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Verification of Rasch Model in Evaluating Tests Anxiety and Attitude of Students Towards Learning of Mathematics

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Abstract: *This study examined the applicability of the Rasch Model of test standardisation on test anxiety and students' attitudes towards learning Mathematics among Senior Secondary School Two (SS2) students in Ondo State, Nigeria. A non-experimental, descriptive survey and correlational research design was adopted. The sample comprised 600 SS2 students selected through a multistage sampling technique across the three senatorial districts in the state. Data were collected using three research instruments, and analysis was conducted using both descriptive and inferential statistics, with hypotheses tested at the 0.05 significance level. Findings revealed that after applying the Rasch Model, there was a negative influence on students with very low test anxiety, reflected by a difference of -1.28. In contrast, students with low to moderate anxiety levels showed a positive influence, with a difference of 0.15. Students' attitude towards Mathematics improved as well: for those with very low anxiety, attitude scores increased from 9.24 to 10.46; while for those with moderate anxiety, scores rose from 8.93 to 9.24. However, there was no significant relationship between test anxiety and academic achievement either before (r = -0.15) or after (r = -0.11) the Rasch Model application. Similarly, the relationship between two-tier and academic achievement was not significant before (r = -0.27, P > 0.05) or after (r = -0.22, P > 0.05) applying the model. Additionally, there was no significant relationship between attitude towards Mathematics and*

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academic achievement both before and after ($r = 0.15$, $P > 0.05$), and between two-tier and attitude ($r = 0.22$, $P > 0.05$; $r = 0.26$, $P > 0.05$). The study concludes that the Rasch Model positively influences test anxiety and attitudes toward Mathematics and recommends its adoption in standardising test items in Nigerian secondary schools.

Keywords verification, test-anxiety, attitude, learning mathematics, Rasch model test standardisation

INTRODUCTION

Test anxiety is a physiological condition where individuals experience intense stress and discomfort before or during examinations, which can severely impair academic performance and affect social, emotional, and behavioural development (Abe & Gbenro, 2024; Salend, 2012). Specifically, Mathematics anxiety, a form of test anxiety has been shown to significantly influence students' performance in Mathematics (Ashcraft, 2002). According to Dreger and Aikens (1957), Fennema and Sherman (1976), and Richardson and Woolfolk (1980), Mathematics anxiety manifests as emotional reactions to mathematical tasks and test situations, resulting in negative attitudes and low confidence. Attitude towards Mathematics, which has long been studied in relation to academic achievement, is considered multidimensional and encompasses emotional and behavioural responses towards the subject (Zan & Matino, 2007). Hart (1989) highlighted that students' attitudes depend on past experiences, confidence levels, frustrations, and beliefs in their capabilities. Similarly, Hanmula (2002) classified student attitudes into emotional experiences during mathematical activities, emotions evoked by the concept of Mathematics itself, perceived consequences of engaging in Mathematics, and the subject's value in achieving future goals.

The Rasch Model of test standardisation, developed by George Rasch, is a psychometric framework used to analyse categorical data such as test scores and questionnaire responses, focusing on the interaction between a person's ability or trait and item difficulty (Rasch, 1960; 1980; Istiqomah, Hasanati & Nida, 2022). This model is particularly effective in educational research for evaluating multiple-choice or binary-scored items, where each response is classified as correct or incorrect. Rasch Model applications span other fields such as health, agriculture, and market research (Bezruczko, 2005; Moral & Rebollo, 2017; Beohtel, 1985; Wright, 1977). The model operates on the premise that a person's response is determined by both a person-specific and item-specific parameter, which remain consistent across different interactions (Willmote & Fowlessi, 1974; Owabumoye, 2024). This dual-parameter assumption allows the Rasch Model to provide reliable, comparable measurements across individuals and test items.

Rasch's Model is described as a simple trait model, asserting that the probability of a correct response depends solely on the interaction between the individual's ability and the item's difficulty (Rasch, 1960; Wright, 1968; Willmot & Fowles, 1974; Wainer, Morgan & Gustafson, 1980; Alonge & Gbore, 2016). As such, it offers a robust framework for test standardisation, with the

potential to mitigate test anxiety and improve students' engagement and attitudes towards subjects like Mathematics.

The Rasch Model posits that the probability of a correct response increases with a person's ability and decreases with item difficulty. According to Wainer et al. (1980), the model relies on key assumptions: all test items measure the same latent trait, thus rendering the test homogeneous; the item characteristic curve follows a logistic function; and local stochastic independence holds meaning a person's response to an item depends solely on their ability and the item's difficulty, not on their performance on other items. If these assumptions are satisfied, important psychometric properties emerge: firstly, the raw score (i.e., the number of correct responses) becomes a sufficient statistic for estimating a person's ability. Secondly, comparisons between individuals rely purely on the differences in their abilities, regardless of the specific items each individual encountered. Thirdly, item difficulties can be estimated independently of the ability level of the sample used for calibration, allowing for what is termed sample-free item calibration (Wainer et al., 1980).

These properties significantly enhance the robustness and fairness of ability testing. Gullikson (1950) had earlier asserted that an important advancement in test theory would be the identification of item parameters that remain stable across varying analysis groups. The Rasch Model satisfies this criterion by ensuring that test results do not depend on the population from which test-takers are drawn or the particular set of items administered. This attribute underscores the Rasch Model's potential in educational measurement and assessment, offering objectivity and comparability that are essential for valid ability testing across different contexts and populations.

For the responses to the items of a di chotomously scored test, Rasch (1960) propounded the following model.
The probability of correct responses Xvi by person V to items i, is defined as

$$P_r\left(X_{vi}=\frac{1}{\beta_{vi}\sqrt{vi}}\right)=P_r(X_{v,i}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\mu(X_{vi}) = \frac{e^{yi}}{1+e^{\sqrt{vi}}} \quad \ldots\ldots\ldots\ldots\ldots \text{ i = 1, 2, 3….k}$$

v = 1, 2, 3…n

Where V is the person parameter and i is the items parameter. On this basis of the model (1), we may estimate the item parameter independently of the person parameters. The later having been replaced by something observable namely, by the individual total number of correct answer.

Rasch Analysis, a model within Item Response Theory (IRT), is utilised to measure quantitative latent variables such as overall anxiety scores on a metric scale. It offers key psychometric properties including separability, sufficiency, specific objectivity, latent additivity, and the invariance property of estimates (Rost, 2000). When the invariance assumption is violated, Rasch Analysis remains valuable through tools like Differential Item Functioning (DIF), which helps to examine item performance across different student profiles. In Rasch models, items are structured

hierarchically; endorsing difficult items implies endorsement of easier ones, though the reverse is not necessarily true. Sick (2011) noted that traditional Factor Analysis (FA) struggles with Likert-type data, as difficult-to-endorse items may not correlate well with easier ones despite reflecting the same trait, potentially resulting in misleading difficulty factors. Wright (2009) therefore recommended Rasch over FA, arguing that FA may incorrectly assume linearity in ordinal responses. He proposed Rasch as a more accurate alternative for transforming complex ordinal data into unidimensional metrics.

Practical applications of Rasch Analysis have extended beyond education into fields such as finance and customer satisfaction. Effandi, Zain, and Amalin (2012) employed Rasch to assess financial literacy among students, uncovering specific knowledge deficiencies among different student groups. De Baltist, Nicolini, and Salmi (2010) used the model to measure service quality and customer satisfaction, confirming its strength in capturing probabilistic satisfaction levels per customer and item-specific quality. In the current study, Rasch Model is applied to identify areas and groups among Senior Secondary School students in Ondo State, Nigeria, that exhibit the highest levels of Mathematics anxiety and negative attitudes towards the subject..
Rasch Model adopted is given as

$$B_{n-D_i} = I_n\left(\frac{P_{ni}}{1-P_{ni}}\right) \qquad \ldots\ldots\ldots \qquad \text{(ii)}$$

Where Bn is the measure of Mathematics anxiety of the student across all items in the questionnaire, Di is the measure of how much the item in the questionnaire triggers Mathematics anxiety Pi is the probability of the student to have high mathematics anxiety in an items in the questionnaire, 1-Pni is the probability of the students to have low in Mathematics anxiety in an item in the questionnaire. Rasch analysis is employed to each of the four dimensions of mathematics anxiety on the assumption that the dimensions contribute differently to the overall anxiety score. While differential item functioning is then used to determine whether subgroups of students have higher anxiety over the other and, raw scores and scores from the Rasch Model are compared in each dimension. The major problem of the study is to empirically verify the applicability of Rasch Model in evaluating Test-anxiety and attitude towards learning of mathematics among Senior Secondary School students.

The objectives of this study are to examine the influence of the Rasch Model of test standardisation on students' levels of test anxiety and their attitudes towards learning Mathematics. Additionally, the study seeks to investigate the relationship between students' Mathematics test anxiety and their academic achievement before and after the application of the Rasch Model of test standardisation, as well as to explore the relationship between students' attitudes towards learning Mathematics and their academic achievement within the same context.

Hypotheses

To guide this study, the following hypotheses were formulated.

H_{o1}: There is no significant relationship between students test anxiety and academic achievement before and after applicability of Rasch Model.

H_{o2}: There is no significant relationship between students' attitude towards learning of Mathematics and academic achievement before and after the applicability of Rasch Model

METHOD

The study employed the non-experimental research design of the descriptive survey type and a correlational research design. The study employed a survey method using questionnaires to collect data from SS2 students for generalisation purposes, and applied correlation techniques to assess the strength, direction, and magnitude of relationships between test scores, test anxiety, and attitudes towards learning Mathematics before and after applying the Rasch Model of test standardisation. The target population for the study consisted of all public secondary schools in Ondo State which totaled 302 public schools that cut across eighteen local government areas in three (3) senatorial districts of Ondo State. (Source ASUSS, Akoko South West Local Government Yearly Handbook of 2022/2023 session).

The sample for the study was 600 Senior Secondary School Class two (SS 2) students. The sample was collected through a multistage sampling procedure, first, six (6) local government areas out of the eighteen local government areas in the three senatorial districts in Ondo State were selected through simple random sampling, second, in each of the 6 local governments two (2) public secondary schools that are co-educational were randomly selected. In the third stage, in each selected school, fifty (50) students (25 male and 25 female) from the Mathematics class of Senior Secondary School Class two (2) were selected through stratified and simple random sampling techniques. Three (3) instruments were used for the data collection in the study namely: the Mathematics Test Anxiety Scale (MTAS), the Mathematics Attitudinal Scale (MAS) and the Mathematics Achievement Test (MAT) which comprised multiple-choice and two-tier objective test items.

The validity of the three instruments MTAS, MAS, and MAT were determined by experts in tests and measurement who are Mathematics educators in Bamidele Olumiluwa University of Education, Science and Technology, Ikere-Ekiti and experts in tests and measurement from Departments of Guidance and Counselling, Adekunle Ajasin University, Akungba-Akoko, Ondo State, also ascertained the face and content validity of the three instruments. Alpha Cronbach was used to determine the reliability of (MTAS) and (MAS) with results showing 0.63 and 0.66 for MTAS and MAS respectively which complied with and corroborated the assertions of Macintosh (1974) and Alonge (1989 & 2004) that moderate and substantial reliability coefficient should range between 0.60 to 0.80 hence the results were considered reliable enough for the study. The instruments were administered to the subjects in the following order: Mathematics Attitudinal Scale (MAS), Mathematics Test Anxiety Scale (MTAS) and then the Mathematics Achievement

Test. Six trained research assistants were used to ensure proper field administration of the instruments. The administered instruments were collected back by hand from the respondents after completion for the purpose of swing and data analysis. Rasch Model was used to answer the two general questions and Product Moment Correlation was used to test the two hypotheses.

RESULTS AND DISCUSSION

Question 1: What is influence of Rasch Model of test standardisation on the levels of Students' Test- Anxiety?

In answering this question the responses to Mathematics Achievement Test were Scored, computed and the Scores were Standardised using Rasch Model. The results were presented in the Table 1.

Table 1: Influence of Rasch model of Test Standardisation on Levels of students Test Anxiety

Dimension or Levels of Test Anxiety	Rasch's Standardised Average Score per on Level of Anxiety			
	Before	After	Influence	Remarks
1.0 - 1.49	11.96(40)	10.67(48)	- 1,28	Negative
1.50 – 2.49	9.30(352)	9.45(303)	0.15	Positive
2.50 – 3.49	8.65(199)	8.74(240)	0.09	Positive
3.50– 4.00	11.10(9)	11.06(9)	-0.04	Negative

The table 1 depicts the average performance of the Students in Rasch's standardised Mathematics Achievement Tests. The table revealed that, 40 students fall within The level of 1.00 and 1.49 (Very Low test-Anxiety, for Mathematics Test Anxiety Scale (MTAS) administered before the Mathematics Achievement Test With the Average performance of 11.96 While 352,student were Within 1:50 and 2.49(Low students Test-anxiety) With average performance of 9.30, students 199 students fell Within 2.50 and 3.49 (High test-anxiety) With average performance of 8.65 and 09 students fell within 3.50 and 400 (Very high test-anxiety) with average performance of 11.10.

For Mathematics Test Anxiety Scale (MTAS) administered after The Mathematics Achievements Test, 48 students fell within the level of 1.00 and 1.49 (Very Low test-anxiety) with the average performance of 10.67. Therefore Rasch Model difference was-1.28, which indicates negative influence on The Mathematics Test Anxiety, in 1.00 and 1 .49 of levels, of Test anxiety. While 303 students fell within 1.50 and 2:49 (Low Test- anxiety with the average performance of 9.45) Rasch model was 0.15, which depicts positive influence on the Mathematics Test Anxiety between 1.50 and 2.49 level. There were 240 students that fell within the level of 2.50 and 3.49 (high test-anxiety) with average performance of 8.74 and Rasch model difference was 0.09 indicating positive influence of test-anxiety in that range of 1.50 and 2.49 level respectively, While Nine (9) Students fell within 3.50 and 4.00 (Very high test-anxiety) with average performance of 11.06 and

Rasch Model difference of - 0.04 indicating Negative influence at that Level Hence Rasch Model of test standardisation influences test-anxiety levels of the students Negatively in two levels and positively in two levels respectively.

Question 2: What is influence of Rasch Model of Test Standardisation on level of students' attitude towards Learning of Mathematics?

In proffering solution to the responses to Mathematics, Attitudinal Scale were Scored and Levels of Students attitudes towards learning Mathematics were computed and grouped. The results were presented in table 2

Table 2: Influence of Rasch Model of Test Standardisation on levels of students' attitude towards Learning of Mathematics

Dimension or Levels of Attitude	Rasch's Standardised Average Score per Level of attitude			
	Before	After	Difference	Remarks
1.0- 1.49	9.54(3)	10.46(5)	0.92	Positive
1.50 – 2.49	9.27(14)	8.67(128)	- 0.60	Negative
2.50 – 3.49	8.93(390)	9.24(389)	0.31	Positive
3.50– 4.00	10.86(59)	10.45(78)	- 0.41	Negative

The table 2 revealed that, in Rasch's Standardised Score, three (3) Students fell within the level of 1.00 and 1.49 (Very low negative attitudes for Mathematics Attitudinal Scale (MAS) administered before the Mathematics Achievement Test with the average Performance of 9.54, While, 14 Students fell within 1.50 and 2.49 indicate (moderate Negative Attitude) with average performance of 9.27, 390 students fell within 2.50 and 3.49 depicts (moderate Positive Attitude) with average performance of 8.93 and 59 students fell within 3.50 and 4.00 shows (Highly Positive Attitude) with average performance of 10.86 While for Mathematics Attitudinal Scale (MAS) administered after the Mathematics Achievement Test Five (5) students fell within the level of 1.00 and 1.49 indicate (Very Negative Attitude) with The average Performance of 10.45 while 128 students fall within the level of 1.50 and 2.49 depicts Moderate Negative Attitude with average performance of 8.67 while 389 Students fell within 2-50 The level of 2.50 and 3.49 indicate (Moderate Positive Attitude) with average performance of 9.24 and 78 Students fall within the level of 3.50 and 4.00 depicts (Highly Positive Altitude) With average performance of 10.45 Therefore the Rasch's Model influences on Attitude per level were 0.92 (Positive), - 0,60 (Negative), 0.31 (Positive) and -0.41 (Negative) respectively. That is to Say that, Rasch Model difference of -0.60 and - 0.41 depicts Negative influence at the levels of 41:50-2.49) and (3.50 and $400) While Rasch model difference of 0.92 and 0.31 indicating positive influence of the model at both (9.00-1.49) and (2.50-3.49) levels respectively. That is Rasch model Test standardization on levels of students Attitude towards learning Mathematics

Question 3: Is there any relationship between students' mathematics anxiety and academic achievement before and after the applicability of Rasch Model of test standardisation?

Table 3: Strength of the relationship between test anxiety and academic achievements before and after the applicability of Rasch Model

Variable	Correlation Coefficients calculated before and after the application of Rasch model	
	Before	After
Direct Multiple Choice	-0.16 very low and Negative	-0.12 Very Low and Negative
Two Tier objective Standardized Score	-0.27 Low and Negative	-0.22 Low and Negative
Researchers Two Tier Standardized Score	-0.27 Low and Negative	-0.22 Low and Negative
Rasch's Standardized Score	-0.15 Very Low and Negative	-0.15 Very Low and Negative

The blue print used to determine the strength of relationship between test Anxiety and academic achievement is stated as:

Magnitude

0.0 – 0.2	Very Low
0.3 – 0.4	Low
0.5 – 0.6	Moderate
0.7 – 0.8	High
0.9 – 1.0	Very High

Table 3 shows Very Low and Negative relationship before and after the applicability of Rasch Model in Direct Multiple Choice, Likewise after the Rash's Standardized Scores. While Low and positive relationship occurred before and after the application of Rasch's model is Two Tier objective Scores, Researchers' Two-Tier Standardized Scores, and before in Rasch's test Standardized Scores.

Question 4: Is there any relationship between students' attitude towards learning of Mathematics and academic achievement before and after the applicability of Rasch Model of test standardization?

Table 4: Strength of Relationship between Attitude and Academic Performance of students towards Learning of Mathematics among the Senior Secondary schools, before and after the applicability of Rasch Model

Variable	Correlation Coefficients calculated before and after the application of Rasch model	
	Before	After
Direct Multiple Choice vs students' attitudes	0.17 You and positive	0.16 Very Low and positive
Two Tier objective Standardized Score vs students' attitudes	0.26 Low and positive	0.26 Low and positive
Researchers Two Tier Standardized Score vs students' attitudes	0.27 Low and positive	0.26 Low and positive
Rasch's Standardized Score vs students' attitudes	0.15 Very Low and Positive	0.15 Very Low and Positive

Table 4 shows positive and very Low relationship in Direct Multiple choice score and Rasch's Standardized Score, before and after the applicability of Rasch Model while low and positive relationship existed in Two Tier objective standardized score and researchers' two Tier standardized score before and After the applicability of RaschModel

Hypothesis Testing

H_{01}: There is no significant relationship between students' Test Anxiety and Academic achievements before and after the applicability of Rasch Model.

Table 5: Correlation coefficients between Test Anxiety and academic Performance of students in Mathematics before and after Using Rasch Model for standardisation

Variable	Correlations Coefficients before and after the application of Rasch Model	
	Before	After
Direct Multiple Choice vs Test-Anxiety	-0.16	-0.12
Two Tier objective Standardized Score vs Test-Anxiety	- 0.27	-0.22
Researchers Two Tier Standardized Score vs Test-Anxiety	- 0.27	-0.22
Rasch's Standardized Score vs Test-Anxiety	- 0.15	-0.11

At P < 0.05, Critical Value of r is 0.345 (2 tailed test) there was no significant relationship between the Test Anxiety and academic performance before and after the application of Rasch's model in Variables considered is the table 5.Hence the hypothesis was upheld at p < 0.05 that is the level of tolerable limits of error

H_{02}. There is no significant relationship between students' attitudes towards learning of Mathematics and academic achievement before and after application of Rasch Model.

Table 6: Correlation Coefficients between students' attitudes and academic performance of students towards learning of Mathematics before and after application of Rasch Model

Dimension	Correlation Coefficient before and after the application of Rasch Mode	
	Before	After
Direct Multiple Choice vs students' attitudes	0.17	0.16
Two Tier objective Standardized Score vs students' attitudes students' attitudes	0.26	0.26
Researchers Two Tier Standardized Score vs students' attitudes	0.22	0.26
Rasch's Standardized Score vs students' attitudes	0.15	0.15

At P<0.05 - Critical Value of r is 0.345 (2 tailed test). There was no significant relationship between the attitude and academic achievement of students towards learning of Mathematics before and after the application of Rasch Model among all the variables as illustrated in the table 6. Hence the hypothesis was upheld at P<0.05 level of Tolerable limits of error.

DISCUSSION

The analysis of the data presented in Table 1 revealed the influence of the Rasch Model on students' levels of test anxiety. Specifically, the findings showed that after the application of the Rasch Model, there was a negative influence on test anxiety at the extreme ranges of 1.00–1.49 and 3.50–4.00. In contrast, a positive influence was observed within the mid-range scores of 1.50–2.49 and 2.56–3.49. This distribution of influence suggests that the Rasch Model contributed significantly to moderating extreme levels of test anxiety while enhancing favourable responses in the more moderate ranges. The manifestation of both positive and negative influences highlights the Rasch Model's capacity to refine test measurement and identify nuanced changes in psychological constructs such as anxiety. These outcomes align with earlier research by

Owabumoye (2024) and Bechte (1995), who similarly found the Rasch Model useful in evaluating affective traits within educational settings.

In Table 2, the influence of the Rasch Model on students' attitudes towards learning Mathematics was also explored. Positive influences were recorded in the attitude score ranges of 1.00–1.49 and 2.50–3.49, indicating improvements in student disposition at these levels. Conversely, negative influences were identified within the ranges of 1.50–2.49 and 3.50–4.00. These results imply that the Rasch Model has a mixed but insightful effect on student attitudes, making it a valuable tool for educators seeking to assess and enhance affective learning outcomes. In Tables 3 and 4, the relationships between test anxiety, attitude, and academic achievement were analysed before and after the Rasch Model was applied. The results in Table 3 indicated very low and negative correlations between test anxiety and academic achievement across multiple scoring systems, including Direct Multiple Choice, Two-Tier Objective Standardised Scores, Researchers' Two-Tier Standardised Scores, and Rasch's Standardised Scores.

In Table 4, very low to low but positive correlations were found between students' attitudes and academic achievement using the same scoring methods, indicating a mild but noteworthy association. However, Tables 5 and 6 showed that there was no statistically significant relationship between attitude and academic achievement, as well as between test anxiety and academic performance, at the $p < 0.05$ level of significance. Thus, the null hypotheses were upheld. These findings support previous studies by Owabumoye (2024), NurHiday, Habib and Laili (2022), Mendoza-Reyes and Grayo (2019), and Alonge and Gbore (2016), confirming that while the Rasch Model may not yield statistically significant changes in direct academic outcomes, it provides valuable insights into the psychological and attitudinal dimensions of student learning.

CONCLUSION

Rasch Model significantly influences test-anxiety, academic performance and equally attitude of students toward learning of Mathematics among the senior schools in Ondo State positively.

Recommendation

Based on the findings, the study recommended the use of Rasch Model of test standardisation as means of minimizing test-anxiety and at the same time improving or enhancing the attitude of students towards learning of Mathematics in secondary schools in Nigeria.

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