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Patterns of Students' Errors in Solving Algebraic Equations: A Newman Error Analysis of Senior Secondary School Students in Northwestern Nigeria

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Abstract

Algebraic equation solving remains challenging for many secondary school students, with errors often reflecting underlying conceptual, comprehension, and procedural difficulties. This study investigated the patterns of errors committed by Senior Secondary School II (SS II) students when solving algebraic equations in Kankia Education Zone, Katsina State, Nigeria, using Newman's Error Analysis (NEA) as the diagnostic framework. A cross-sectional descriptive research design with a diagnostic assessment approach was adopted. The population comprised 4,683 SS II students, from which 130 students were selected through multistage sampling involving simple random selection of two co-educational public secondary schools and intact class sampling. Data were collected using the Algebraic Equation Diagnostic Test (AEDT), comprising six structured essay questions. The instrument was validated by two experts in Mathematics Education and yielded a test–retest reliability coefficient of .82. Data were analysed using frequencies, percentages, and a chi-square goodness-of-fit test. Sixteen specific error types were identified, with errors in tabulating values and selecting appropriate graph scales being most frequent (8.4% each). Comprehension errors were the most prevalent Newman category (27.0%), followed by transformation (26.1%) and process skills (22.8%). The distribution differed significantly across categories, $\chi^2(4) = 37.83$, $p < .001$. The findings highlight the need for diagnostic and formative assessment that prioritises students' comprehension and transformation of algebraic tasks to inform targeted instruction and remediation.

Keywords: algebraic equations, Newman error analysis, mathematical errors, error patterns, secondary school students, diagnostic assessment, mathematics education, Nigeria

1 Introduction

Mathematics is a fundamental discipline that supports scientific advancement, technological innovation, economic development, and informed decision-making. It develops learners' logical reasoning, analytical thinking, quantitative literacy, and problem-solving abilities, which are essential for participation in an increasingly knowledge-based society. Consequently, mathematics occupies a central position in school curricula and provides a foundation for learning in science, technology, engineering, and mathematics (STEM) fields. In Nigeria, mathematics is a compulsory subject at the secondary school level and serves as an important prerequisite for entry into many science- and technology-related programmes in higher education. Beyond its role in academic progression, mathematics contributes to the development of critical thinking and problem-solving competencies that are relevant to individual and national development (Kilpatrick et al., 2001). Algebra constitutes an important component of school mathematics because it marks a transition from arithmetic reasoning to more abstract and symbolic forms of mathematical thinking. Through algebra, learners develop the ability to represent relationships symbolically, generalize patterns, formulate mathematical models, and solve problems involving unknown quantities. Proficiency in algebraic reasoning is therefore essential for subsequent learning in functions, calculus, statistics, and mathematical modelling. Despite its importance, algebra remains a challenging area of mathematics for many secondary school students (Ginga & Zakariya, 2020). Students frequently experience difficulties with variables, equality, symbolic manipulation, simplification, substitution, and the selection and application of appropriate solution procedures (Ashlock, 2023; Thomas & Mahmud, 2021). Such difficulties can impede the development of mathematical competence and limit students' preparedness for advanced mathematics and STEM-related learning.

Students' difficulties in algebra are particularly evident in the errors they make while solving mathematical problems. Errors in algebraic equation solving may arise from misconceptions, incomplete understanding of mathematical concepts, weak procedural knowledge, inappropriate application of rules, or difficulties in interpreting and representing mathematical information. These errors are not necessarily random; rather, they may reveal how students understand mathematical concepts and where their reasoning breaks down during problem solving. Consequently, examining students' errors provides more diagnostic information than focusing exclusively on whether a final answer is correct or incorrect. A systematic analysis of errors can therefore help teachers identify specific learning difficulties and provide targeted instructional support. The need for such diagnostic analysis is particularly important in the Nigerian secondary school context, where students continue to experience challenges in mathematics achievement and algebraic reasoning. Performance reports from major secondary school examinations, including the West African Senior School Certificate Examination (WASSCE) and National Examination Council (NECO) examinations, have repeatedly highlighted difficulties in areas involving algebraic manipulation, equation solving, simplification, and the application of mathematical procedures. However, achievement scores alone provide limited information about the specific nature and sources of these difficulties. Understanding the errors embedded in students' solution processes is therefore necessary for moving from the identification of poor performance to the diagnosis of the underlying learning problems.

One framework that provides a systematic approach to diagnosing students' mathematical errors is Newman's Error Analysis (NEA). Originally proposed by Newman (1977), the framework conceptualizes mathematical problem solving as a sequence involving five stages: reading, comprehension, transformation, process skills, and encoding. Reading involves correctly interpreting the words, symbols, and information presented in a problem; comprehension concerns understanding what the problem requires; transformation involves selecting and formulating an appropriate mathematical strategy; process skills refer to the accurate execution of mathematical procedures; and encoding involves expressing and presenting the solution appropriately. An error at any of these stages may prevent a student from obtaining a correct solution. The framework therefore enables researchers to move beyond the identification of incorrect answers and determine the stage at which students' problem-solving processes fail. Previous empirical studies have demonstrated the usefulness of Newman's Error Analysis in identifying systematic patterns of mathematical errors. Studies by Thomas and Mahmud (2021), Margaretha et al. (2022), Awarsari et al. (2023), and Utami et al. (2024) have reported that students' errors occur across different Newman categories, although the dominant categories vary across mathematical topics and educational contexts. Transformation and process skills errors have frequently been identified as prominent, reflecting difficulties in selecting appropriate mathematical procedures and executing them accurately. Other studies, including Zakaria and Maat (2010) and Abdul Rahman and Mohamad Foad (2021), have similarly shown that students' algebraic difficulties involve both conceptual and procedural weaknesses. These findings indicate that students' errors can provide important evidence about the nature of mathematical learning difficulties and the stages of problem solving that require instructional attention.

Despite these contributions, important gaps remain in the existing literature. First, empirical research applying Newman's Error Analysis specifically to algebraic equation solving among secondary school students in Nigeria remains limited, particularly in northwestern Nigeria. Second, existing studies have often focused on describing individual error types without sufficiently examining how errors are distributed across Newman's five diagnostic categories. Third, relatively little evidence is available on whether the observed differences in the frequencies of error categories are statistically significant. Addressing these gaps is important because the relative prevalence of error categories can provide stronger evidence about the stages of mathematical problem solving at which students experience the greatest difficulty. The need for such evidence is particularly relevant in Kankia Education Zone of Katsina State, where secondary school students are expected to develop competence in algebra as part of the senior secondary mathematics curriculum. Difficulties involving symbolic manipulation, equation transformation, simplification, substitution, graphical representation, and procedural execution may hinder students' ability to solve algebraic problems successfully. However, there is limited empirical evidence documenting the specific types of errors committed by students in this context or establishing which stages of the Newman problem-solving process account for the greatest proportion of these errors. Without such diagnostic evidence, instructional responses may remain general rather than targeted at the specific difficulties experienced by learners.

Therefore, this study investigated the patterns of errors committed by Senior Secondary School students when solving algebraic equations in Kankia Education Zone, Katsina State, Nigeria, using Newman's Error Analysis. The study specifically identified the types and frequencies of errors committed by students, examined the distribution of these errors across the five Newman error categories, and determined whether the frequencies of errors differed significantly across the categories. By providing empirical evidence on the nature and distribution of students' algebraic errors, the study contributes to the growing literature on diagnostic assessment in mathematics education and provides context-specific evidence that may support more targeted instruction, formative assessment, and remediation of algebraic difficulties among secondary school students in Nigeria.

Accordingly, the study addressed the following research questions:

1. What types of errors do Senior Secondary School students commit when solving algebraic equations?

2. Which Newman error categories are most prevalent among Senior Secondary School students solving algebraic equations?
3. Do the frequencies of students' error types differ significantly across Newman error categories?

2 Theoretical Framework/Literature Review

2.1 Theoretical Framework

This study is anchored on Newman's Error Analysis (NEA), developed by Newman (1977) as a diagnostic framework for examining the processes underlying students' mathematical problem solving. Unlike conventional assessment approaches that focus primarily on whether a student's final answer is correct or incorrect, NEA provides a systematic means of identifying the stage at which difficulties occur during the solution process. The framework conceptualizes mathematical problem solving as involving five sequential stages: reading, comprehension, transformation, process skills, and encoding. Reading involves accurately interpreting the words, symbols, and information presented in a mathematical problem; comprehension refers to understanding the meaning and requirements of the problem; transformation involves selecting and formulating an appropriate mathematical strategy; process skills concern the accurate execution of the required mathematical procedures; and encoding involves expressing and presenting the resulting solution appropriately. Failure at any of these stages may lead to an incorrect solution, even when a learner possesses partial knowledge of the mathematical concept involved.

The NEA framework is particularly relevant to the present study because solving algebraic equations requires students to progress through multiple stages of mathematical reasoning, from interpreting the given information and understanding the requirements of the equation to selecting appropriate procedures, carrying out algebraic operations, and presenting the final solution. Errors occurring at these stages may therefore reflect different forms of conceptual and procedural difficulty. By classifying students' written responses according to the five Newman categories, the framework enables the study to move beyond identifying individual errors to examining broader patterns in students' mathematical difficulties.

Previous studies have demonstrated the usefulness of Newman's Error Analysis in diagnosing students' difficulties across different areas of mathematics, including algebra (Thomas & Mahmud, 2021; Awarsari et al., 2023; Utami et al., 2024). The framework provides a structured basis for identifying specific error types, determining the prevalence of errors within each diagnostic category, and examining whether the distribution of errors differs significantly across categories. Accordingly, NEA serves as the theoretical lens for the present study and provides the basis for interpreting the patterns and distribution of errors committed by Senior Secondary School students while solving algebraic equations. Its application is expected to generate diagnostic evidence that can guide mathematics teachers in identifying students' specific learning difficulties and designing more targeted instructional and remedial strategies.

2.2 Students' Errors in Algebraic Equation Solving

Solving algebraic equations requires the integration of conceptual understanding and procedural fluency. Conceptual understanding enables students to interpret variables, equality relationships, algebraic symbols, and mathematical relationships, while procedural fluency enables them to apply appropriate rules and operations accurately and efficiently (Kilpatrick et al., 2001). Difficulties in either dimension may result in errors during equation solving. Such errors may therefore reflect more than simple computational inaccuracies; they may indicate weaknesses in students' understanding of algebraic concepts, interpretation of mathematical information, selection of appropriate solution strategies, or execution of mathematical procedures. Students commonly experience difficulties involving variables, equality, operational signs, symbolic manipulation, substitution, simplification, and the application of algebraic procedures (Ashlock, 2023; Thomas & Mahmud, 2021). These difficulties may be associated with weak foundational knowledge, misconceptions about algebraic concepts, overreliance on memorised procedures, and insufficient opportunities to engage in meaningful mathematical reasoning. Consequently, students may produce recurring errors when solving equations, even when they demonstrate partial knowledge of the underlying concepts.

The identification and analysis of these errors are important for understanding how students approach algebraic problem solving. Examining only the final answer provides limited information about the source of an incorrect solution, whereas analysing students' written solution processes can reveal the specific difficulties underlying their performance. Diagnostic error analysis therefore provides teachers and researchers with evidence about the nature and frequency of students' errors and the stages of problem solving at which difficulties are most likely to occur. Such evidence can support more targeted instructional decisions, formative assessment, and remedial interventions aimed at addressing students' conceptual and procedural weaknesses in algebra. In the context of the present study, analysing students' errors in solving algebraic equations provides a basis for identifying specific error types and determining their distribution across Newman's five diagnostic categories. This approach is particularly important in contexts where evidence on students' algebraic error patterns remains limited, as it enables instructional responses to be informed by the actual difficulties demonstrated in students' solution processes rather than by achievement scores alone.

2.3 Empirical Review

Empirical evidence indicates that students' difficulties in solving algebraic equations arise from a combination of conceptual misunderstandings and procedural weaknesses rather than isolated computational mistakes. Zakaria and Maat (2010), for example, reported that students experienced difficulties in manipulating algebraic expressions and selecting appropriate solution procedures, reflecting weaknesses in their understanding of algebraic concepts. Similarly, Abdul Rahman and Mohamad Foad (2021) found that students' errors in quadratic functions extended beyond computational inaccuracies to include difficulties in symbolic representation and mathematical reasoning. These findings are consistent with Ashlock (2023), who argued that recurring mathematical errors often provide evidence of underlying misconceptions and incomplete conceptual understanding. Collectively, these studies demonstrate the importance of examining students' solution processes to identify the nature and sources of errors rather than relying solely on final answers.

Research employing Newman's Error Analysis has further demonstrated that students' errors occur at different stages of mathematical problem solving. Thomas and Mahmud (2021) identified transformation and process skills errors as prominent among students solving quadratic equations, suggesting difficulties in selecting appropriate solution strategies and executing mathematical procedures accurately. Similarly, Fauzi et al. (2022), Awarsari et al. (2023), and Utami et al. (2024) reported errors across different Newman categories, although the relative prevalence of the categories varied across mathematical topics and learning contexts. These findings suggest that students' mathematical difficulties are systematic and that the dominant error category may depend on the nature of the mathematical content, students' prior knowledge, and the instructional context.

Despite these contributions, important gaps remain in the empirical literature. Much of the existing research on Newman's Error Analysis has been conducted outside Nigeria, particularly in Asian educational contexts, limiting the extent to which its findings can be generalized to Nigerian secondary school students. Furthermore, previous studies have often focused primarily on identifying and describing students' error types, with comparatively limited attention to statistically examining whether the frequencies of errors differ significantly across Newman's five diagnostic categories. Such analysis is important because it provides stronger evidence about the relative concentration of students' difficulties across the stages of mathematical problem solving.

The reviewed literature therefore establishes the value of systematic error analysis while revealing a need for context-specific evidence on algebraic equation solving among Nigerian secondary school students. In particular, empirical evidence remains limited regarding the specific types of errors committed by students and the distribution of these errors across Newman's reading, comprehension, transformation, process skills, and encoding categories in northwestern Nigeria. The present study addresses this gap by applying Newman's Error Analysis to students' solutions of algebraic equations in Kankia Education Zone, Katsina State, Nigeria. Specifically, the study identifies the types and frequencies of errors, determines the most prevalent Newman error categories, and statistically examines whether the observed frequencies of errors differ significantly across the five categories. This approach extends existing research by providing context-specific diagnostic evidence on students' algebraic difficulties and by demonstrating the extent to which their errors are concentrated at particular stages of the mathematical problem-solving process.

3 Materials and Methods

3.1 Research Design

This study adopted a cross-sectional descriptive research design with a diagnostic assessment approach to investigate the patterns of errors committed by Senior Secondary School students while solving algebraic equations. The design was appropriate because the study sought to identify, classify, and analyse students' existing errors without manipulating instructional conditions or introducing any intervention. Students' written solutions were examined using Newman's Error Analysis (NEA) framework to determine the specific types of errors committed, the distribution of errors across the five Newman categories, and the relative prevalence of different error categories. The design was therefore suitable for generating diagnostic evidence on students' algebraic problem-solving difficulties within the natural school setting.

3.2 Study Area, Population and Sample

The study was conducted in Kankia Education Zone, Katsina State, Nigeria, which comprises public secondary schools located in Kankia, Kusada, and Ingawa Local Government Areas. The target population consisted of 4,683 Senior Secondary II (SS II) students enrolled in public secondary schools during the 2024/2025 academic session. SS II students were selected because algebraic equations constitute an important component of the mathematics curriculum at this level and require students to demonstrate both conceptual understanding and procedural competence. A sample of 130 SS II students was selected using a multistage sampling procedure. First, two co-educational public secondary schools were selected through simple random sampling. Subsequently, one intact SS II class was selected from each of the participating schools, and all students in the selected classes took part in the study. The use of intact classes helped preserve the natural classroom setting and minimized disruption to regular school activities while providing an appropriate sample for the diagnostic analysis of students' algebraic errors.

3.3 Instrumentation

Data were collected using the Algebraic Equation Diagnostic Test (AEDT), adapted from Gitonga (2010). The instrument consisted of six structured essay questions covering linear equations, simultaneous equations, quadratic equations, and algebraic word problems. The essay format required students to show their complete solution procedures, thereby providing sufficient evidence for identifying and analysing errors occurring at different stages of mathematical problem solving.

Students' written responses were systematically examined and coded using Newman's Error Analysis (NEA) framework (Newman, 1977). The framework classifies mathematical errors into five hierarchical categories: reading, comprehension, transformation, process skills, and encoding. These categories provided the basis for identifying specific error types, classifying the errors into the appropriate Newman categories, and determining their frequencies and distribution across the five stages of mathematical problem solving.

3.4 Validity and Reliability of the Instrument

The Algebraic Equation Diagnostic Test (AEDT) was subjected to face and content validation by two experts in Mathematics Education from Ahmadu Bello University, Zaria. The experts assessed the instrument in terms of clarity, content relevance, curriculum coverage, and appropriateness for Senior Secondary School II students. Their observations and recommendations were considered and incorporated into the final version of the instrument.

To establish the reliability of the instrument, a pilot study was conducted with 30 SS II students from a public secondary school outside the study area. Item analysis was performed to determine the difficulty and discrimination indices of the test items, and items that met the established psychometric criteria were retained. The reliability of the AEDT was subsequently determined using the test–retest method, with the Pearson Product-Moment Correlation coefficient yielding a reliability coefficient of 0.82. This coefficient indicates that the instrument had an acceptable level of temporal stability and was considered suitable for data collection.

3.5 Data Collection Procedure

Ethical approval to conduct the study was obtained from the relevant educational authorities, including the Katsina State Ministry of Education, the Kankia Zonal Education Office, and the principals of the participating schools. Participation was voluntary, and students were informed about the purpose of the study. The confidentiality and anonymity of participants were maintained throughout the research process, and the data collected were used solely for academic purposes.

The Algebraic Equation Diagnostic Test (AEDT) was administered by the researcher with the assistance of mathematics teachers in the participating schools under normal classroom conditions. Students were given sufficient time to complete the test because the primary objective was to examine their mathematical solution processes rather than their speed of completion. Following administration, the completed scripts were collected and scored using an approved marking guide. Each student's written response was subsequently examined systematically, and identified errors were coded according to the five categories of Newman's Error Analysis: reading, comprehension, transformation, process skills, and encoding. The frequencies of individual error types and the distribution of errors across the five Newman categories were then computed for the entire sample.

3.6 Data Analysis

The data were analysed using frequencies, percentages, and a chi-square (χ^2) goodness-of-fit test. Frequencies and percentages were used to describe the types and distribution of errors across Newman's five error categories. The chi-square goodness-of-fit test was used to determine whether the observed frequencies of errors differed significantly across the five categories at the 0.05 level of significance. The analysis was based on the total of 356 classified errors identified from students' responses.

4 Results

4.1 Results of the Algebraic Equation Diagnostic Test

Students' responses to the Algebraic Equation Diagnostic Test (AEDT) were examined and coded using Newman's Error Analysis (NEA) framework. Frequencies and percentages were computed to identify the specific errors committed by students and their distribution across the Newman error categories. The results are presented according to the research questions.

Research Question One

What types of errors do Senior Secondary School students commit when solving algebraic equations in Kankia Education Zone, Katsina State, Nigeria?

To answer this research question, students' written solutions were examined to identify and classify the specific errors committed during algebraic equation solving. The frequencies and percentages of the identified errors are presented in Table 1.

Table **1**

Specific Errors Identified in Students' Solutions of Algebraic Equations

S/N	Error Type	Frequency	Percentage
1	Error in placing the right sign	18	5.1
2	Error in eliminating one unknown	22	6.2
3	Error in taking the LCM	26	7.3
4	Error in calculations	15	4.2
5	Error in tabulating values	30	8.4
6	Error in collecting similar terms	23	6.5
7	Error in taking a proper scale for graphs	30	8.4
8	Error in plotting graph points	22	6.2
9	Error in identifying coefficients	25	7.0
10	Carelessness	22	6.2
11	Omission	22	6.2
12	Premature approximation	18	5.1
13	Wrong simplification	17	4.8
14	Substitution errors	21	5.9
15	Transformation errors	25	7.0
16	Encoding errors	20	5.6
	Total	**356**	**100.0**

Table 1 presents the specific errors identified in students' solutions of algebraic equations. A total of 356 errors were identified across the analysed responses, comprising 16 distinct error types. The most frequently observed errors were errors in tabulating values and errors in taking a proper scale for graphs, each occurring 30 times (8.4%), followed by errors in taking the LCM (26, 7.3%) and errors in identifying coefficients and transformation errors, each occurring 25 times (7.0%). The least frequently observed error was error in calculations, which occurred 15 times (4.2%).

Research Question Two

Which Newman error categories are most prevalent among Senior Secondary School students solving algebraic equations?

To answer this research question, the specific errors identified in students' solutions were classified according to Newman's five error categories: reading, comprehension, transformation, process skills, and encoding. The frequencies and percentages of errors in each category are presented in Table 2.

Table **2**

Distribution of Students' Errors According to Newman's Error Categories

Newman Error Category	Frequency	Percentage
Reading Errors	36	10.1
Comprehension Errors	96	27.0
Transformation Errors	93	26.1
Process Skills Errors	81	22.8
Encoding Errors	50	14.0
Total	**356**	**100.0**

Table 2 shows that comprehension errors were the most prevalent, accounting for 96 (27.0%) of the 356 errors identified. This was followed by transformation errors (93; 26.1%) and process skills errors (81; 22.8%). Encoding errors accounted for 50 (14.0%), while reading errors were the least prevalent, with 36 (10.1%) occurrences. Thus, comprehension constituted the most frequent Newman error category, whereas reading errors were the least frequently observed among students solving algebraic equations. Figure 1 presents a graphical illustration of the distribution of students' errors across the five Newman error categories. The figure further shows the predominance of comprehension and transformation errors relative to the other categories.

Figure **1**

Distribution of students' error types

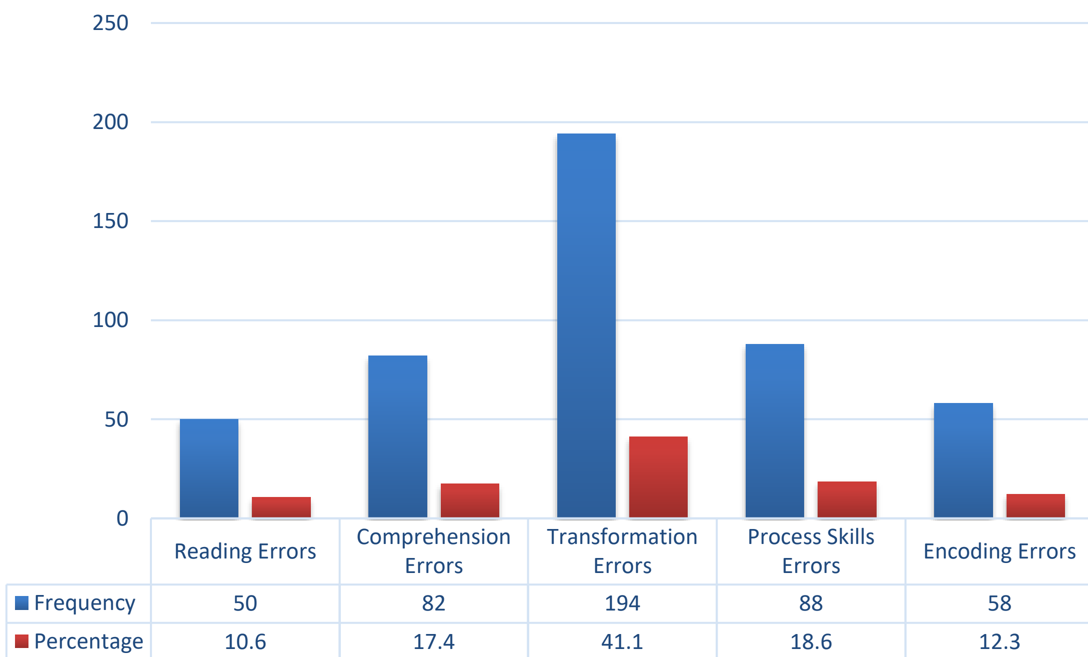

Figure 1 presents the distribution of students' errors across the five Newman error categories. The results show that Comprehension Errors were the most prevalent, accounting for 27.0% (96) of the total 356 errors identified. This was followed by Transformation Errors, which accounted for 26.1% (93), and Process Skills Errors, with 22.8% (81). Encoding Errors constituted 14.0% (50), while Reading Errors were the least frequently observed, accounting for 10.1% (36) of the total errors. Thus, Comprehension Errors represented the most frequently occurring Newman error category, whereas Reading Errors were the least prevalent among the students' errors in solving algebraic equations.

Research Question Three

Do the frequencies of students' error types differ significantly across Newman error categories?

To determine whether the frequencies of students' errors differed significantly across the five Newman error categories, a chi-square goodness-of-fit test was conducted. The analysis was based on the 356 classified errors identified from students' responses. The observed frequencies of reading, comprehension, transformation, process skills, and encoding errors were compared with the expected frequencies under the assumption of an equal distribution across the five categories. The results are presented in Table 3

Table **3**:

Chi-Square Goodness-of-Fit Test of the Distribution of Students' Errors Across Newman Error Categories

Newman Error Category	Observed Frequency	Percentage	Expected Frequency
Reading errors	36	10.1	71.2
Comprehension errors	96	27.0	71.2
Transformation errors	93	26.1	71.2
Process skills errors	81	22.8	71.2
Encoding errors	50	14.0	71.2
Total	**356**	**100.0**	**356**

Note. Expected frequency = 356/5 = 71.2.

The results presented in Table 3 indicate that the frequencies of students' errors varied across the five Newman error categories. Comprehension errors had the highest frequency (96; 27.0%), followed by transformation errors (93; 26.1%) and process skills errors (81; 22.8%). Encoding errors accounted for 50 (14.0%) of the classified errors, while reading errors were the least frequent, with 36 (10.1%). A chi-square goodness-of-fit test was conducted to determine whether these observed differences in error frequencies were statistically significant. The result was statistically significant, $\chi^2(4) = 37.83$, $p < .001$, indicating that the frequencies of students' errors differed significantly across the five Newman error categories. Thus, the distribution of errors was not uniform across the categories, with comprehension and transformation errors occurring more frequently than reading and encoding errors.

Below is a more concise, journal-appropriate version that directly addresses the findings, literature, implications, limitations, and future research.

5 Discussion

The findings indicate that students' difficulties in solving algebraic equations involved both conceptual and procedural weaknesses. The most frequent specific errors were related to tabulating values and selecting appropriate graph scales, suggesting difficulties in representing and organizing mathematical information. This finding is consistent with Ashlock (2023), Zakaria and Maat (2010), and Abdul Rahman and Mohamad Foad (2021), who reported that students' algebraic errors commonly arise from weaknesses in symbolic representation, conceptual understanding, and procedural application. Across Newman's five error categories, comprehension errors were most prevalent (27.0%), followed by transformation (26.1%) and process skills errors (22.8%), while reading errors were least frequent (10.1%). The significant chi-square result further confirms that students' errors were not uniformly distributed across the categories. The predominance of comprehension errors suggests that difficulties in understanding mathematical information may precede and contribute to subsequent errors in selecting and executing solution procedures. This finding partly contrasts with Thomas and Mahmud (2021), Fauzi et al. (2022), Awarsari et al. (2023), and Utami et al. (2024), who reported transformation and process skills errors as more prominent. The difference may be attributable to variations in mathematical content, learners' prior knowledge, and instructional contexts. Nevertheless, the present findings reinforce the value of Newman's Error Analysis for identifying specific points of breakdown in students' mathematical reasoning.

Theoretically, the findings support the applicability of Newman's Error Analysis in diagnosing algebraic difficulties beyond simple right-or-wrong assessment. Practically, they suggest that algebra instruction should place greater emphasis on students' comprehension of mathematical tasks before focusing on procedural execution. Teachers should use diagnostic and formative assessment to identify comprehension and transformation difficulties and provide targeted feedback and remediation. The study is limited by its relatively small sample drawn from two schools within one education zone, which may constrain the generalizability of the findings. Future studies should examine larger and more diverse samples across different Nigerian educational contexts and investigate whether targeted interventions addressing comprehension and transformation errors can improve students' algebraic problem-solving performance.

6 Conclusion

This study examined the patterns of errors committed by Senior Secondary School students when solving algebraic equations using Newman's Error Analysis. The findings revealed 16 specific error types, with errors in tabulating values and taking appropriate graph scales occurring most frequently. Across the five Newman categories, comprehension errors were most prevalent, followed by transformation and process skills errors, while reading errors were least frequent. The significant variation across error categories confirms that students' difficulties are systematic rather than random. The study contributes to mathematics education by demonstrating the value of Newman's Error Analysis as a diagnostic framework for identifying specific stages of difficulty in algebraic problem solving. The findings highlight the need for mathematics teachers to move beyond assessing final answers and systematically examine students' solution processes, particularly their comprehension and transformation of mathematical tasks. Integrating diagnostic assessment and targeted remediation into algebra instruction may help address these difficulties and strengthen students' conceptual and procedural competence. Future research should extend this investigation to larger and more diverse populations and examine the effectiveness of targeted interventions designed to reduce the most prevalent error categories.

7 Declarations

Conflict of Interest: The authors declare neither financial nor non-financial conflict of interest.

Author Contributions: Author 1 conceptualised the study, carried out the research, and wrote the manuscript. Author 2 and Author 3 conceptualised study supervised the research and wrote the manuscript.

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