving mathematical problems. Pupils must be able to sustain concentration over time, manage multiple steps in problem-solving, and retain relevant information in working memory.

These mental processes underpin successful reasoning and are important indicators of academic potential, this potential have been argued in literature that the biological attribute of being male or female could also interfere with mathematical ability as some researchers have presented a case of male superiority over female in mathematical ability and quantitative reasoning while some have made a contrary submission or expressed sex neutrality in mathematical and quantitative reasoning abilities of pupils. These observations highlight the need to explore how quantitative reasoning ability predicts Mathematics achievement across different demographic groups.

Investigating the relationship between pupils' quantitative reasoning abilities and their Mathematics performance could inform strategies for improving teaching practices, developing appropriate interventions, and promoting equitable learning outcomes., quantitative reasoning is a foundational skill essential for mathematical success and lifelong problem-solving. It involves understanding and analysing numerical data, recognizing patterns, and applying logic to solve real-world problems. The development of quantitative reasoning in primary school pupils supports not only academic achievement but also prepares them for future roles in a technology-driven society. Given the centrality of this skill in education and national development, it is imperative to examine its impact on Mathematics performance.

EMPIRICAL REVIEW

In a study conducted by Adey and Shayer (2018), they observed that, quantitative reasoning is one of the strongest predictors of success in advanced science courses. Pupils with strong reasoning abilities are more likely to perform well in scientific thinking tasks such as identifying variables, drawing conclusions, and testing hypotheses. Tobin and Capie (2019) supported this assertion, noting that reasoning skills are keys to developing science process skills and ensuring long-term retention of scientific knowledge. Research have shown that pupils with strong cognitive skills tend to exhibit better quantitative reasoning abilities and perform more effectively in Mathematics (Nogues, 2021). In the same vein Prager et al. (2020) found that early development of relational quantitative reasoning strongly predicts later Mathematics achievement, even when controlling for other factors.

According to Gustafsson and Balke (2003), Quantitative Reasoning Ability (QRA) forms the cognitive backbone of mathematical learning, accounting for up to 40% of variance in Mathematics achievement among pupils. Also, Lynn and Meisenberg (2016), in their cross-national analysis, reported a correlation of 0.92 between national average QRA and student educational attainment in Mathematics and science, while Rindermann and Neubauer (2014), working with German pupils observed that quantitative reasoning abilities showed a strong correlation ($r = 0.63$) with Mathematics performance. These findings suggest that QRA is not merely associated with Mathematics performance but is potentially one of its strongest cognitive foundations.

Pupils who demonstrate strong quantitative reasoning tend to approach mathematical problems with confidence and are better able to transfer concepts across different contexts. Quantitative reasoning is essential not just for academic success but also for solving real-world problems in line with this, Sirhan (2017) found that pupils are more motivated to engage with mathematical content when problems are presented in real-world contexts. Garcia, Torres, Mendez, and Alvarez, (2021) explored how technology-assisted learning affected quantitative reasoning among high school students in Chile. Using a quasi-experimental design, they found that students who used Mathematics applications and real-time feedback systems significantly improved their performance in standardized quantitative reasoning tests compared to a control group; this study demonstrated a relationship between quantitative reasoning and mathematics achievement.

Although, Kim, Johnson, Patel, and Reid, (2018) criticized the over-reliance on standardized testing as a measure of academic achievement in Mathematics. Through a mixed-methods analysis involving 600 students, the study showed that while some students performed well on tests, these assessments did not reflect deeper reasoning or long-term understanding in a similar submission. Owusu, Boateng, Nartey, & Quaye, (2020) examined rural Ghanaian schools and argued that socioeconomic barriers heavily influence Mathematics performance, rendering many achievement-focused interventions ineffective without addressing broader systemic issues. While Lopez, Green, Martin, & Zhao, (2018), challenged the assumption that quantitative reasoning alone predicts Mathematics achievement, through a study involving 800 middle school students, they found that while quantitative reasoning correlated with Mathematics success, factors such as self-efficacy, classroom engagement, and teacher feedback were often stronger predictors. The study concluded that overemphasizing cognitive skills may overlook important motivational and contextual variables. Also, Ahmed, Suleiman, Davies, & Chen, (2021) explored the role of

language proficiency in mathematical reasoning among multilingual learners. The study revealed that students with high quantitative reasoning ability still underperformed in Mathematics due to language comprehension barriers, suggesting that reasoning skills alone do not fully account for achievement. This finding challenges the predictive validity of quantitative reasoning across diverse student populations.

Gender differences in quantitative reasoning have been widely discussed in educational research. Uyigüe and Omorogiuwa (2015) noted that boys often exhibit more positive attitudes towards Mathematics, relating this to the study conducted by Boaler, Williams, Jansen, and Dweck, (2019) across middle schools in California to examine the impact of growth mindset interventions on students' performance in Mathematics. Their findings showed significant gains in students' Mathematics achievement and problem-solving abilities among those exposed to growth-oriented instruction. The study emphasized the role of mindset, supportive environments, and personalized learning paths,

Halpern (2017), report that male pupils tend to outperform females in quantitative reasoning tasks. While Nworgu (2011) and Chukumah and Orheruata (2023) observed that male pupils tend to perform better than their female counterparts in national Mathematics examinations. However, other research indicate that these differences may be small or context-dependent and that it could be influenced more by social, cultural, and educational factors rather than innate ability Hines, (2015) and Wang & Degol, (2020) supports this position, they reported that, females excelled in certain reasoning abilities than males. This show that superiority in quantitative reasoning and mathematical abilities is not gender identities, rather it cut across genders depending on the prevailing circumstances and contextual variables at play at a given time.

Rodriguez, Patel, Kim, and Ahmed (2019) explored gender differences in the predictive relationship between quantitative reasoning and Mathematics achievement among 9th-grade students in the U.S. The study found that quantitative reasoning significantly predicted Mathematics achievement more strongly for male students than for female students. They attributed this to differences in spatial reasoning and Mathematics confidence. Similarly, Benson, Clarke, Ibrahim, & Taylor, (2020) investigated the influence of gender on reasoning and performance in advanced Mathematics in Nigerian secondary schools. They found that male students demonstrated stronger quantitative reasoning skills, which were more predictive of their performance in Mathematics examinations compared to female students.

Contrary to these assertions stated above, Miller, Gordon, Evans, and Zhou (2018) examined the

interaction between gender and quantitative reasoning in predicting Mathematics outcomes using a large national dataset in the United Kingdom, their findings indicated no significant gender differences in how quantitative reasoning predicted Mathematics performance, suggesting that both males and females benefit equally from strong reasoning abilities. Also, Okafor, Mensah, Bello and Hassan (2021) investigated the relationship between quantitative reasoning and Mathematics achievement in senior secondary schools in Ghana, their analysis showed that gender did not moderate the relationship between quantitative reasoning and Mathematics scores. Both genders exhibited similar predictive strength, challenging commonly held assumptions of male superiority in reasoning-based tasks. These inconsistent findings suggest that sex-related differences in quantitative reasoning may be influenced by social, cultural, and environmental factors rather than inherent ability alone.

In this study the researchers are committed to exploring empirically using samples of pupils drawn from public primary schools across the seven Local Government Areas (LGAs) in Edo South Senatorial District to contribute to this important academic discourse and also providing an informed recommendations that will help in advancing the course of education generally and in Edo State given the renewed commitments through the Edo Basic Sector Transformation (EdoBEST) initiatives of the Edo state government in improving the educational lots of the Edo child.

Research Questions and Hypotheses

To guide the study the following research questions and hypotheses were raised and formulated respectively:

Research questions:

1. What is the level of pupils' achievement scores in Quantitative Reasoning in Edo South Senatorial District?
2. What is the level of pupils' achievement scores in Mathematics in Edo South Senatorial District?
3. Will Quantitative reasoning scores predict pupil's Mathematics achievement in Edo South Senatorial District?
4. Will there be sex difference in the relationship between Quantitative reasoning scores and pupil's Mathematics achievement in Edo South Senatorial District?

Hypotheses:

Research questions three and four were hypothesized as hypotheses one and two respectively and

tested at .05 alpha level of significance.

1. Quantitative reasoning scores will not significantly predict pupil's Mathematics achievement in Edo South Senatorial District.
2. There is no significant sex difference in the relationship between Quantitative reasoning scores and pupil's Mathematics achievement in Edo South Senatorial District

METHODOLOGY

The study adopted a survey research design of the correlational approach. This design is appropriate because it allows the researcher to collect and analyse data from many participants to determine the relationship between variables—in this case, between quantitative reasoning ability and Mathematics achievement.

The study population consisted of 14,947 Primary four pupils (7,695 males and 7,252 females) enrolled in 537 public primary schools across the seven Local Government Areas (LGAs) in Edo South Senatorial District. (SUBEB, 2024). The sample size for the study is 375 pupils, determined using Krejcie and Morgan's (1970) sample size table. A multi-stage sampling procedure was used: Stage One: Three LGAs (Egor, Oredo, and Ovia-North-East) were selected using simple random sampling (ballot method). Stage Two: From each selected LGA, two public primary schools were randomly selected using the ballot method with replacement, resulting in six schools. Stage Three: Pupils were selected using stratified sampling by sex, with 170 males and 205 females chosen proportionately, ensuring a gender representation of 45% males and 55% females.

The Quantitative Reasoning Ability Test (QRAT) was used to assess pupils' reasoning ability related to Mathematics. It consisted of 15 multiple-choice questions (options A–D) covering numerical operations, pattern recognition, logical reasoning, and basic problem-solving skills. The QRAT items were adapted from standardized placement and promotional exams conducted in the 2022/2023 and 2023/2024 academic sessions by the SUBEB. To ensure reliability, the test-retest method was applied; it yielded a reliability coefficient of 0.99, indicating high reliability.

The researcher, with assistance from three trained research assistants, visited the selected schools to administer the QRAT. The test was administered under standardized examination conditions. Pupils were allotted one hour to complete the QRAT. Collected data were analysed using mean, standard deviation, regression analysis and the Fisher's-Z statistics. Hypotheses were tested at $\alpha = 0.05$. Pupils' performance scores were categorized using the following grading scale: A (70–100%) – Excellent, B (60–69%) – Very Good, C (50–59%) – Good, D (45–49%) – Fair, E (40–44%) – Poor, F (0–39%) – Fail.

RESULTS

Result obtained from analysed data to address the research questions raised and the formulated hypotheses are presented below.

Research Question 1: What is the level of pupils’ achievement scores in Quantitative Reasoning in Edo South Senatorial District?

Table 1:

Descriptive Analysis of Pupils’ Achievement in Quantitative Reasoning

Variable	Sum	Min. Score	Max. Score	Total Score Obtainable	Mean (%)	Std. Dev	Remarks
Quantitative Reasoning	3628	3.00	14.00	15.00 (100%)	9.67 (64.5%)	2.07	“B” Good

N = 375

Table 1 shows the pupils’ achievement scores in Quantitative Reasoning. Among 375 pupils, scores ranged from 3.00 to 14.00 out of 15. The mean score was 9.67 (64.5%), which is above the average benchmark of 50%. The standard deviation of 2.07 indicates moderate variability in scores. Thus, pupils’ achievement in Quantitative Reasoning in Edo South Senatorial District is considered good.

Research Question 2: What is the level of pupils’ achievement scores in Mathematics in Edo South Senatorial District?

Table 2:

Descriptive Analysis of Pupils’ Achievement in Mathematics

Variable	Sum	Min. Score	Max. Score	Total Score Obtainable	Mean (%)	Std. Dev	Remarks
Mathematics	8317	14.00	28.00	30.00 (100%)	22.18 (73.9%)	2.69	“A” Very Good

N = 375

Table 2 reveals pupils’ Mathematics achievement scores ranged between 14.00 and 28.00. The mean score of 22.18 (73.9%) is well above average, with a moderate standard deviation of 2.69. This indicates a very good level of proficiency in Mathematics.

HYPOTHESES TESTING

Hypothesis 1: Quantitative reasoning scores will not significantly predict pupil’s Mathematics achievement in Edo South Senatorial District.

Table 3:

Regression Analysis of Quantitative Reasoning on Mathematics Achievement

Model	Sum of Squares	df	Mean Square	F	Sig. (P-value)
Regression	462.440	1	462.440	76.847	.000
Residual	2244.589	373	6.018		
Total	2707.029	374			

$R = .413$, $R^2 = .171$, $p < .05$

The regression results in Table 3 indicates that quantitative reasoning scores significantly predicted Mathematics achievement ($F = 76.847$, $p = .000$). The R^2 value suggests that 17.1% of the variance in Mathematics scores can be explained by quantitative reasoning. Therefore, the null hypothesis is rejected.

Hypothesis 2: There is no significant sex difference in the relationship between Quantitative reasoning scores and pupil’s Mathematics achievement in Edo South Senatorial District.

Table 4:

Fisher’s-Z test of Difference in the Relationship between Quantitative Reasoning Scores and Pupil’s Mathematics Achievement Scores by sex

Sex	N	r	Z	p-value	Decision
Male	170	.498	2.29	.022	Significant
Female	205	.298			

$\alpha = .05$, $p < .05$

Table 4 shows difference in the relationship between quantitative reasoning scores and pupil’s Mathematics achievement scores by sex. From the table the number of male respondents ($N = 170$ while female ($N = 205$ the correlation coefficient ($r = .498$ and $.298$ respectively. The calculated Z -value = 2.29, this value is significant, testing at .05 alpha levels. The p -value = .022 when compared with alpha (.05) is less. Therefore, the null hypothesis is rejected. This implies that there is a sex difference in the relationship between Quantitative reasoning scores and pupil’s Mathematics achievement scores; the relationship is stronger for male pupils.

DISCUSSION OF FINDINGS

The findings reveal that pupils in Edo South Senatorial District demonstrate a high level of academic achievement in Quantitative Reasoning, with a percentage mean score of 64.5%, and very good achievement in Mathematics, with a percentage mean of 73.9%. These results are an indication of a good and very good academic achievement in quantitative reasoning abilities and Mathematics proficiency respectively. The result is a pointer to the fact that investment and engagement made by the state government in the EdoBEST initiative could explain the academic gains as recorded by this study, because before the intervention the academic achievement pose a challenge for education stakeholders in the state, Olamide (2022).

The predictive analyses in hypothesis one confirms that quantitative reasoning significantly predicts Mathematics achievement, with quantitative reasoning quantitative reasoning accounting for 17.1% of variance Mathematics achievement. This finding agrees with previous research that linked numerical reasoning to mathematical success (Green & Bunge, 2017; Prager et al., 2020; Ricart & Estrada, 2022). The assertions of Gustafsson and Balke (2003) and Lynn & Meisenberg (2016), can be applied within the context of this discussion, that quantitative reasoning ability is the cognitive backbone of mathematical learning as the study has lay credence empirically to this assertion by showing that the relationship and predictive power of QRA is quite significantly large given the numerous factors (Lopez, Green, Martin, & Zhao, 2018), that interplay in shaping mathematic achievement of pupils. The finding has great implication for in a time like this when there is an increasing emphasis on Mathematics education due to its significance in scientific and technological development. It therefore behoves the government, education stakeholders and development partners in Edo state education sector and other states and Nigeria at large to harness the insight as provided in this study to effectively meet the educational gains in Mathematics for scientific and technological advancement of the education sector.

Result obtained for hypothesis two on sex differences in the relationship between quantitative reasoning and Mathematics achievement, was significant, being stronger in the male cohort than that of the female. The findings re-echoed that males tend to show higher engagement and performance in mathematical reasoning tasks (Uyigue & Omorogiuwa, 2015; Chukumah & Orheruata, 2023; Rodriguez, Patel, Kim, & Ahmed, (2019). Although Hines, (2015) and Wang & Degol, (2020) stayed neutral in this debate, asserting that there is ordinarily no gender disparity in numerical abilities of male and female students that other contextual variables could interplay to determine academic achievement in this field while Miller, Gordon, Evans, and Zhou, (2018);

Okafor, Mensah, Bello, & Hassan, (2021) failed to give support to male superiority in mathematical ability and quantitative reasoning. From the study the relationship was significantly strong for both genders, however it was significantly stronger for the male pupils. The implication of this finding is that given the predictive power of quantitative reasoning on Mathematics achievement, any approach aimed at enhancing Mathematics achievement by leveraging on quantitative reasoning should be channelled more and intentionally and systematically to the female gender to bridge the imbalanced as revealed in this study.

CONCLUSION

Based on the findings of this study, it was concluded that pupils' quantitative reasoning ability and Mathematics achievement scores are above average across public primary schools in Edo South Senatorial District. Quantitative reasoning ability significantly predicts Mathematics achievement. Additionally, there is a sex difference in the relationship between quantitative reasoning scores and Mathematics achievement, with male pupils showing a stronger association compared to female pupils.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made:

1. Schools should strengthen pupils' quantitative reasoning skills by employing more innovative approach to teaching to sustain and improve academic achievement in Mathematics.
2. Educators should leverage pupils' quantitative reasoning skills to enhance Mathematics performance by integrating reasoning-based problem-solving activities into Mathematics instruction.
3. Since male pupils show a stronger link between quantitative reasoning and Mathematics achievement, teachers should adopt targeted instructional strategies that address the diverse learning needs of both male and female pupils, with support aimed at improving females' quantitative reasoning skills.
4. Primary schools and Mathematics instructors should encourage the inclusion of quantitative reasoning exercises, such as logical puzzles and analytical tasks, in the curriculum to promote pupils' problem-solving abilities and deepen their mathematical understanding.

REFERENCES

- Adey, P., & Shayer, M. (2018). *Raising Cognitive Standards: Cognitive Intervention and Academic Achievement*. London: Routledge
- Ahmed, S., Suleiman, K. A., Davies, H. M., & Chen, Y. (2021). *Language Proficiency and Mathematical Achievement: Questioning the Predictive Power of Quantitative Reasoning*. *International Journal of Educational Research*, 107, 101742. <https://doi.org/10.1016/j.ijer.2021.101742>
- Benson, A. K., Clarke, T. O., Ibrahim, A. L., & Taylor, J. M. (2020). *Exploring Gender Disparities in Quantitative Reasoning and Math Performance among Nigerian Secondary Students*. *African Journal of Educational Studies*, 12(2), 134–149. <https://doi.org/10.4314/ajes.v12i2.10>
- Boaler, J., Williams, C., Jansen, A., & Dweck, C. (2019). *The Influence of Mindset and Instructional Design on Student Achievement in Middle School Mathematics*. *Journal of Educational Psychology*, 111(4), 765–778. <https://doi.org/10.1037/edu0000327>
- Brainly. (2022). What is Mathematics? Principles to Actions: Ensuring Mathematical Success for All. *National Council of Teachers of Mathematics*.
- Chukumah, F. C., & Orheruata, A. M. (2023). Gender Disparities in Mathematics Achievement in Nigerian Primary schools. *African Journal of Educational Studies*, 13(1), 45–56
- Federal Republic of Nigeria (FRN). (2018). *National Policy on Education* (6th ed.). NERDC Press.
- Garcia, R., Torres, M., Mendez, L., & Alvarez, S. (2021). *Technology Integration and Quantitative Reasoning Outcomes in Secondary Education*. *Computers & Education*, 165, 104133. <https://doi.org/10.1016/j.compedu.2021.104133>
- Green, A. E., & Bunge, S. A. (2017). Fluid Reasoning and its Role in Mathematics Skill Acquisition. . *Numerical and Arithmetical Cognition: Patterns of Functions and Deficits in Children at Risk for a Mathematical Disability*. *J. Exp. Child Psychol.* 1999, 74, 213–239. <https://doi.org/10.1006/jecp.1999.2515>
- Gustafsson, J. E., & Balke, G. (2003). General Cognitive Abilities as Predictors of School Achievement and Performance in Mathematics: Evidence From Longitudinal Research. *Intelligence*, 31(2), 203–231. [https://doi.org/10.1016/S0160-2896\(02\)00114-4](https://doi.org/10.1016/S0160-2896(02)00114-4)
- Halpern, D. F. (2017). *Sex Differences in Cognitive Abilities* (5th ed.). Psychology Press.
- Hines, M. (2015). Sex Differences in Mathematical and Spatial Reasoning: Empirical Evidence and Developmental Implications. In S. M. Kosslyn & R. M. Shiffrar (Eds.), *Understanding Gender and Mathematics* (pp. 59–74). Oxford University Press.
- Kim, H., Johnson, R., Patel, S., & Reid, M. (2018). *Rethinking Mathematics achievement: The limitations of standardized testing in assessing reasoning skills*. *Educational Research Review*, 25, 1–12. <https://doi.org/10.1016/j.edurev.2018.07.002>
- Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, 30(3), 607–610. <https://doi.org/10.1177/001316447003000308>
- Lopez, M. R., Green, T. J., Martin, K. A., & Zhao, L. (2018). *Beyond Reasoning: Exploring Affective and Contextual Predictors of Mathematics Achievement*. *Contemporary Educational Psychology*, 55, 21–32. <https://doi.org/10.1016/j.cedpsych.2018.08.004>
- Lynn, R., & Meisenberg, G. (2016). National IQs Predict Differences in Student Achievement in Mathematics and Science: Evidence from TIMSS 2011. *Intelligence*, 55, 105–108. <https://doi.org/10.1016/j.intell.2016.01.007>

- Miller, D. H., Gordon, K. A., Evans, P. R., & Zhou, N. Y. (2018). *Quantitative reasoning and Mathematics performance: Do gender differences matter?* British Journal of Educational Psychology, 88(3), 325–340. <https://doi.org/10.1111/bjep.12186>
- National Policy on Education. (2018). Federal Republic of Nigeria. NERDC Press.
- Nogues, R. M. (2021). The Cognitive Underpinnings of Quantitative Reasoning in Early Learners. *Cognitive Development Quarterly*, 8(1), 25–38.
- Nworgu, B. G. (2011). *Educational Research: Basic Issues and Methodology* (3rd ed.). University Trust Publishers.
- Okafor, C. U., Mensah, A. D., Bello, R. A., & Hassan, S. M. (2021). *Revisiting gender and cognitive predictors of Mathematics achievement in West African classrooms*. International Journal of Educational Development, 86, 102480. <https://doi.org/10.1016/j.ijedudev.2021.102480>
- Olamide F. (2022). EdoBEST will Transform Basic Education, says World Bank. Punch online 28th October 2022. <http://punching.com>
- Owusu, A., Boateng, D., Nartey, G., & Quaye, E. (2020). *Contextual factors limiting academic achievement in Mathematics: A study of rural schools in Ghana*. African Educational Research Journal, 8(3), 566–574. <https://doi.org/10.30918/AERJ.83.20.098>
- Prager, E. O., Sera, M. D., & Carlson, S. M. (2020). Relational Reasoning in Early Childhood: A Predictor of Mathematical Achievement. *Journal of Experimental Child Psychology*, 192, 104778. <https://doi.org/10.1016/j.jecp.2019.104778>
- Ricart, A., & Estrada, J. (2022). Quantitative Reasoning as Predictor of Mathematics Achievement. *Intelligence*, 42, 70–78. <https://doi.org/10.1016/j.intell.2013.11.001>
- Rindermann, H., & Neubauer, A. C. (2014). Processing speed, working memory, and general intelligence as predictors of academic achievement. *Intelligence*, 42, 70–78. <https://doi.org/10.1016/j.intell.2013.11.001>
- Rodriguez, L. M., Patel, S. R., Kim, J. H., & Ahmed, Z. (2019). *Gender differences in the impact of quantitative reasoning on Mathematics achievement*. Journal of Educational Psychology, 111(6), 1102–1113. <https://doi.org/10.1037/edu0000358>
- Sirhan, G. H (2017). Learning Difficulties in Chemistry: An Overview. *Journal of Turkish*
- Smith, A. (2022) Making Mathematics Count: The Report of Professor Adrian Smith’s Inquiry into Post-14 Mathematics Education; The Stationery Office: London, UK, 2004. Available online: <http://www.mathsinquiry.org.uk/report/MathsInquiryFinalReport.pdf>
- SUBEB (Edo State Universal Basic Education Board). (2024). Enrollment Statistics and Academic Records.
- Tobin, K. G. & Capie, W. (2019). The Developing and Validation of a Group Test of Logical Thinking. *Educational and Psychological Measurement*, 41,413-423.
- Uyigüe, A. V., & Omorogiuwa, K. O. (2015). Attitude towards Mathematics and Mathematics Self-Efficacy as Factors Affecting Academic Achievement of Secondary School Students in Mathematics in Benin City. *Journal of Educational Research and Development*, 9(1), 1-8.
- Valanides, N.C. (2010). The Structural Coherence of Students Conceptions in Mechanics and Conceptual Change. *International Journal of Science Education*, 25, 539-561
- Wang, M. T., & Degol, J. (2020). Gender Differences in Mathematics Achievement: A Meta-Analytic Synthesis of Recent Research. *Review of Educational Research*, 90(4), 651–687. <https://doi.org/10.3102/0034654320924515>

