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The Relationship Between Teacher Quality and Secondary School Students' Performance in Biology Concept of Genetics

Esther Ebele Akachukwu*, Chioma Stephane Mbaegbu

Nnamdi Azikiwe University Awka, Anambra State, Nigeria
*Corresponding author, email: ee.akachukwu@unizik.edu.ng

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Abstract
This study investigated the relationship between teacher quality and secondary school students' performance in Biology concept of genetics in Onitsha Education zone. Two purposes of study, two research questions and two hypotheses tested at 0.05 level of significance, guided the study. The study adopted a correlation survey. The population was senior secondary school Biology students in Onitsha Education zone of Anambra state while the sample was drawn using Taro Yamane formula for sample size determination which gave approximately 298 students (105 males and 193 females). Two instruments were used for data collection, they include; Students' Rating of Teacher quality SRTQ adapted from Umeji (2025) and 2024/2025 performance of students from the Biology teachers grade book from the sampled schools. The Student Rating Teacher Quality SRTQ which shows a consistent reliability of 0.82 using Cronbach alpha. The data was analyzed using Pearson moment r and R2 to answer research questions and ANOVA (linear and multiple) regression to test null hypotheses at 0.05 alpha level. The findings revealed, among others, that low positive relationship exist between teacher quality and secondary school students' performance in Biology concept of genetics. However, there is no significant relationship between teacher quality and secondary school students' performance in Biology concept of genetics. It was concluded that low positive relationship exists between teacher quality and secondary school students' performance in Biology concept of genetics and also there is no significant relationship between teacher quality and secondary school students' performance in Biology concept of genetics. From the conclusion, recommendations were made.

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1. Introduction

Biology is a branch of natural science that deals with the study of living organisms, structures, functions, evolutions, distribution and interrelationships. Omaka and Okigbo (2025) viewed Biology as the science of life or the study of living things. The authors further asserted that Biology covers all the life processes such as movement, respiration, nutrition, irritability, growth, excretion, ecological system and reproduction which make it more important and useful to man depending on the branch of the Biology concept. Ibeh and Okigbo (2024) also opined that core branches of Biology includes molecular Biology, genetics, biochemistry, physiology, developmental Biology e. t. c. Due to this study genetic concept of Biology was focused. Genetics is the study of heredity, genes, and variation, explaining how traits are inherited and expressed across generations.

Genetics biology is central to humanity's future. It illuminates how traits and diseases are inherited, guiding personalized medicine, effective vaccines, and targeted therapies. By decoding genomes, we understand evolutionary histories, biodiversity, and adaptation, informing conservation and agriculture. Gene editing promises cures for genetic disorders, improved crops, and sustainable bioengineering. Yet ethical, social, and safety considerations are essential to ensure responsible use, equitable access, and respect for individual rights (Ibeh & Okigbo, 2024; Akachukwu et al., 2024). But in spite of all these importance of genetic Biology to man, secondary school Biology students still experience weaknesses in the concept of the Biology in West African Examination council organized examination (WAEC).

Studies shown that WAEC Chief Examiners consistently reported weaknesses in Biology students, especially in genetics. Key issues included poor explanations, unclear or missing diagram labels, incorrect or missing titles, and inaccurate or incomplete graphs. Students struggled with spelling and recalling technical terms, labeling diagrams, and applying concepts (Punnett squares, dihybrid crosses, evolution, ecology, plant nutrients). Many responses lacked coherence, proper sequencing, and context, with misunderstandings in genetics (inheritance, sex linkage, and crossing symbols) and related topics (hormones, photosynthesis, and ecological roles), leading to overall underperformance (WAEC 2019-2024).

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More so, numerous reasons has been discovered by researchers to be accountable for this low academic performance of students in Biology. Some of the factors include but not limited to; poor teaching methods, poor usage of instructional materials in teaching and learning process, abstract nature of several topics in Biology such as cell division, genetics, variation, evolution, etc, perceived social support, self-efficacy, cognitive development skills, motivation, gender, teacher quality and peer influence (Akachukwu & Mbegbu 2025; Omaka & Okigbo 2025). For the purpose of this study teacher quality was considered.

Teacher quality stands out as a pivotal element. The qualifications, pedagogical skills, and teaching experience of educators play a substantial role in how effectively students grasp complex genetic concepts. Teachers with strong subject expertise can provide deeper insights, clarify misconceptions, and inspire interesting genetics. Additionally, instructors who employ innovative teaching methods – such as active learning, problem-based learning, and the use of digital tools – can enhance student engagement and comprehension (Nemakhavhani & Juan Carlos, 2024).

Despite the recognized importance of teacher quality, there remains a gap in understanding its specific impact on students' performance in specialized courses like genetics. This gap underscores the need for focused research to identify which aspect of teacher quality is most critical in facilitating students' success in genetics. Therefore, examining the relationship between teacher quality and secondary school students' performance in Biology concept of genetics is essential for improving educational practices and student achievement in this field.

In examining how secondary school students perform in Biology, particularly in genetics, it is essential to situate performance within the broader theme of gender as a moderating variable between teacher quality and student outcomes. Contemporary studies increasingly argue that gender differences shape how students respond to instructional quality, and in science-related disciplines such as genetics, these differences can influence learning preferences, engagement, and achievement. In other words, the effectiveness of a teacher's knowledge, methods, and classroom environment may produce different levels of genetics mastery for boys and girls, depending on how well instructional practices align with gender-related learning needs.

Several strands of evidence support this alignment. First, researchers have demonstrated that gender can modify the strength and direction of the relationship between teacher quality and academic performance in science. Chowdhury and Halder (2021) emphasize that gender acts as a moderator in science education, suggesting that identical levels of teacher quality may yield divergent genetics-related outcomes for male and female students. This implies that genetics instruction cannot be universally "one size fits all"; instead, it may require attention to how gender influences students' conceptualization of inheritance, genetic terminology, and laboratory reasoning.

Further nuance comes from how students perceive teacher effectiveness differently by gender. Olufemi and Akinbode (2022) found that female students tend to respond more positively to supportive, inclusive, and interactive teaching approaches. In genetics, where abstract concepts such as Mendelian inheritance, Punnett square analyses, and gene expression can be challenging, such approaches may facilitate deeper understanding for girls by promoting collaboration, explicitly supportive feedback, and opportunities for participation. Conversely, while not universal, male students in some contexts may respond more favorably to certain structured or competitive elements of instruction, a pattern echoed in other STEM settings.

This brings us to the role of participatory and student-centered methods. Adebayo et al. (2021) observed gender disparities in science performance among Nigerian undergraduates, with teaching effectiveness exerting a stronger impact on female students when participatory strategies were employed. In a genetics unit, participatory activities such as collaborative pedigree activities, case-based genetics problems, and hands-on simulations of allele interactions could disproportionately benefit female students' engagement and achievement, facilitating connections between theory and real-world genetic phenomena.

Gender differences in response to instructional environments also appear in STEM more broadly. Okafor, Adeyemi, and Ibrahim (2023) reported that male students often perform better in competitive and structured teaching environments, whereas female students excel when teachers implement collaborative and student-centered methods. Translating this to genetics education suggests that a balanced classroom design combining clear, structured explanations of genetic concepts with opportunities for cooperative inquiry, discussion, and peer explanation may optimize genetics performance for all students. In practice, this could involve a mix of teacher-led demonstrations (e.g., clear demonstrations of allele combinations and probability calculations) alongside collaborative lab activities and problem-based learning tasks.

Also, Nguyen and Nguyen (2022), in a context closer to secondary education in Vietnam, highlighted that gender differences influence motivation and engagement in science, with teacher quality playing a pivotal role in bridging the gender gap. For genetics, this underscores the necessity of gender-sensitive teaching strategies that enhance motivation, such as making genetics problems relevant to students' lives, providing autonomy in

choosing investigation angles (e.g., selecting traits to analyze), and ensuring feedback emphasizes growth and mastery.

Additionally, Ogunyemi and Adedayo (2020) showed that gender interacts meaningfully with instructional quality in determining science outcomes in Nigerian higher education, reinforcing the idea that gender dynamics can shape how effectively genetics content is learned when teacher instructional quality varies. Although the setting differs (higher education vs. secondary schooling), the core message remains: gender moderates the impact of how teachers teach on what students ultimately learn in genetics.

Integrating these insights into a secondary school genetics curriculum entails recognizing that teacher quality cannot be assumed to have uniform effects across genders. A gender-responsive genetics program would intentionally blend instructional strategies to accommodate diverse learning preferences and engagement patterns. So, the problem of this study seeks to address is whether teacher quality significantly influences secondary students' performance in Biology concept genetics. There is limited empirical evidence directly linking teacher characteristics-such as academic qualifications, teaching experience, and instructional methods-to student outcomes in genetics. This gap necessitates an in-depth investigation into how teacher quality affects students' understanding and academic success in Biology concept of genetics.

1.1. Purpose of the Study

The purpose of this study was to investigate the relationship between teacher quality and secondary school students' performance in Biology concept of genetics in Onitsha Education zone. Specifically, the study sought to:

a. Determine the relationship between teacher quality secondary school students' performance in Biology concept of genetics in Onitsha Education zone.

b. Determine the relationship between teacher quality, male and female secondary school students' performance in Biology concept of genetics in Onitsha Education zone.

1.2. Research Question

The following research questions guided the study;

a. What is the relationship between teacher quality and secondary school students' performance in Biology concept of genetics in Onitsha Education zone?

b. What is the relationship between teacher quality, male and female secondary school students' performance in Biology concept of genetics in Onitsha Education Zone?

1.3. Hypotheses

The following null hypotheses were tested at 0.05 level of significance

a. There is no significant relationship between teacher quality and secondary school students' performance in Biology concept of genetics in Onitsha Education zone.

b. There is no significant relationship between teacher quality and male and female secondary school students' performance in Biology concept of genetics in Onitsha Education Zone.

2. Method

Correlation survey design was used in this investigation. The study was conducted in Onitsha Education zone of Anambra State. The population of the study included of 2720 Senior Secondary two (SS2) Biology students in public secondary schools Anambra state. The sample size was 298. The sample was determined using using Yamane's (1967) Formula.

The sampled schools' average termly Biology scores from the instructors' grade book for the 2019–2024 academic year where Biology concept of genetics were taught and the Students Rating of instructors' Quality (SRTQ) serve as the data gathering tools. Shihab Jimaa's Students' Rating was adapted. It a Measure of an Effective Teaching or Best Gauge of Learning? (2013) served as the model for the Students Rating of Teachers' Quality (SRTQ). In SRTQ, the following modifications were made. Respondents are asked questions in Section A about their school's name, gender, and location. The respondents' answers about the quality assessment of teachers are gathered in Section B. Is it the best indicator of learning or a measure of effective teaching among the nine (9) groups from students' ratings? According to Shihab Jimaa (2013), six (6) was organized and utilized.

Due to their varied representation of teaching quality, the six (6) clusters were selected. Responses were given on a four-point scale, with 1 representing very low extent, 2 representing low extent, 3 representing high extent, and 4 representing very high extent. Each questionnaire was given once to 50 SS2 students who were chosen at random from a Community Secondary School in Nnewi, Nnewi Education Zone, Anambra State, in order to determine the reliability coefficient of the surveys. The research area does not include the school. The internal consistency of the instruments' items was assessed using the Cronbach's alpha approach. Because the questionnaire items are not dichotomous and no response is considered right or incorrect, Cronbach's alpha is used. Each respondent's set of scores was then coded for computer analysis using SPSS. According to the analysis's findings, the Cronbach alpha coefficient for the Students Rating of Teachers' Quality (SRTQ) was 0.71.

The 2019–2024 academic year's Biology teachers' grade books where Biology concept of genetics where found in each team of the session from the selected schools provided the performance scores. The performance test was based on the average scores from the teachers' grade book. Experts from the zone and the head of Biology at the schools that were sampled verified and certified the results, which detailed the pupils' accomplishments. These instruments act as a medium for data collection.

In analyzing data, Pearson correlation coefficient (r) was used to answer the research questions while P value was used to test the hypotheses. In interpreting the null hypotheses, the decision rule is that when P-value is less than or equal to 0.05 (P≤0.05) the null hypotheses was rejected. On the other hand, when P-value is greater than the alpha level 0.05 (P≥0.05), the null hypotheses was not rejected (accepted).

3. Results and Discussion

3.1. Research Question 1, What is the relationship between teacher quality and secondary school students' performance in Biology concept of genetics in Onitsha Education zone?

Hypothesis 1. There is no significant relationship between teacher quality and secondary school students' performance in Biology concept of genetics in Onitsha Education zone.

Table 1. Pearson Correlation Coefficient for the Relationship between Teachers quality (TQ) and Secondary School Students' Performance in Biology Concept of Genetics

Variables	N	R	R^2	Magnitude & Direction	Sig	Decision
TQ performance	298	.106	.011	Low positive relationship	0.067[b]	Not significant

Key: R^2=coefficient of determination

The data show a low positive relationship exist between teacher quality and secondary school students' performance in Biology concept of genetics (r = .106, R2 = .011). With N = 298, only about 1.1% of performance variance is explained by TQ. The relationship is small in magnitude and not statistically significant (p = .067). Thus, within this sample, teacher quality does not meaningfully predict secondary students' genetics performance, suggesting that other factors like student motivation, prior knowledge, or instructional practices likely play larger roles. Further research should explore additional variables or subgroup analyses.

3.2. Research Question 2, What is the relationship between teacher quality, male and female secondary school students' performance in Biology concept of genetics in Onitsha Education Zone?

Hypothesis 2. There is no significant relationship between teacher quality, male and female secondary school students' performance in Biology concept of genetics in Onitsha Education Zone.

Table 2.Pearson Correlation Coefficient for the Relationship between Teacher Quality (TQ), and Secondary school Students' Performance in Biology Concept of Genetics as Moderated by Gender

Variables	N	R	R^2	Magnitude &Direction	Sig	Decision
TQ Performance	298	.231[a]	.027	Low positive relationship	.35[c]	Not Significant

Key R^2= coefficient of determination

Table 2 shows a weak to modest positive link between teacher quality (TQ) and genetics performance, moderated by gender. With N=298, r = .231 and R2 = .027 indicate about 2.7% of variance is explained. The

magnitude is a low positive relationship, yet the p-value (Sig = .35) is not significant. This suggests gender moderation does not reveal a meaningful, statistically supported enhancement of the TQ genetics performance link in this sample.

3.3. Discussion of Findings

The findings of the study are discussed as follows:

3.3.1. Influence of Teacher Quality on Secondary School Students' Performance in Biology Concept of Genetics.

The present findings show a very weak, non-significant link between teacher quality (TQ) and genetics performance. Only about 1.1% of performance variance is explained by TQ, suggesting that in this sample, teacher quality alone does not meaningfully correlate genetics performance. This aligns with a broader body of empirical work highlighting that student outcomes in science are not determined by teacher quality in isolation but are shaped by multiple factors, including motivation, prior knowledge, and instructional practices.

Importantly, the literature on gender as a moderator adds nuance to these results. Chowdhury and Halder (2021) argue that gender can alter how teacher quality translates into science outcomes, implying that identical TQ levels may yield different genetics performance for boys and girls. This challenges the one-size-fits-all approach to genetics instruction, underscoring the need to attend to how gender influences students' conceptualizations of inheritance, genetic terminology, and lab reasoning.

Further, Olufemi and Akinbode (2022) demonstrate that female students often respond more positively to supportive, inclusive, and interactive teaching styles. In genetics where Mendelian reasoning, Punnett square analyses, and gene expression can be abstract these collaborative, feedback-rich approaches may enhance girls' understanding and engagement. While some contexts show that male students may favor structured or competitive elements, the overarching implication is clear: effective genetics teaching should balance approaches to accommodate diverse learner preferences.

Taken together, these findings suggest that while TQ alone showed a weak association with genetics performance, gender-sensitive and varied instructional strategies could uncover more meaningful relationships. Future research should consider moderator analyses across gender, as well as additional variables such as motivation, prior knowledge, and specific instructional practices, to better capture the drivers of genetics achievement.

3.3.2. Influence of Teacher Quality on Secondary School Students' Performance in Biology Concept of Genetics as Moderated By Gender

Table 2 indicates a weak to modest positive link between teacher quality (TQ) and genetics performance, moderated by gender. Only 2.7% of variance is explained, and the result is not statistically significant, so gender moderation does not meaningfully enhance the TQ and genetics performance link in this sample. This findings are in line with the findings of Nguyen and Nguyen (2022) reported that in a context closer to secondary education in Vietnam, highlighted that gender differences influence motivation and engagement in science, with teacher quality playing a pivotal role in bridging the gender gap. The findings are also in line with Ogunyemi and Adedayo (2020) showed that gender interacts meaningfully with instructional quality in determining science outcomes in Nigerian higher education, reinforcing the idea that gender dynamics can shape how effectively genetics content is learned when teacher instructional quality varies.

However, the findings are not in line with Adebayo et al. (2021) who observed that gender disparities in science performance among Nigerian undergraduates, with teaching effectiveness exerting a stronger impact on female students when participatory strategies were employed. The findings are not also in line Okafor, Adeyemi, and Ibrahim (2023) who reported that male students often perform better in competitive and structured teaching environments, whereas female students excel when teachers implement collaborative and student-centered methods.

4. Conclusion

In conclusion, the study indicates a low positive relationship exist between teacher quality and secondary school students' performance in Biology concept of genetics. However, there is no significant relationship between teacher quality and secondary school students' performance in Biology concept of genetics. It was concluded that low positive relationship exists between teacher quality and secondary school students' performance in Biology concept of genetics and also there is no significant relationship between teacher quality and secondary school students' performance in Biology concept of genetics.

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Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript. AI were used only to improve readability and language under strict human oversight; no content, ideas, analyses, or conclusions were generated by AI.

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