DEVELOPMENT AND VALIDATION OF STUDENTS' MATHEMATICS PERFORMANCE SKILLS TEST FOR SENIOR SECONDARY SCHOOL II IN ABIA STATE

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Abstract

The study was to developed and validated students' mathematics performance skills test for Senior Secondary Schools in Abia State. Three research questions guided the study and one null hypothesis were formulated and tested at 0.5 level of significance. The accessible population of the study was made up of 28,720 Senior Secondary Two Mathematics students which comprises 13391 males and 15329 female students. The sample size comprised 200 Mathematics students of which 122 are males and 78 are females obtained through Simple random sampling technique. Instrumentation design was the design of the study, with four Senior Secondary School Mathematics in Abia State while sample of two hundred (200) SS2 students was used. The researcher developed an instrument tilted Students' Mathematics Performance Skills Test (SMPST) with reliability co-efficient of 0.89. The instrument was used to carry out the study. Data obtained were subjected to statistical analysis. Scheuneman statistic was used to answer research questions and the hypotheses. The analysis of the data indicated that the developed Students Mathematics Performance Skills Test Senior Secondary Schools has high psychometric properties in terms of validity. That the developed Students Mathematics Performance Skills Test (SMPST) of senior secondary school II students of Abia State has high reliability index estimated to be 0.89 and inter rater reliability index of 0.88 using Cronbach's Alpha formula. That the four items had a very high discriminating attributes. This implies that Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School II Students in Abia State are good assessment tools for Performance Test. Based on the findings, it was recommended among others that the developed Mathematics Performance Skills Test instrument should be used by Mathematics teachers and the items of the SMPST developed should serve as template to develop other Performance Skills Test in Mathematics.

Keywords: Development, Validation, Performance Skills, Test, Mathematics

Introduction

Education is widely recognized and embraced as a strategic tool for addressing the multifaceted challenges of national development. Achieving national development through human capacity building requires equipping citizens with the knowledge, skills, and competencies necessary for critical thinking, problem-solving, and adaptation to the evolving demands of society. In this regard, Mathematics stands out as a vital instrument for tackling national development challenges. Mathematics is the science of structure, order, and relationships, rooted in fundamental practices such as counting, measuring, and describing the shapes of objects. It encompasses logical reasoning, quantitative calculations, and a progressive journey toward idealization and abstraction (Ezewu, 2014). The discipline of Mathematics has evolved over

centuries from practical applications like counting, calculation, measurement, and the systematic study of shapes and motions of physical objects. It is one of humanity's oldest intellectual pursuits, with evidence of its practice as far back as historical records exist (Anaekwe, 2014). Today, Mathematics serves as a foundational tool across a wide range of disciplines, including natural sciences, engineering, medicine, and social sciences, playing a pivotal role in shaping modern society and addressing complex development issues. Furthermore, Mathematics is a foundational requirement for advancing education in diverse fields, including pure sciences, technology, social sciences, and various disciplines within the humanities. Recognizing its critical importance, the Federal Republic of Nigeria (2017) mandated the compulsory inclusion of Mathematics in the curricula of basic and secondary schools.

Academic achievement in Mathematics is widely regarded as a key predictor of overall academic success among students. The discipline's relevance extends beyond the classroom, as a solid understanding of Mathematics is vital for grasping the inner workings of society. Its practical applications pervade daily life, and mastery of appropriate mathematical concepts is essential for success in virtually any career path. Without this foundational knowledge, failure in both academic and professional endeavors becomes an unavoidable consequence. Despite the acknowledged importance of Mathematics and its applications, teaching and learning the subject in Nigerian secondary schools face persistent challenges. An analysis of students' performance in the May/June West African Senior School Certificate Examination (WASSCE) reveals concerning trends. Pass rates for Mathematics were recorded as 38.50% in 2015, 35.66% in 2016, 51.73% in 2017, 56.17% in 2018, 47.39% in 2019, 46.87% in 2020, 44.93% in 2021, and 50.52% in 2022. Over the past decade, the average pass rate has stagnated at approximately 46.47%, as highlighted in the West African Examinations Council (WAEC) Chief Examiners' reports (2015–2022). This consistent underperformance has raised significant concerns among educators, policymakers, and other stakeholders, emphasizing the urgent need for interventions to address these challenges and improve students' outcomes in Mathematics.

The persistently low pass rates in Mathematics have sparked widespread concern, prompting a deeper examination of the factors contributing to students' poor performance and the broader impact on overall academic achievement. This issue has become a shared priority for educators, policymakers, parents, and other stakeholders in the education sector. According to educators, researchers, and the Chief Examiners of the West African Examinations Council (WAEC), several challenges have been identified as root causes. These include incomplete content coverage, teachers skipping critical topics, ineffective assessment methods, students' difficulties with mathematical calculations, and challenges in graphical presentation and interpretation (Orluwene & Ottawa, 2017). Additionally, teachers often neglect comprehensive performance assessments during teaching, learning, and grading, which adversely impacts students' preparedness for the Senior Secondary Certificate Examination (SSCE). The poor performance of students in Mathematics during senior secondary school external examinations, such as those conducted by the West African Examinations Council (WAEC), can be attributed to a variety of challenges. According to the WAEC Chief Examiner's report in 2022, the decline in students' performance compared to previous years highlights the urgent need to improve academic outcomes by focusing on robust internal assessments that adequately prepare students for external evaluations.

One significant issue affecting students' performance is their inability to respond effectively to Performance Test-related questions. This problem often originates in the classroom, where teachers fail to prioritize process evaluation for topics requiring detailed step-by-step examination. Instead, many teachers assess psychomotor tasks using the same methods and marking criteria as cognitive-based

questions, depriving students of the opportunity to develop essential psychomotor skills (Anazia, 2019). Consequently, students who are not properly equipped with these foundational skills and knowledge in the classroom remain unaware of the specific features and techniques needed to approach such questions in external examinations. This lack of preparation ultimately leads to poor performance in these critical assessments.

A performance test is a specialized form of assessment designed to evaluate an individual's ability to perform specific tasks or skills in real-world or simulated settings. Unlike traditional tests that primarily assess knowledge recall or conceptual understanding, performance tests emphasize the practical application of skills and abilities (Obinne, 2018). These tests are widely used in educational, professional, and vocational contexts to measure proficiency in tasks requiring hands-on demonstration or practical execution. In essence, incorporating performance tests as a common and integral form of assessment, alongside cognitive evaluation, is essential for effectively gauging the extent of learners' mastery of knowledge and skills. Performance tests offer a more practical approach to assessing students' abilities, providing insights into their application of learned concepts in real-world or simulated scenarios. Akanwa and Ihechu (2019) emphasize that assessment is central to the overall quality of teaching and learning, underscoring its significance in driving educational outcomes. For a norm-referenced performance test to be both effective and widely accepted, it must possess certain critical properties, particularly test validity and reliability. Test validity ensures that the assessment measures the specific skills or knowledge it is intended to evaluate, while reliability guarantees consistency and accuracy in measuring student performance. However, as Osadebe (2019) highlights, many secondary school teachers, especially in Mathematics, encounter significant challenges in constructing tests that meet these criteria. This gap in test development skills undermines the accuracy and effectiveness of assessments, ultimately affecting students' academic outcomes and their preparedness for further education or careers.

In the field of Measurement and Evaluation, experts consistently underscore the importance of test validity in assessment practices. Drost (2018) defines validity as the degree to which a test accurately measures the construct it is intended to evaluate. By prioritizing validity and reliability in test construction, educators can ensure that assessments are both fair and effective, ultimately fostering a deeper understanding of Mathematics and supporting students' academic success. A comprehensive understanding and application of validity principles play a crucial role in developing and implementing effective assessments in educational settings. Validity ensures that a test accurately measures what it is designed to measure, making it a cornerstone of assessment design. Equally important is reliability, another fundamental psychometric property, which reflects the consistency and stability of a test's measurements. Drost (2018) defines reliability as the degree to which test items yield consistent results when administered under different conditions, to various examinees, or with alternative instruments targeting the same construct or skill. Interestingly, as Agbaegbu, Akanwa, and Ihechu (2017) note, a test may be reliable but not valid, implying that while the results may be consistent, they may not accurately reflect the intended construct. A specific aspect of reliability, inter-rater reliability, measures the level of agreement among independent raters or observers when assessing the same phenomenon. High inter-rater reliability is vital for minimizing bias and ensuring the credibility and reproducibility of findings, particularly in qualitative research. This reliability is typically measured using statistical tools such as Cohen's Kappa, Intraclass Correlation Coefficient (ICC), and percentage agreement (McHugh, 2012).

Achieving high inter-rater reliability requires clear operational definitions, thorough training for raters, and standardized evaluation criteria (Hallgren, 2012). Together, validity and reliability serve as the

foundation for ensuring the adequacy and accuracy of scientific research procedures (Bajpai & Bajpai, 2014). Research supports the importance of developing high-quality instruments for assessment. Akaezue (2019) demonstrated that well-designed tests could achieve high content validity, appropriate difficulty levels, strong discriminatory indices, and internal consistency with low standard error of measurement. Dorothy, Ezenwa, and Ezeudu (2015) validated an instrument for assessing students' practical performance in electrical installations, revealing reliability indices ranging from 0.86 to 0.97 using Cronbach's Alpha. Similarly, Oribhabor and Osaze (2016) showed that a Mathematics Achievement Test instrument for Senior Secondary Schools exhibited strong psychometric properties, including appropriate difficulty and discrimination indices and high reliability.

The process of validation ensures that the instrument is accurate, reliable, and effective in measuring the intended construct, producing consistent results (Abonyi, 2018). The study of Mathematics at the senior secondary school level is integral to equipping students with fundamental skills, knowledge, and competencies essential for problem-solving and effective interaction with their environment. By validating and improving performance tests in Mathematics, this research seeks to enhance students' psychomotor skills and overall educational outcomes, contributing significantly to the broader educational framework. Despite its broad importance, the psychomotor domain remains largely neglected in the teaching and assessment of Mathematics. Unfortunately, many of the testing instruments currently employed, especially those developed by secondary school Mathematics teachers, lack the psychometric rigor necessary for effective student evaluation. These teacher-made tests often rely on superficial validation methods, such as face or construct validity, while neglecting essential psychometric properties like reliability, discrimination, difficulty, and functionality. As a result, these assessments fall short of meeting the required standards for accurately measuring students' performance. Osadebe (2014) emphasizes that such inadequacies hinder the realization of broader educational objectives. In response to these challenges, this study aims to develop and validate a standardized instrument specifically designed to assess students' performance in Senior Secondary School Mathematics, with a particular emphasis on the psychomotor domain. This research is especially significant within the context of Abia State, where the use of valid and reliable performance tests in Mathematics is notably limited. By addressing these shortcomings, the study seeks to enhance assessment practices, thereby ensuring that the overarching goals of Mathematics education—fostering critical thinking, practical skills, and comprehensive learner development—are effectively achieved.

Research Questions

The following research questions were ask in the study:

1. What is the Validity of Students Mathematics Performance Skills Test (SMPST) for Senior secondary school two in Abia state?
2. What is the inter rater reliability of Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School II (SS2)?
3. What is the discrimination power of Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School II (SS2)?

Hypotheses

The null hypothesis formulated were tested at 0.05 level of significance.

H_{01}: Items of Students Mathematics Performance Skills Test does not significantly discriminate between high achievers and low achievers students.

Method

This study adopted an instrumentation research design. According to Kpolovie (2020), instrumentation research is specifically employed for test construction when the goal is to measure and evaluate psychological traits. The study was conducted in Abia State, Nigeria. The target population consisted of all Senior Secondary School Two (SS2) students enrolled in Mathematics in public Senior Secondary Schools across the state. The accessible population comprised 28,720 SS2 Mathematics students, including 13,391 males and 15,329 females (Statistics Unit, Abia State Ministry of Education, 2021). The sample size for the study was 200 Mathematics students, comprising 122 males and 78 females. A simple random sampling technique was used to select four public secondary schools for the study. The research instrument for data collection was the Students' Mathematics Performance Skills Test (SMPST). This test was developed by the researcher to measure students' performance in Mathematics and ensure uniformity. The draft SMPST was validated by three experts in Science Education (Measurement and Evaluation Unit and Mathematics Unit) at Michael Okpara University of Agriculture, Umudike. To establish the reliability of the SMPST, the instrument was subjected to trial testing. It was administered to a sample of 50 SS2 Mathematics students randomly selected from public secondary schools in Imo State, which was outside the study area. The scores from the trial testing were analyzed using Cronbach's alpha formula to determine the internal consistency of the SMPST, yielding a reliability coefficient of 0.89.

The researcher prepared 200 copies of the SMPST and personally visited the four selected government secondary schools with the consent and approval of the school authorities. The SMPST was administered directly to the students, with the researcher present during the exercise to provide clarifications where necessary. Each student was allocated two and half hours to complete the SMPST questions. The researcher remained on-site throughout the exercise to monitor the process and collect the completed test copies immediately afterward. The administration of the SMPST was carried out in stages over six weeks. Students were required to answer 10 items per week, culminating in a total of 60 items. These 60 items were systematically divided into six units, with each unit containing 10 items. This staggered approach ensured that students were not overburdened and could respond accurately and focused. The data collected were analyzed according to the research questions and hypotheses formulated for the study. Scheuneman statistics were employed to address research questions 1 and 2, while Kendall's Coefficient of Concordance (W) was used for research question 2. A point biserial correlation of at least 0.3 was considered for each item to determine the discrimination level. The pilot test revealed that the SMPST was both reliable and valid for assessing the performance of SS2 Mathematics students. The high reliability score demonstrated consistent performance across test items, while the validity measures confirmed alignment with the targeted psychomotor skills. However, minor revisions were made to improve clarity and efficiency, including adjustments to item wording and time allocation.

Results

Research Question One

What is the validity of Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School II Students in Abia State?

Table 1: Validity of Mathematics Performance Skills Test (SMPST)

Items	Infit	Outfit	Items	Infit	Outfit
1	1.03	1.11	**31**	1.24	1.36
2	1.06	1.09	**32**	1.25	1.39
3	0.74	0.85	**33**	1.34	1.47
4	1.34	1.44	**34**	1.36	1.41
5	0.61	0.97	**35**	1.01	1.03
6	0.70	0.91	**36**	0.88	0.97
7	1.04	1.08	**37**	1.05	1.09

8	0.97	1.05	**38**	0.82	0.87
9	0.76	0.86	**39**	0.91	0.96
10	1.05	1.09	**40**	0.92	0.98
11	0.74	0.78	**41**	1.06	1.10
12	0.81	0.86	**42**	0.96	0.99
13	0.94	0.98	**43**	0.76	0.83
14	0.65	0.93	**44**	0.88	0.92
15	1.06	1.09	**45**	0.94	0.98
16	1.03	1.07	**46**	1.86	2.48
17	1.36	1.48	**47**	0.86	0.98
18	1.68	1.74	**48**	1.84	1.97
19	0.74	0.95	**49**	1.69	1.71
20	1.03	1.11	**50**	1.01	1.32
21	0.75	1.05	**51**	0.96	1.07
22	1.08	1.11	**52**	1.06	1.10
23	0.85	0.91	**53**	0.91	1.04
24	0.86	0.91	**54**	0.95	1.05
25	0.85	0.92	**55**	0.91	0.97
26	0.74	0.78	**56**	0.77	0.82
27	0.81	0.87	**57**	0.84	0.89
28	0.88	0.91	**58**	0.94	0.99
29	0.82	0.86	**59**	0.87	0.94
30	0.95	0.99	**60**	1.05	1.11
Mean	**0.99**	**1.09**			
SD	**0.49**	**0.54**			

Table 1 shows the result of the fit statistic of validity of Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School two Students in Abia State. The result showed that the Mathematics Performance Skills Test had the infit statistic ranging from 0.61 to 1.86; and outfit statistic range from 0.78 to 2.48 respectively. In the items of SMPST, It is only item numbers 18 (that has infit of 1.68 and outfit of 1.74), 46 (has infit of 1.86 and outfit of 2.48), 48 (that has infit of 1.84 and outfit of 1.97) and 49 (has infit of 1.69 and outfit of 1.71), beyond the accepted range of 0.7 – 1.5. The fit statistic of the Students Mathematics Performance Skills Test apart from item 18, 46, 48 and 49 indicate that all the items are perfectly valid. The mean of the infit and outfit are 0.99 and 1.09 respectively. The spread of the infit and outfit and their mean indicate highly valid items (since their mean are sufficiently close to one). This implies that, apart from items 18, 46, 48 and 49 of SMPST, all other items of SMPST are valid and showed unidimensionality.

Research Question Two:

What is the inter rater reliability of Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School two (SS2)?

Table 2: Inter Rater Reliability of Mathematics Performance Skills Test (SMPST)

Kendall's Coefficient of Concordance (w)	Kendall's Coefficient of Concordance (w) Based on Standardized Items	N of Items
.88	.88	60

Table 2 revealed that the inter rater reliability index of the Students Mathematics Performance Skills Test

Instrument was estimated to be 0.88 using Cronbach's Alpha formula. This shows that the Students Mathematics Performance Skills Test Instrument developed is highly reliable.

Research Questions Three

What is the discrimination power of Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School II Students in Abia State?

Table 3: Item parameters (discrimination power) of Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School II Students in Abia State

Items	Slope	Items	Slope	Items	Slope
1	0.24	**21**	0.51	**41**	2.34
2	0.15	**22**	0.53	**42**	0.84
3	0.23	**23**	0.61	**43**	1.07
4	0.34	**24**	0.12	**44**	0.68
5	0.41	**25**	1.13	**45**	1.85
6	0.22	**26**	1.25	**46**	0.97
7	0.42	**27**	0.62	**47**	0.24
8	0.55	**28**	1.32	**48**	0.35
9	0.62	**29**	1.14	**49**	0.25
10	0.21	**30**	0.98	**50**	0.68
11	0.15	**31**	0.23	**51**	0.55
12	0.96	**32**	1.15	**52**	3.27
13	0.47	**33**	0.64	**53**	1.06
14	0.26	**34**	0.44	**54**	1.15
15	0.17	**35**	0.33	**55**	0.93
16	0.16	**36**	1.17	**56**	1.32
17	0.53	**37**	0.26	**57**	0.22
18	0.85	**38**	0.16	**58**	0.74
19	0.72	**39**	3.31	**59**	0.33
20	0.21	**40**	0.92	**60**	0.22
Mean			**0.74**		
SD			**0.43**		

Table 3 revealed that twenty one (21) items (35%), that is items 1, 2, 3, 4, 6, 10, 11, 14, 15, 16, 20, 24, 31, 35, 37, 38, 47, 49, 57, 59 and 60 within the value range of .01 - .34 indicated very low discriminating values, while fifteen (15) items (25%), that is items 5, 7, 8, 9, 13, 17, 21, 22, 23, 27, 33, 34, 36, 48 and 51 within the value range of .35 - .64 indicated low discriminating values. Also, twenty (20) items (33%), that is item 12, 18, 19, 25, 26, 28, 29, 30, 32, 40, 42, 43, 44, 46, 50, 53, 54, 55, 56 and 58 within the value range of .65 - 1.34 indicated moderate discriminating values and (39, 41, 45 & 52) items (7%) had values of 3.31, 2.34, 1.85 and 3.27 respectively, meaning that the four items had a very high discriminating attributes. This implies that Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School two Students in Abia State are good assessment tools for Performance Test.

Hypothesis One

Items of Students Mathematics Performance Skills Test does not significantly discriminate between high achievers and low achievers students

Table 4: Chi-square Summary of Discriminate in Students Mathematics Performance Test

Decoys	Percentage	Item favoured due to Discriminate	Df	Chi-square	Sig.(2-tailed)
Low Achievers	85	45(30)			
High Achievers	15	15(30)	1	18.64	0.001
Total	**100**	**60**			

χ^2 tabulated at 0.05 level of significant with 1 df = 3.84

Data in Table 4 shows that the chi-square calculated value of 18.64 is greater than the tabulated chi-square value of 3.84 when tested at 0.05 level of significance with 1 degree of freedom. Therefore, the null hypothesis which states that Students Mathematics Performance Skills Test items does not significantly discriminate between high achievers and low achievers students is thereby rejected. It implies that Items of Students Mathematics Performance Skills Test significantly discriminate between high achievers and low achievers students.

Discussions of Findings

The study showed that the developed students mathematics performance skills test for Senior Secondary Schools two has high psychometric properties in terms of validity. The fit statistic of the Students Mathematics Performance Skills Test apart from item 18, 46, 48 and 49 indicate that all the items are perfectly valid. The finding is in agreement with the finding of Akaezue, (2019) who found out that the test has high content validity, the items of the test are suitable in terms of its difficulty and discriminatory indices and also the test and its entire subsections have high degree of internal consistency with a low standard error of measurement.

The study revealed that the inter rater reliability index of the Students Mathematics Performance Skills Test Instrument was estimated to be 0.88 using Cronbach's Alpha formula. This shows that the Students Mathematics Performance Skills Test Instrument developed is highly reliable. The finding is in line with the finding of Anyanwu (2019) who developed and validated an instrument for assessment of students' Performance Test in Mathematics in senior secondary schools revealed that out of the 72 items, 38 were found to be valid and the inter-rater reliability using Kendalls coefficient of concordance was 0.812.

The study revealed that the developed Students Mathematics Performance Skills Test (SMPST) has high psychometric properties in terms of discrimination. That twenty one (21) items (35%), indicated very low discriminating values, while fifteen (15) items (25%), indicated low discriminating values. Also, twenty (20) items (33%), indicated moderate discriminating values and (39, 41, 45 & 52) items (7%) had values of 3.31, 2.34, 1.85 and 3.27 respectively, meaning that the four items had a very high discriminating attributes. This implies that Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School II Students in Abia State are good assessment tools for Performance Test. The corresponding hypothesis affirmed that Items of Students Mathematics Performance Skills Test significantly discriminate between high achievers and low achievers students. The finding is in agreement with the finding of Akaezue, (2019) whose study found out that the difficulty level of the test ranges from 0.325 to 0.855 while the discriminatory level ranges from 0.15 to 0.48.

Conclusion

The study developed and validated instrument for assessment of students' Performance Skills Test for Senior Secondary School Mathematics in Abia State. Based on the findings of the study, the researcher concludes that the developed Students Mathematics Performance Skills Test for Senior Secondary Schools has high psychometric properties in terms of validity. The fit statistic of the Students Mathematics Performance Skills Test apart from item 18, 46, 48 and 49 indicate that all the items are perfectly valid and that the developed Students Mathematics Performance Skills Test (SMPST) of senior secondary school II students of Abia State has high reliability index estimated to be 0.89.

Finally, the researcher concluded that the developed Students Mathematics Performance Skills Test (SMPST) has high psychometric properties in terms of discrimination. That twenty one (21) items (35%), indicated very low discriminating values, while fifteen (15) items (25%), indicated low discriminating values. Also, twenty (20) items (33%), indicated moderate discriminating values and (39, 41, 45 & 52) items (7%) had values of 3.31, 2.34, 1.85 and 3.27 respectively, meaning that the four items had a very high discriminating attributes and that the inter rater reliability index of the Students Mathematics Performance Skills Test Instrument was estimated to be 0.88. This implies that Students Mathematics Performance Skills Test (SMPST) for Senior Secondary School II students in Abia State are good assessment tools for Performance Test.

Recommendations

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

1. The developed Mathematics achievement test instrument should be used by Mathematics teachers and the items of the SMPST developed should serve as template to develop other Performance Skills Testin Mathematics.
2. The psychometricians and measurement expert should organize workshops to educate teachers on test development.
3. The ministry of education and universities should try and assist students who are interested to study a research on item response theory to get software and necessary computer packages.
4. Teachers in the secondary schools should adopt and use the instrument in the assessment of students' Performance Test in Mathematics especially in geometry (construction and loci).

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