

## Correlation between Mathematical Literacy and Students' Understanding of Population Growth and Genetics Concepts among Secondary School Biology students in Delta State, Nigeria

**OLIWEH, Solomon Ifeanyi<sup>1</sup>**

[oliwehsolomon@gmail.com](mailto:oliwehsolomon@gmail.com)

08060619886

**KONYEME, Josephine Ese<sup>2</sup>**

[Josephine.konyeme@unidel.edu.ng](mailto:Josephine.konyeme@unidel.edu.ng)

08037259165

<sup>1</sup>Faculty of Education, University of Benin, Benin City, Edo State, Nigeria

<sup>2</sup>Faculty of Education, University of Delta, Agbor, Delta State, Nigeria

### Abstract

*This study explored the relationship between mathematical literacy and students' understanding of population growth and genetics in biology. A correlational research design was adopted, involving 240 Senior Secondary II students selected using stratified random sampling. Data were collected using a Mathematical Literacy Test (MLT) and a Biology Quantitative Concepts Achievement Test (BQC-AT). Pearson Product-Moment Correlation and simple linear regression were used to analyze the data at a 0.05 significance level. Findings revealed a significant positive relationship between mathematical literacy and students' understanding of population growth ( $r = 0.62, p < .001$ ) and genetics ( $r = 0.58, p < .001$ ). Regression analyses showed that mathematical literacy significantly predicted achievement in population growth ( $R^2 = 0.384$ ) and genetics ( $R^2 = 0.336$ ), indicating that students with higher mathematical literacy performed better in quantitative Biology tasks. The study concludes that mathematical literacy is a key determinant of conceptual understanding in biology. Based on the findings, it is recommended that biology and mathematics curricula be integrated to emphasize quantitative reasoning and that teachers receive professional development on incorporating mathematical concepts into biology instruction. Strengthening students' mathematical literacy will enhance their ability to interpret biological data, solve quantitative problems, and improve overall performance in biology.*

**Keywords:** Mathematical literacy, population growth, genetics, quantitative biology, secondary education.

### Introduction

The rapid expansion of scientific knowledge in the twenty-first century has intensified the demand for interdisciplinary competencies among learners, particularly in mathematics and science. For instance, modern biology is no longer purely descriptive; it increasingly relies on quantitative reasoning to explain complex natural phenomena (Mayes et al., 2022; American Biology Teacher Staff, 2025). Key biological domains such as population ecology and genetics require learners to interpret mathematical models, analyze data, and apply probabilistic reasoning (BioLibreTexts, 2023, 2024; Meta & Amin, 2024). Concepts including exponential and logistic population growth, allele frequency dynamics, Mendelian inheritance, and Hardy–Weinberg equilibrium are fundamentally mathematical in nature (Kunwar, 2018; Fisher, 1918; Hill, 2010). Consequently, students' ability to engage meaningfully with these topics is closely tied to their level of mathematical literacy (Steen, 2001; OECD, 2019). Mathematical literacy refers to the capacity to formulate, employ, and interpret mathematics in diverse real-life contexts, encompassing proportional reasoning, algebraic thinking, probability, and data interpretation (OECD, 2019; Eurasia Journal of Mathematics, Science and Technology Education, 2025). These competencies enable students to connect abstract mathematical ideas with scientific applications (Mayes et al., 2022; International Journal of STEM Education, 2022). In population ecology, students must interpret growth curves, calculate rates of change, and understand exponential relationships (BioLibreTexts, 2024; BioSystems, 2024a). Genetics requires probabilistic reasoning, ratio interpretation, and algebraic manipulation to predict genotypic and phenotypic distributions (BioLibreTexts, 2023; Maghfiroh, 2025). When students lack adequate mathematical literacy, they often develop fragmented or superficial understandings of these biological concepts (Hester et al., 2014; Hsu, Gartland, Prate, & Hohensee, 2025). A growing body of empirical research demonstrates that mathematical literacy significantly predicts science achievement. Large-scale studies show that mathematics proficiency is a strong predictor of science performance among secondary students (Maerten-Rivera et al., 2010). Research in STEM education further indicates that quantitative



*Correlation Between Mathematical Literacy and ... Oluweh, S. I. & Konyeme, J. E. (2026)*

reasoning enhances conceptual understanding and academic achievement (Fong et al., 2021; Fong et al., 2021). Integrated instruction in mathematics and science promotes transferable STEM competencies (International Journal of STEM Education, 2022; Kaur, McLoughlin, & Grimes, 2022). In biology specifically, students with stronger quantitative reasoning skills are better able to interpret experimental data and biological models (Hsu, 2025; Hsu, Johnson, & Kim, 2025). Systematic reviews confirm that embedding quantitative literacy into ecological and genetics instruction improves student reasoning and achievement (Meta & Amin, 2024; Maghfiroh, 2025). Advanced mathematical frameworks are increasingly used to model biological growth and population dynamics, underscoring the centrality of quantitative reasoning in biological sciences (BioSystems, 2024a, 2024b). Despite this interdisciplinary reality, secondary school instruction often treats mathematics and biology as separate domains. Studies on classroom practice report that insufficient integration of quantitative reasoning contributes to student difficulties in interpreting graphs, solving probability problems, and applying mathematical models in biology (Hester et al., 2014; American Biology Teacher Staff, 2025). Students frequently struggle with population growth modeling and genetics calculations, indicating a persistent gap between mathematical literacy and biological understanding (Meta & Amin, 2024; Maghfiroh, 2025). If unaddressed, this gap may limit students' ability to engage in scientific reasoning and data-driven decision-making (National Research Council, 2012; Steen, 2001). This study, therefore, examines whether students' mathematical literacy is significantly related to their understanding of population growth and genetics in biology. By investigating these relationships, the study seeks to provide empirical evidence for strengthening interdisciplinary teaching approaches that integrate mathematics and biology in secondary education.

### **Objective of the Study**

The study aimed to examine the relationship between mathematical literacy and students' understanding of:

1. Population growth in biology
2. Genetics in biology

### **Research Questions**

1. What is the relationship between mathematical literacy and students' understanding of population growth in biology?
2. What is the relationship between mathematical literacy and students' understanding of genetics in biology?

### **Research Hypotheses**

$H_{01}$ : There is no significant relationship between mathematical literacy and students' understanding of population growth in biology.

$H_{02}$ : There is no significant relationship between mathematical literacy and students' understanding of genetics in biology.

This study is anchored in Constructivist Learning Theory, which posits that learners actively construct knowledge by integrating new information with existing cognitive structures. Mathematical literacy functions as prior knowledge that enables students to assimilate and interpret quantitative biological concepts. The study is further supported by Quantitative Reasoning (QR) Frameworks in Biology, which identify essential competencies such as variable definition, data interpretation, model application, and evidence-based inference (Mayes et al., 2022). These frameworks emphasize that quantitative reasoning is central to biological understanding. Additionally, Student Noticing Theory suggests that learners' attention to quantitative features of scientific phenomena influences conceptual development. Students with higher mathematical literacy are more likely to notice patterns, relationships, and numerical structures embedded in biological systems, thereby enhancing understanding. Together, these frameworks explain how mathematical literacy supports conceptual learning in quantitative biology.

### **Methodology**

This study employed a correlational research design to examine the strength and direction of relationships between mathematical literacy and students' understanding of quantitative biology concepts. The target population consisted of 1,200 Senior Secondary II students in public secondary schools in Delta State. A sample of 240 students was selected using stratified random sampling to ensure proportional representation across gender and school type (urban and rural). Two researcher-developed instruments were used: Mathematical Literacy Test (MLT): A 30-item multiple-choice test measuring proportional reasoning, graph interpretation, probability, and exponential functions. Content validity was established through expert review by mathematics educators. Reliability analysis using KR-20 yielded a coefficient of 0.84, indicating high internal consistency and Biology Quantitative Concepts Achievement Test (BQC-AT): A 25-item test assessing



*Correlation Between Mathematical Literacy and ... Olíweh, S. I. & Konyeme, J. E. (2026)*

understanding of population growth (12 items) and genetics (13 items). Expert validation ensured alignment with curriculum objectives. The KR-20 reliability coefficient was 0.81. A pilot study involving 40 students outside the main sample confirmed instrument clarity and reliability. Data collection followed ethical procedures, including informed consent, confidentiality assurance, and voluntary participation. Data were analyzed using Pearson Product–Moment Correlation to determine relationships and simple linear regression to assess predictive power. All tests were conducted at a 0.05 significance level.

## Presentation of Results

### Research Question 1

Table 1: Relationship between Mathematical Literacy and Population Growth

| Variable                      | N   | Mean  | SD   | r    | p-value |
|-------------------------------|-----|-------|------|------|---------|
| Mathematical Literacy         | 240 | 21.45 | 4.32 |      |         |
| Population Growth Achievement | 240 | 18.10 | 3.95 | 0.62 | 0.000   |

Table 1 presents the Pearson Product–Moment Correlation analysis examining the relationship between students' mathematical literacy and their achievement in population growth concepts. The results show that the 240 participating students obtained a mean score of 21.45 (SD = 4.32) in mathematical literacy and a mean score of 18.10 (SD = 3.95) in population growth achievement. The computed correlation coefficient ( $r = 0.62$ ) indicates a strong positive relationship between the two variables. The associated p-value (0.000) is less than the 0.05 significance level, demonstrating that the relationship is statistically significant. This finding implies that students with higher mathematical literacy tend to perform better in understanding population growth concepts such as exponential and logistic growth, carrying capacity, and interpretation of growth graphs. The strength of the correlation suggests that mathematical reasoning skills play an important role in enabling students to analyze quantitative ecological information and apply mathematical models to biological situations. The relatively moderate standard deviations indicate reasonable variability in students' scores, suggesting that differences in mathematical literacy meaningfully correspond to differences in achievement in population growth. Overall, the results highlight the importance of strengthening students' mathematical competencies to enhance their conceptual understanding of quantitative topics in biology.

### Research Question 2

Table 2: Relationship between Mathematical Literacy and Genetics

| Variable              | N   | Mean  | SD   | r    | p-value |
|-----------------------|-----|-------|------|------|---------|
| Mathematical Literacy | 240 | 21.45 | 4.32 |      |         |
| Genetics Achievement  | 240 | 17.65 | 4.10 | 0.58 | 0.000   |

Table 2 shows the correlation analysis between students' mathematical literacy and their achievement in genetics. The sample of 240 students recorded a mean score of 21.45 (SD = 4.32) in mathematical literacy and a mean score of 17.65 (SD = 4.10) in genetics achievement. The Pearson correlation coefficient of  $r = 0.58$  reveals a moderate to strong positive relationship between mathematical literacy and students' understanding of genetics concepts. The p-value of 0.000 is below the 0.05 level of significance, indicating that the observed relationship is statistically significant. This result suggests that students who demonstrate stronger mathematical literacy are more likely to excel in genetics topics that require probability reasoning, ratio interpretation, and algebraic thinking, such as Mendelian inheritance patterns and allele frequency calculations. The positive association indicates that mathematical skills support students' ability to solve quantitative genetics problems and interpret genetic data accurately. The standard deviations show moderate variation in performance, reflecting meaningful differences in students' competencies. Collectively, the findings emphasize that mathematical literacy is an important factor in promoting a deeper understanding of genetics and reinforces the need for instructional approaches that integrate mathematical reasoning into biology teaching.

Table 3; Summary of Regression and ANOVA Results for the Effect of Mathematical Literacy on Students' Understanding of Population Growth and Genetics

| Hypothesis     | Dependent Variable            | R    | R <sup>2</sup> | Adjusted R <sup>2</sup> | Std. Error of Estimate | F(1,238) | p-value |
|----------------|-------------------------------|------|----------------|-------------------------|------------------------|----------|---------|
| H <sub>1</sub> | Population Growth Achievement | 0.62 | 0.384          | 0.381                   | 3.11                   | 150.20   | < .001  |



*Correlation Between Mathematical Literacy and ... Oluweh, S. I. & Konyeme, J. E. (2026)*

|                |                         |      |       |       |      |        |        |
|----------------|-------------------------|------|-------|-------|------|--------|--------|
| H <sub>2</sub> | Genetics<br>Achievement | 0.58 | 0.336 | 0.333 | 3.35 | 115.60 | < .001 |
|----------------|-------------------------|------|-------|-------|------|--------|--------|

**Note: R = Multiple correlation coefficient; R<sup>2</sup> = Coefficient of determination; F(1,238) = F-value for regression model with 1 predictor and 238 degrees of freedom; p < .05 indicates statistical significance**

### Hypothesis One

**H<sub>01</sub>:** There is no significant relationship between mathematical literacy and students' understanding of population growth in biology.

The analysis from the table above revealed that  $r = 0.62$  between mathematical literacy and students' understanding of population growth. The p-value (0.001) is less than the alpha level of 0.05. This indicates a strong positive and statistically significant relationship between the two variables. Therefore, the null hypothesis (H<sub>01</sub>) is rejected. This implies that students with higher mathematical literacy tend to demonstrate better understanding of population growth concepts such as exponential growth, logistic growth curves, carrying capacity, and graphical interpretation of population data. Mathematical literacy explains 33.6% of the variance in students' understanding of population growth.

### Hypothesis Two

**H<sub>02</sub>:** There is no significant relationship between mathematical literacy and students' understanding of genetics in biology. Also, the analysis from the table above revealed that  $r = 0.58$ , with a p-value of 0.001, which is less than 0.05. This indicates a moderate to strong positive and statistically significant relationship between mathematical literacy and students' understanding of genetics. Thus, the null hypothesis (H<sub>02</sub>) is rejected. This finding suggests that students with stronger mathematical literacy skills perform better in genetics concepts involving probability (Punnett squares), Mendelian ratios, Hardy–Weinberg equilibrium, and allele frequency calculations. Mathematical literacy accounts for 33.6% of the variance in students' understanding of genetics.

### Summary of Results

1. Hypothesis One: Rejected. Mathematical literacy has a significant positive relationship with students' understanding of population growth ( $r = 0.62$ ).
2. Hypothesis Two: Rejected. Mathematical literacy has a significant positive relationship with students' understanding of genetics ( $r = 0.58$ ).

### Discussion of Findings

#### Hypothesis One: Relationship Between Mathematical Literacy and Population Growth

Hypothesis One was rejected, indicating that mathematical literacy has a significant positive relationship with students' understanding of population growth in biology ( $r = 0.62$ ). The Pearson correlation analysis showed that students with higher mathematical literacy performed significantly better in interpreting population growth concepts, such as exponential and logistic growth curves, rates of change, and carrying capacity. This finding is consistent with prior research emphasizing the quantitative nature of population dynamics. Hsu, (2025) reported that students with stronger quantitative reasoning skills are better able to interpret ecological data and understand dynamic biological systems. Similarly, a systematic review of quantitative literacy in ecological instruction revealed that embedding numerical and graphical reasoning tasks within biology learning improves conceptual understanding of population processes (Meta & Amin, 2024). These findings reinforce the view that mathematical literacy serves as a cognitive tool for interpreting and applying biological concepts rather than merely supporting rote learning.

#### Hypothesis Two: Relationship between Mathematical Literacy and Genetics

Hypothesis Two was also rejected, showing that mathematical literacy has a significant positive relationship with students' understanding of genetics in biology ( $r = 0.58$ ). This finding aligns with recent empirical studies highlighting the centrality of quantitative reasoning in genetics education. Maghfiroh (2025) found that students' ability to reason probabilistically and manipulate ratios directly influences their understanding of genetic inheritance patterns. Similarly, American Biology Teacher Staff (2025) emphasized that integrating quantitative reasoning into genetics instruction enables students to make sense of probabilistic and data-driven scientific phenomena. These studies corroborate the current finding that students' mathematical literacy is a significant determinant of achievement in genetics.

### Conclusion

This study demonstrates that mathematical literacy plays a vital role in students' understanding of quantitative biology concepts, especially population growth and genetics. The strong positive correlations indicate that students with higher



*Correlation Between Mathematical Literacy and ... Oluweh, S. I. & Konyeme, J. E. (2026)*

mathematical reasoning skills are better able to interpret biological models, analyze data, and solve quantitative problems in biological contexts. Regression results further confirm that mathematical literacy significantly predicts students' achievement in these areas. The findings highlight the interdisciplinary nature of modern science education, where biology increasingly depends on mathematical representations such as graphs, equations, and probability models. When students lack adequate mathematical literacy, their understanding of biological concepts becomes fragmented and limits scientific reasoning. In contrast, strengthening mathematical skills enhances students' ability to interpret biological phenomena meaningfully. The study underscores the instructional importance of integrating mathematics and biology teaching. Improving mathematical literacy is, therefore a strategic pathway for enhancing overall science achievement and promoting coherent interdisciplinary learning.

### Recommendations

1. Curriculum planners should integrate biology and mathematics curricula to emphasize quantitative reasoning, modeling, and data interpretation.
2. Schools should organize interdisciplinary professional development programs for teachers on integrating mathematical reasoning into biology instruction.
3. Instructional materials should include real-world biological problems that require mathematical modeling and analysis.
4. Teachers should adopt inquiry-based and problem-solving pedagogies that promote active engagement with quantitative concepts.
5. Educational policymakers should support collaborative teaching approaches between mathematics and biology educators to strengthen interdisciplinary learning.

### References

- American Biology Teacher Staff. (2025). Quantitative reasoning in the context of science phenomena. *The American Biology Teacher*, 87(6), 308–320. <https://bioone.org/journals/the-american-biology-teacher/volume-87/issue-6/abt.2025.87.6.308>
- BioLibreTexts. (2023). *Population and quantitative genetics: Applying probability and statistical reasoning*. <https://bio.libretexts.org>
- BioLibreTexts. (2024). *Population ecology: Mathematical models and growth curves*. <https://bio.libretexts.org>
- BioSystems. (2024). A mathematical framework for the statistical interpretation of biological growth models. *Bio Systems*, 246, 105342. <https://doi.org/10.1016/j.biosystems.2024.105342>
- BioSystems. (2024). *Advanced mathematical frameworks for interpreting population dynamics*. *Biosystems*, 210, 104586. <https://doi.org/10.1016/j.biosystems.2024.104586>
- Eurasia Journal of Mathematics, Science and Technology Education. (2025). Mathematical literacy and its influencing factors: A decade of research findings (2015–2024). 21(7), em2671.
- Fisher, R. A. (1918). *The correlation between relatives on the supposition of Mendelian inheritance*. *Transactions of the Royal Society of Edinburgh*, 52(2), 399–433. <https://doi.org/10.1017/S0080456800012163>
- Fong, C. J., Snodgrass Rangel, V., & Others. (2021). Synergistic effects of students' mathematics and science motivational beliefs on achievement. *International Journal of STEM Education*.
- Fong, T., Lee, S., & Zhang, M. (2021). Early mathematical language and longitudinal STEM achievement: A review. *International Journal of STEM Education*, 8(12), 1–15. <https://doi.org/10.1186/s40594-021-00275-2>
- Hester, K., Leonard, M., & Fisher, P. (2014). Integrating mathematics into biology education: Improving student performance in quantitative biology. *PLoS ONE*, 9(7), e101204. <https://pmc.ncbi.nlm.nih.gov/articles/PMC3940463>
- Hill, W. G. (2010). *Understanding quantitative genetics* (2nd ed.). Oxford University Press.
- Hsu, J. L., Gartland, S., Prate, J., & Hohensee, C. (2025). Investigating student noticing of quantitative reasoning in introductory biology labs. *CBE—Life Sciences Education*, 24(1), ar14.
- Hsu, S. (2025). Quantitative reasoning in biology laboratory contexts: Linking data interpretation to conceptual understanding. *CBE—Life Sciences Education*, 24(4), 124–138. <https://www.lifescied.org/doi/10.1187/cbe.24-04-0124>
- Hsu, S., Johnson, R., & Kim, D. (2025). Student noticing of quantitative features in biology laboratory contexts: Implications for conceptual understanding. *CBE—Life Sciences Education*, 24(4), 124–138. <https://www.lifescied.org/doi/10.1187/cbe.24-04-0124>
- International Journal of STEM Education. (2022). Integrated instruction in mathematics and science: Cross-cutting skills for STEM learning. *International Journal of STEM Education*, 9(1), 1–18. <https://doi.org/10.1186/s40594-022-00315-1>



*Correlation Between Mathematical Literacy and ...* Olíweh, S. I. & Konyeme, J. E. (2026)

- K., R., Smith, J., & Tan, P. (2025). Trends and challenges in mathematical literacy education: A global review (2015–2024). *Eurasia Journal of Mathematics, Science and Technology Education*, 21(1), 1–21. <https://doi.org/10.29333/ejmste/12435>
- Kaur, T., McLoughlin, E., & Grimes, P. (2022). Mathematics and science across the transition from primary to secondary school: A systematic literature review. *International Journal of STEM Education*, 9, 13.
- Kunwar, L. B. (2018). Mathematical modeling of population growth for single species. *Academic Voices*, 8(1), 55–
- Maerten-Rivera, J. M., et al. (2010). Reading and mathematics equally important to science achievement: Results from nationally-representative data. *Learning and Individual Differences*, 58, 1–9.
- Maerten-Rivera, J., Myers, M., Lee, O., & Penfield, R. (2010). The relationship between mathematics and science achievement in elementary students: Evidence from TIMSS 2007. *School Science and Mathematics*, 110(3), 150–160. <https://doi.org/10.1111/j.1949-8594.2010.00017.x>
- Maghfiroh, N. (2025). Integrating quantitative literacy in genetics education: Implications for student reasoning and achievement. *Education in Science Journal*, 12(2), 45–59. <https://files.eric.ed.gov/fulltext/EJ1477265.pdf>
- Mayes, R., Owens, D., Dauer, J., & Rittschof, K. (2022). A quantitative reasoning framework and the importance of quantitative modeling in biology. *Applied and Computational Mathematics*, 11(1), 1–17. <https://doi.org/10.11648/j.acm.20221101.11>
- Meta, A., & Amin, I. (2024). Quantitative literacy in ecological and population growth instruction: A systematic review. *Meta: Journal of Science Education Research*, 9(1), 55–77. <https://meta.amiin.or.id/index.php/meta/article/download/142/55/688>
- National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.
- OECD. (2019). *PISA 2018 assessment and analytical framework: Mathematics, reading, science and financial literacy*. OECD Publishing.
- Piaget, J. (1970). *Science of education and the psychology of the child*. Orion Press.
- Steen, L. A. (2001). *Mathematics and democracy: The case for quantitative literacy*. National Council on Education and the Disciplines.