

## Moderation of Gender and School Location on the Prediction of Test Anxiety on Physics Students' Academic Achievement in Waves Motion

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### ARTICLE INFO

#### Article history:

Submitted : March 18<sup>th</sup>, 2024

Revised : March 25<sup>th</sup>, 2024

Accepted : June, 12<sup>th</sup>, 2024

#### Keywords:

Academic Achievement; Moderation Gender; Moderation School Location; Test Anxiety; Waves Motion



### ABSTRACT

The continuous decline in students' achievement in physics, especially in wave motion, has become a significant concern among education stakeholders. This study, which examines the moderation of gender and school location in predicting test anxiety on students' achievement in wave motion in physics, offers actionable recommendations for improvement. A correlational research design was adopted. Three research questions and three hypotheses informed the study. A sample of 337 students drawn through a multistage sampling procedure was used for the study. Waves Test Anxiety Inventory (WTAI) and Waves Achievement Test (WAT) instruments were used for data collection. Reliability indices of 0.73 and 0.76 using Cronbach alpha and KR-20 were estimated for WTAI and WAT, respectively. The research questions were answered using regression analysis, while ANOVA and t-test results obtained using Hayes' Process Macro were used to test the hypotheses at a 0.05 significance level. Results showed that test anxiety significantly predicts students' achievement in wave motion. The results showed that the moderation of gender in test anxiety prediction was insignificant. However, the location significantly influenced the prediction of test anxiety on students' achievement in wave motion. It was recommended, among others, that physics teachers ensure that lesson contents are duly covered and that a conducive learning environment, clear instructions, and adequate preparations are made available to students before testing them, thereby potentially improving students' academic performance.

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### Introduction

Physics is an integral part of science that facilitates the development of humanity through advancement in science and technology. This is true because, according to Brown & Weidner (2024), physics is concerned with all aspects of nature and extends to other aspects of science like Astronomy and chemistry. Mathematics, Engineering, and Computer Science, among others. Usman & Abubakar (2019) define Physics as the foundation of science and technology, which enables one to acquire knowledge and better understand the laws and principles that govern the world of sciences. Okeke et al. (2022) also refer to Physics as an aspect of

science that studies matter and energy, including their interactions. Physics is a branch of Physical science that studies the behavior and properties of matter about energy. According to Patrick (2018), advancements in physics bring about the development of modern technology, such as electricity, nuclear energy, and rocket science, among others. Moreover, these advancements facilitated by the study of Physics usually come from understanding topics in Physics such as wave motion.

Wave motions, which could be seen as a disturbance, have been described by scholars. According to Zhabinskaya (2024) and Physics & Radio-

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Electronics (2015), wave motion may be a disturbance that travels from one point to another through a material medium or vacuum. Anyakoha (2016) added that waves entail any form of disturbance that travels through a material medium by transferring energy from one point to another without permanently displacing the particles of the medium. Thus, wave motion could be considered as the process in which a disturbance in the form of kinetic energy is propagated, spread out, or transferred through a material medium without displacing the particles of the medium permanently. Correctly understanding waves facilitates improvements in oil exploration, communication, medicine, etc. Daniel (2020) also mentioned that waves are applicable in radio broadcasting, x-rays, microwaves, cell phones, etc. The Encyclopaedia Britannica (2024) reported that waves increase man's understanding of several physical phenomena, such as light and sound, and properties of matter, such as electrons and atoms.

Even though understanding waves is very beneficial, studies have shown that Physics students' achievement, especially in wave motion in Nigerian secondary schools, has been very poor. This is apparent in the studies of scholars such as Ojediran (2016), who carried out an analysis of West African Senior School Certificate Examination (WASSCE) results of students in physics from 2010 to 2015 and found that only 32.64%, 26.80%; 38.81%; 29.17%; 29.27% and 31.28%, respectively had credit pass in physics. Also, the study of Akuche & Akunola (2017) revealed students' poor achievement in Physics. Equally, the West African Examination Council (WAEC) Chief Examiner's report from 2015-2020 also showed a decline in the academic achievement of students in Physics. According to the Chief Examiner, most of the poor achievement of students in Physics was accounted for by their inability to answer questions clearly and correctly on wave motion. These findings are consistent with Ekomaye's (2019) finding that students' poor academic achievement in Physics is because they lack a proper understanding of wave motion. The preceding implies that advancement in sciences aided by the knowledge of Physics and, mainly, wave motion could be on the brink of slowing down or getting truncated since students appear to be achieving poorly in wave motion.

This situation above has become a source of worry for education stakeholders, parents, and researchers. To address the inadequacies in students' achievement in Physics, particularly in waves motion, scholars have identified factors such as students' negative attitude towards Physics, lack of learning resources, poor laboratory infrastructures, poor teaching methods,

teacher qualification, large class size, among others to be responsible for Physics students' poor achievement in waves motion (King'Arù, 2014; Oluwasegun & Ekomaye, 2018). To solve the problem of poor achievement of students in Physics, the government and stakeholders ensured that qualified teachers are employed and relevant learning resources are provided. Yet, Physics students still perform poorly in wave motion. It becomes necessary to investigate such factors as test anxiety, which could be responsible for students' poor achievement in wave motion, as suggested (Beharu, 2018).

A psychological state described by discomfort, panic, worry, increased heart rate, and distress in testing situations felt by students is termed test anxiety (Jerrim, 2022). Ahmad et al. (2018) see test anxiety as a physical, emotional, and mental reaction posed by the fear of failure on a test or examination. It entails worrying, nervousness, or apprehension when a learner faces an examination or test at any stage (Ocheni, 2021). Furthermore, it could be referred to as anticipatory or examination anxiety in examination situations. According to the Anxiety and Depression Association of America (2018), test anxiety can be observed in students when they are unable to stay focused during testing or when they worry about their achievements, find it difficult to solve test problems, become overly sensitive or show low attention, avoid tasks, feel nervous, have rapid heart rate, headaches, vomiting, and so on. The preceding shows that test anxiety could affect one's academics. According to Benjamin & Mohammed (2023) and Ocheni (2021), test anxiety predicts students' academic achievement significantly. On the contrary, Theobald et al. (2022) reported that students' test anxiety and academic achievement are unrelated. This indicates debate among scholars as to whether or not test anxiety can predict students' achievement. As such, further investigation is required to resolve the disagreement between researchers. However, the level of test anxiety experienced by male and female students may differ. In essence, gender could influence the prediction of test anxiety on students' achievement in wave motion.

Gender is a characteristic of women, men, girls, and boys that is socially and culturally constructed to distinguish the roles of men, women, boys, and girls in society (WHO, 2024). In this study, gender may be seen as any distinguishing feature, characteristic, or behavior that separates males from females in society. One could logically assert that gender is essential in the educational system as it appears capable of influencing the curriculum, instructional materials, career choices, and the general behavior of students and teachers. Thus, it could be implied that gender may likely

moderate the prediction of test anxiety on Physics students' academic achievement in waves. According to Okeke et al. (2022), the moderation of gender on the prediction of test anxiety on students' achievement is insignificant. However, Pachaiappan et al. (2023) found that gender significantly moderates the prediction of test anxiety on students' achievement. These differences in the researchers' findings require more clarification. Hence, this study is necessary. Similarly, the environment in which a student learns may also affect their test anxiety level. As such, school location could be a variable that moderates the prediction of test anxiety on students' academic achievement in waves.

The location of a school may play a significant role in how and what an individual learns in school. School location may be referred to where a school is situated; this could be an urban or rural area. Most rural areas lack social facilities like electricity, pipe-borne water supply, tarred roads, good schools, etc., while urban areas have adequate and functional social facilities. These infrastructural differences could affect students' learning environment and, consequently, their learning outcomes and psychological states, such as the feeling of test anxiety.

Mkpaoro & Nwagu (2019) discovered that location significantly influenced the relationship between academic achievement and students' test anxiety. However, Umar (2019) reported that the influence of school location on students' test anxiety is insignificant. This disparity in the findings of researchers calls for further studies.

The preceding shows that contradictions exist among researchers on the prediction of test anxiety on Physics students' achievement in wave motion. Consequently, scholars disagree on the moderation of gender and school location of students in predicting test anxiety on students' achievement. This is because, while some researchers reported significant influences of gender and location on the prediction of test anxiety on students' academic achievement, other researchers found no significant influence of these variables (gender and school location) on the prediction of test anxiety on students' academic achievement. Contradictory findings, as reported above, necessitated further research. More so, studies on test anxiety in wave motion in physics appear to be non-existent. This calls for this study to determine whether gender and school location moderate the prediction of test anxiety on Physics students' academic achievement in wave motion.

The process of describing how the natural world works through applied mathematical formulas is called

Physics. It deals with studying the interaction between the properties of matter and energy. All other natural sciences could be said to have stemmed from physics, as stated by Omosewo (2010). The researcher reiterated that when Physics is applied, it gives rise to Chemistry, while biology is essentially the application of Chemistry. Breakthroughs in electronics that give rise to modern advances in computers and electronics are said to have stemmed from Physics theory (Patrick, 2018). The development of modern supersonic aircraft is also an obvious application of physics (Omosewo, 2010).

In the same way, the application of physics in space and nuclear science assists in improving the economic and military strength of nations. The principles of physics and their applications have given rise to the invention of nuclear reactors, satellites, telecommunications, programming, and information technology. To conveniently study courses such as geology, medicine, engineering, computer science, and so on, physics must first be understood as a prerequisite. Perhaps it is in line with this overwhelming importance of physics and other related sciences that the Nigerian Government has taken bold steps toward the implementation of the Science and Technology Education Post Basic Project (STEPBP) with the assistance of the World Bank (Manklik & Ofodile, 2015). As further reported by Manklik & Ofodile (2015), STEPBP emphasizes the production of adequate and excellent graduates in sciences and technology. This implies that significant efforts must be made to facilitate improvement in science and technology through understanding physics. One of the essential concepts in Physics that facilitate development in science and technology is wave motion.

Waves are concerned with the transfer of energy in the form of disturbance from one point to another through a medium. Waves are classified broadly based on propagation, mechanical, and electromagnetic waves (Zhabinskaya, 2024). Mechanical waves are waves that require a material medium before they can be propagated; they include sound waves, waves on a string, water waves, etc., while electromagnetic waves are waves that do not require a material medium before they are propagated from one place to the other, e.g., light waves, microwaves, radio waves, gamma-ray, x-ray, infrared, etc. (Ocheni, 2021). Equally, based on the vibration of the particles of the medium, waves can either be transverse (when the particle vibrates perpendicularly to the propagation of the waves) or longitudinal (when the particle's vibration is in parallel to the source of propagation of waves). Meanwhile, based on energy, waves can either

be standing/stationary or progressive (Daniel, 2020). As a disturbance, waves are identifiable through reflection, refraction, interference, diffraction, and polarization.

*Reflection of waves:* All waves undergo reflection. It refers to sending off waves from a surface after an incident occurs on the surface.

*Refraction of waves:* This is the bending or the change in the speed and direction of the waves after passing or crossing the boundary between two media of different densities. Once there is refraction, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for a given pair of media ( $\frac{\sin i}{\sin r} = n$ ). The refracted waves and the normal all lie on the same plane according to the law of refraction.

*Interference of waves:* This is when two waves of the same frequency, wavelength, and amplitude traveling in the same direction are superposed as they concurrently pass through a particular point. It can be constructive interference (when the superposition results in more excellent disturbance) or destructive interference (when the combination leads to the cancellation or complete annihilation of the other wave).

*Diffraction of waves* refers to the bending or spreading out of waves after passing through an obstacle or a barrier. Light waves are diffracted through small openings of about  $6.0 \times 10^{-7}$ cm, while sound waves are diffracted through openings of about 50cm.

*Polarization* is a phenomenon that causes a wave (usually light) to vibrate only in one plane. Only transverse waves can be plane polarized, whereas longitudinal waves cannot.

These various properties of waves are mainly described using basic terminologies of waves. They include amplitude, frequency, period, wavelength, wave speed, wave phase, wave trough, wave crest, etc.

*Wave amplitude (A)* refers to the point of maximum displacement of the particles of the medium from its resting position. It is measured in meters (m)

*Frequency (F):* this is the number of complete revolutions or oscillations made by a particle in one second ( $F = \frac{1}{T}$ ). It is measured in Hertz or per second (Hz or  $S^{-1}$ ).

*Period (T)* refers to a particle's time to make one complete revolution or oscillation ( $T = \frac{1}{F}$ ). It is measured in seconds (S).

*Wavelength ( $\gamma$ ):* The distance between two successive crests or troughs, measured in meters (M).

*Wave speed (v):* the distance a wave travels in one second. It is measured in meters per second ( $ms^{-1}$ ). The speed,  $v = \frac{\lambda}{T} = \lambda f$ .

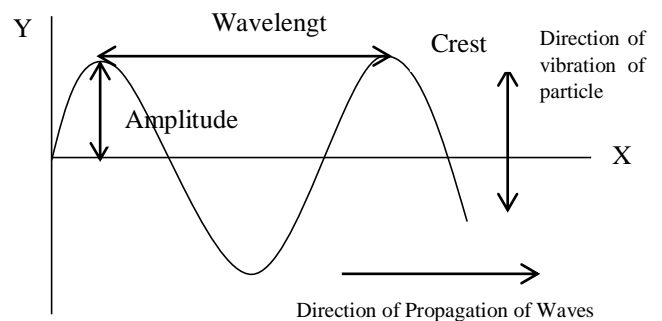
*Wave phase* refers to the state of vibration of a medium particle concerning its mean position or the same position. The expression can give a progressive wave Equation 1.

$$Y = A \sin\left(\frac{2\pi x}{\lambda}\right) \quad (1)$$

A wave motion can be represented in Figure 1.

**Figure 1**

*A Wave Motion*



It is essential to understand that secondary school students must adequately understand the concepts of waves discussed above to attain good academic achievement.

Academic achievement implies the degree of success a learner attains after teaching and learning. It is students' performance or outcome in intellectual domains taught at school, college, or university (Ocheni, 2021). It shows how much teaching and learning have occurred (Onukwufor & Ugwu, 2017). In the context of this study, academic achievement is the attainment of academic goals or instructional objectives and targets by a learner at the end of the teaching and learning processes. Academic achievement enables us to predict whether instructional or behavioral objectives were met. Thus, it is clear that the place of academic achievement in educational settings must be considered. This means that academic achievement is an indicator of success. According to Nwadinigwe & Azuka-Obieke (2012), poor academic achievement is any academic achievement that the examiners see as failing to meet the required benchmark. It is when a student's performance is below his expected ability. It could be a result of several factors, one of which is test anxiety. Thus, this study examined the prediction of test anxiety on students' achievement.

Empirical findings on the prediction of test anxiety on students' achievement, as well as the moderating role of gender and school location, abound. The study of Oluoch et al. (2018) and Balogun et al. (2017) found that test anxiety predicts students' achievement. The study of Khizar et al. (2015) revealed that test anxiety does not predict students' achievement. The study by Agra et al. (2018) showed that gender influences the relationship between test anxiety and students' achievement. Alam (2016) also found that gender influences the test anxiety level of students. However, Ahmad et al. (2018) found that the influence of gender on the test anxiety level of students is not significant. Furthermore, Goswami & Roy (2017) reported that the level of test anxiety of students is influenced by school location. This is similar to the findings of Sultan & Bhat (2019) that location determines students' test anxiety levels. Furthermore, the study by Mkpaoro & Nwagu (2019) revealed that school location influences the prediction of test anxiety on student's achievement. However, the study of Ntibi & Edoho (2017) showed that the location of students does not influence the relationship between test anxiety and academic achievement.

The preceding reviewed studies show inconsistencies in the researchers' reports. More so, evidence shows that studies on test anxiety and achievement in wave motion are yet to be carried out. Thus, this study investigated the moderation of gender and school location in predicting test anxiety on physics students' academic achievement in wave motion. Specifically, this study determined the predictive power of test anxiety on Physics students' achievement in wave motion, the moderation of gender on the prediction of test anxiety on Physics students' achievement in wave motion, and the moderation of school location on the prediction of test anxiety on Physics students' academic achievement in waves motion.

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## Methods

### Design of the Study

This study used a correlational research design to establish a relationship between two or more variables. It also applied this design to seek to establish the relationship between test anxiety, gender, school location, and Physics students' academic achievement in wave motion.

### Research Subjects

This study used all physics students in senior secondary school II (SSII) in the Education Zone C area of Benue state, with a population of 2696. A multistage sampling procedure involving simple

random sampling (balloting with replacement), proportionate stratified random sampling, and a purposive sampling technique was used to draw a sample of 337, which comprised 171 males and 166 females, as well as 188 urban and 149 rural school students.

### Research Instruments

A Waves Test Anxiety Inventory (WTAI) adapted from Spielberger (1980) and a Waves Achievement Test (WAT) instrument designed by the researcher were used in the collection of data. The WTAI instrument was made up of 20 items with a scale of 1-4 to indicate the level of test anxiety among students, while the WAT instrument was made up of 20 multiple-choice test items with four options; one option was the correct response (key) while three options were incorrect (distractors). A score of 4 marks was assigned to the key, while a 0 mark was awarded to any wrong response. This will give a total score of 80 for all correct responses.

### Validation of Instruments

Three experts conducted the face validation for the instruments. One was from Research Measurement and Evaluation, one from Physics, and one from Psychology units, all from the Faculty of Education, University of Nigeria, Nsukka. Content validation was established for WAT using a specifications table aligned with the modified Bloom's taxonomy. On the other hand, construct validation was done for the WTAI instrument using factor analysis involving principal axis factoring with varimax rotation. Twenty (20) Factorially pure items were selected and used for the study. A benchmark of 0.40 was used to select factorially pure items as suggested by (DeVellis, 2012).

### Reliability of Instruments

The instruments were trial tested on 20 physics students, and the reliability of the WTAI instrument was estimated to be 0.73 using the Cronbach alpha method since the responses are structured polytomously. At the same time, KR-20 was employed to estimate the reliability index of WAT, which was 0.76 because the scoring was dichotomous.

### Data Collection and Analysis

The data were collected using the direct delivery technique (DDT) to ensure a 100% return rate. They were analyzed using SPSS version 23. Regression was used to answer the research questions. ANOVA was used to test hypothesis 1, while a t-test and its associated probability value obtained using Andrew Hayes' Process Macro were used to test hypotheses 2 and 3 at the 0.05 significance level.

## Result and Discussions

The result in Table 1 shows that the correlation coefficient between test anxiety and Physics students' achievement in waves is 0.29, indicating a low relationship. Table 1 further reveals that test anxiety has a predictive power of 0.08, representing 8% of Physics students' academic achievement in waves. This means that test anxiety predicts students' achievement in waves. The result showed an F-ratio of 29.94 with an associated exact probability value of 0.00. This means that the predictive power of test anxiety on Physics students' academic achievement in waves is significant.

**Table 1**

*Prediction of test anxiety on Physics students' achievement in Waves motion*

Model	N	R	R <sup>2</sup>	SE	F	P
1	337	.29 <sup>a</sup>	.08	9.71	29.94	.00

Table 2 shows that the correlation coefficient between test anxiety and Physics students' achievement in waves as moderated by gender is 0.32, indicating a moderate relationship. Furthermore, the table indicates that the predictive power of test anxiety on Physics students' achievement in waves as moderated by gender is 0.10, implying that 10% of the prediction of test anxiety on Physics students' achievement in waves is moderated by gender. Further analysis revealed that the t-value of -0.66 with an associated exact probability value of 0.51 obtained indicates that the moderation of gender on the prediction of test anxiety on Physics students' achievement in waves is insignificant.

**Table 2**

*Moderation of gender on the prediction of test Anxiety on physics Students' Achievement in waves*

Model	Interaction	N	R	R <sup>2</sup>	SE	t	P
1	Test anxiety * Gender	337	.32	.10	.09	-0.66	.51

Table 3 shows that the correlation coefficient between test anxiety and Physics students' achievement in waves as moderated by location is 0.40, meaning a moderate relationship exists among the variables. Furthermore, from the table, the predictive power of test anxiety on Physics students' achievement in waves as moderated by gender is 0.16, implying that 16% of the prediction of test anxiety on Physics students' achievement in waves is moderated by location. Consequently, Table 3 shows that the t-value of -2.08 with an associated exact probability value of 0.04

indicates that the moderation of location in predicting test anxiety on physics students' achievement in waves is significant.

**Table 3**

*Moderation of location on the prediction of test anxiety on Physics students' achievement in waves*

Model	Interaction	N	R	R <sup>2</sup>	SE	t	P
1	Test anxiety * Gender	337	.40	.16	.09	-2.08	.04

The study showed that the predictive power of test anxiety On physics students' achievement in wave motion is significant. This means that the achievement of Physics students in waves depends on their test anxiety level. This result could have been like this because such indicators of test anxiety as worry, restlessness, lack of concentration, and forgetfulness, among others, would have stirred up Physics students' test anxiety, thus making it to predict their achievement in waves. The result of this study is strengthened by the findings of Balogun et al. (2017), (Oluoch et al. (2018), and Benjamin & Mohammed (2023) that test anxiety predicts student achievement significantly. However, a disparity was found in the study of Theobald et al. (2022), where it was reported that test anxiety does not predict students' achievement. These differences may be due to other factors such as subject areas, teachers' instructional procedures, and students' characteristics.

This study also showed that gender moderates the prediction of test anxiety on Physics students' achievement in wave motion. However, the moderating role of gender was not significant. This result is not surprising because both male and female students experience such feelings as uneasiness, discomfort, tension, forgetfulness, and worry, which reflects test anxiety. This could have predicted test anxiety in Physics students' achievement in wave motion was not different for male and female students. This result is consistent with the findings of Ahmad et al. (2018) that gender does not influence the prediction of test anxiety on students' achievement. On the other hand, Pachaippan et al. (2023) and Agra et al. (2018) disagreed, reporting that gender influences the prediction of test anxiety on students' achievement. These inconsistencies in findings may be due to the characteristics of the students, such as age, parents' qualifications, and self-esteem, among others.

Findings from the study indicate that location moderates the prediction of test anxiety on Physics students' achievement in waves. Further analysis showed that the moderating role of location on

Physics students' achievement in waves is significant. This implies that the prediction of test anxiety on urban Physics students' achievement in waves differs from that of rural students. This result is plausible since students in different locations could experience tension, discomfort, and worry based on their immediate and socializing environmental conditions. This result is supported by the findings of Goswami & Roy (2017) as well as the study of Sultan & Bhat (2019) and Mkpaoro & Nwagu (2019) that location influences the prediction of test anxiety on students' achievement. Contradicting these findings, Joseph Effiom-Edem Ntibi & Edoho (2017) reported that location does not influence the prediction of test anxiety on students' achievement. These differences could be due to students' personality traits such as self-efficacy, age, and locus of control.

## Conclusions

Based on this study's result, the conclusion is that test anxiety predicts Physics students' achievement in wave motions significantly. However, the prediction of test anxiety on Physics students' achievement in wave motion is not significantly different for male and female students. On the other hand, test anxiety predicts urban and rural Physics students' achievement in wave motion differently. Based on the main findings of this research, recommendations that can be given include: physics teachers should ensure that lesson contents are duly covered and that a conducive learning environment, clear instructions as well and adequate preparations are made available to students before testing them; physics teachers should ensure that instructional processes are duly delivered without any gender difference; stakeholders should make efforts to ensure that such factors as location do not bring bias in the teaching and learning process for students; students should ensure that they prepare adequately by reading their books and ensuring understanding to overcome worries, tensions, and discomfort, among others which could lead to test anxiety.

## Acknowledgments

The researchers are grateful to God Almighty and to all the research participants for their cooperation and involvement, which led to the success of this study.

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