Error Analysis of Lower Basic Education Number and Numeration Skills: Implication for Remediation

Stephen Banwar Wanlor (Ph.D.)[1]*, Tali Jonah Dashe (Ph.D.)[2]

Federal University Of Education, Pankshindepartment Of Primary Education Studies

[*]Corresponding Author

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ABSTRACT

The study conducted an Error Analysis of Lower Basic Education Number and Numeration Skills with implication for remediation. The purpose of the study was to analyze the errors that primary three pupils made from the content area of numbers and numerations from the 9-Year Lower Basic Education Curriculum Guide. The researchers employed the cross-sectional survey research design. The target population was pupils in primary three in Pankshin LGA from the Central Geo-Political Zones of Plateau State, Nigeria. A sample size of 235 pupils was obtained through a simple random sampling technique. The instrument for the study called Error Analysis of Lower Basic Education Numbers and Numeration Test (EALBENNT) was developed by the researchers using the modified Blooms Taxonomy of Educational Objectives. The instrument was validated by mathematics experts. A reliability coefficient of 0.78 was obtained using the Cronbach Alpha method. The data obtained were analyzed using the Statistical Package for Social Science (SPSS) and Microsoft Excel. The findings revealed that the pupils committed 80% conceptual errors, 9% procedural errors, 6% computational errors and 5% careless errors The result further showed a significant difference in scores of respondents based on school type: public (M=6.99, SD=1.69) and private (M=7.41, SD= 1.66); T (233) = -2.21, p = .03. and no significant difference in scores based on school location:urban (M=7.20, SD=1.71) and rural (M=5.70, SD= 1.59); T (233) = 1.94, p = .054. It was concluded that error analysis can help greatly in ascertaining the major challenges faced by the lower basic pupils and recommended among others that Lower Basic Education mathematics teachers should include error analysis as a method of assessment.

Keywords: Numbers and numeration; error analysis and remediation

INTRODUCTION

The researchers' experiences in teaching students' mathematics in colleges of education revealed that most students cannot add, subtract, multiply or divide simple Lower Basic Education numbers and numeration problems from mathematics without using either calculators or their handsets. These students do not know the procedures for solving such problems. These show that the students with problems of this nature had no proper backgrounds on numbers and numeration at the Lower Basic Education level. This implies that such students found difficulty in understanding of secondary school mathematics. Thus, if a child fails to have a proper grasp of numbers and numerations other subsequent topics in mathematics like measurements, practical and descriptive geometry, and every day statistics will be difficult to understand.

Teachers are supposed to analyze how children solve mathematics' problems and to find out the strengths and weaknesses of such children. When children's wrong answers are analyzed to find out the root causes of the failure, it is called error analysis. When a program is designed to address the causes of the failure, it is called remediation. Unfortunately, Lower Basic Education teachers either do not know how to conduct error analysis or do not have the time for it. In the light of these, the study sought to develop and validate test items in number and numeration content of the Lower Basic Three pupils. This provides teachers with empirical evidence on the types of errors that pupils commit when they administer the instrument to them, know the types of errors and to organize remedial teaching to those in need. It will help pupils struggling behind to catch up with those succeeding in mathematics in the classroom.

Problem Statement

Students' poor performances in secondary schools' certificate examinations like West African Examination Council (WAEC) and National Examination Council (NECO) among others had their roots in how the students were taught mathematics at the lower Basic Education Level. The justification for this poor performance is due to primary school teachers' inability to perform error analysis on the items that pupils fail either during classwork, assignments, tests or examinations in Nigeria as it is in developed countries of the world like Britain and the United States of America. The inability to teach mathematics without using error analysis is a traditional approach to teaching of mathematics that does not pave way for the inculcation of the 21^{st} century skills commonly called the 4 Cs (critical, creative, collaborative and communication). In view of the above this study seeks to find out the types of errors the pupils make in numeracy skills and to provide interventions where necessary.

Objectives Of The Study

Generally, the study aimed at conducting errors analysis of Lower Basic Education three pupils on numbers and numerations geared towards organizing remedial teaching to correct the errors. Specifically, the study sought to:

1. Find out the conceptual errors pupils made on the instrument
2. Find out the procedural errors pupils made on the instrument
3. Fine out the extent of computational errors pupils made on the instrument
4. Find out the careless errors the pupils made on the instrument.
5. Find differences in the error mean scores of pupils based on their gender, school type and school location.

LITERATURE REVIEW

The lower basic education in Nigeria is that education that is offered free and compulsory for children of age 6 years to 8 years (FRN, 2013). Two of the objectives of this level of education are the inculcation of numeracy skills and developing logical thinking in the children (FRN, 2013). A number is an arithmetic value that is used in representing quantities and with which calculations can be done. The absence of a quantity is symbolized as '0' called 'zero'. Single numbers like 1 2 3 4 5 6 7 8 and 9 are called digits while a combination of two or more of them give the digit's number (Vendatu Master Class, 2022). Numeration is the process by which numbers are expressed in words. Numeracy is the ability to make use of figures to solve problems and form the basis upon which all other contents of mathematics are built. They are used in running the day-to-day activities of both children and adults (Efelunni, Ugwu, Okpala, Aneke, Ibiam, Ugochukwu & Olesaeke, 2022). Numbers form the foundation upon which science, technology and engineering are built. Unfortunately, there is a public outcry by teachers, parents, students and government about the poor performance of senior secondary school students in mathematics which frustrates them from gaining access into tertiary institutions. This poor performance can be averted if teachers use errors analysis as a method of teaching and provide remedial instruction for pupils at the lower basic education level and continue to use it at the upper basic education because it facilitates the application of the 21^{st} century skills of creative thinking, critical thinking, communication and collaboration (4 C's).

Remedial teaching as defined by Wanlor, Wakjissa and Mustapha (2022, p. 85) "is a kind of instruction which teachers offer to pupils who are backward in learning mathematics to measure up with their normal peers after an error analysis has been conducted". It tries to be specific, exact and causes pupils to correct their errors and hence pave ways to prevent future ones.

Error analysis is the first approach in diagnostic assessment which seeks to find out the types of errors pupils are making and why they are making it. It seeks to establish patterns on errors which might be consistent and later design and implement an instructional programme to address that pupil's specific needs (Brown, 2016). Error analysis in mathematics is the method of identifying, categorizing and determining the systematic nature of the error by reviewing mathematical task given to pupils so as to ascertain the patterns of misconceptions and possibly give explanations to their causes (Center for Advance Research in Language Acquisition, 2022, & Lai, 2012). They are used in identifying careless, factual, computational, conceptual and procedural errors. Others are problem solving, understanding of problems, converting of problem sentences into mathematics and planning and implementing the settlement plan (Nuraini, Cholifah, 2019 & Schneider, n. d.).

When pupils fail to follow the correct steps, it is called a procedural error, when basic facts are not remembered to be applied such as addition, subtraction, multiplication and division it is called factual errors. Carless errors occur when the pupils know how to solve the problem but because of fastness or thinking about a different phenomenon write an incorrect answer from the intended answer, copying the problem wrongly or writing wrong number, or dropping a negative sign and so on. Conceptual errors occur when pupils apply a different concept to solve a given problem apart from the required method to solve it. The pupils might get the answer perfectly right but have gone completely off- point. They have solved a different problem apart from the one asked. In computational errors the pupils incorrectly add, subtract, multiply or divide the given problem and hence produce incorrect results. In a multi- steps problem, any incorrect operation means that the rest of the steps after it will be wrong (Lake, 2016 & Lai; 2012).

The importance of error analysis is to take mathematics pressure off the pupils, promote critical and creative thinking as pupils try to critique some one's else work and make sense of others' thinking, helps pupils to work together in collaboration and talk the talking (communication). In the same vein it helps teachers to identify disabilities of low performing pupils, direct instruction towards individual, or group areas of needs, pupils lacking information processing power, pupils who do not practice, pupils who exhibit mathematics anxiety and difficulties in visual and auditory processing, helps teachers to have deeper understanding of the pupils and where they have problems and providing remedial instruction to the pupils as individuals, focus group or an entire class among others (Lai, 2012 & Schneider, n. d.)

Soe (2021) outlined five steps to conduct error analysis to include collecting data for error analysis either through observations in class or through experimentation by giving tests in longitudinal or cross-sectional survey, identifying the errors, classifying the errors, explaining the errors and evaluating the errors. The later gives teachers or researchers the feedback for remedial programme or intervention. While Nuraini and Cholifa (2019) put forward seven steps for error analysis such as collecting pupils works, asking how pupils respond and looking for patterns, looking for "exceptions" describing the patterns observed in simple words and asking pupils directly for confirmation, the current study adapted some of these steps in conducting error analysis that were found convenient during the study.

Empirical studies conducted by Daymude (2010) on test error analysis in mathematics education using a mixed method approach revealed that most common errors students committed were as a result of not knowing how, forgetfulness, arithmetic errors, and running out of time. Further students test score improved with error analysis and that middle ability students tend to benefit more than struggling and excelling students. Rushton (2018) conducted research on teaching and learning mathematics through error analysis and found that combining the use of correctly worked exercises with error analysis helped researchers to have an increased mathematical understanding of their students as well as the students finding the use of error analysis to be essential to their learning processes. There was a significant difference in delayed post test scores of students. Krishnasamy and Abdullah (2015) conducted research on the types of student errors in mathematical symbols, graphs and problem-solving, found that 57% of the students made conceptual errors, 24 % made careless errors, 13 % made problem solving errors, and 6 % made value errors. Major reasons that the respondents gave were lack of understanding, procedures being forgotten, negligence in transcending information from the questions, carelessness and guess work. Adams, Mclaren,Durkin, Mayer, Rittle-Johnson, Isotani and Velson (2014) conducted research on using erroneous examples to improve mathematics learning and found that students in the erroneous example group performed significantly better on a delayed post test administered one week later (d=.62). Students in the erroneous example group were also more accurate at judging whether their post-test answers were correct. This, they said helped students to overcome misconceptions and build lasting understanding of decimals. This research differed from these empirical works in terms of population and sample, scope, instrument used, mathematics content for which error analysis was conducted and remedial teaching or intervention. But were similar in terms of design and purpose.

Research Questions

The following research questions were raised to guide the survey

1. To what extent will the pupils exhibit conceptual errors on the instrument?
2. To what extent will the pupils exhibit procedural errors on the instrument?
3. To what extent will the pupils exhibit computational errors on the instrument?
4. To what extent will the pupils exhibit careless errors on the instrument?

Hypotheses

In order to guide the study, the following null hypotheses were tested at .05 level of significance.

1. There is no significant difference in the error mean scores of pupils based on their gender (males and females) on the instrument
2. There is no significant difference in the mean scores of the pupils based on their school types (public and private) on the instrument
3. There is no significant difference in the error mean score of pupils based on their school locations (urban and rural) on the instrument

METHODOLOGY

The study was carried in Pankshin LGA. Pankshin LGA is one of the 17 LGAs located in the Central Senatorial Zone of Plateau State, Nigeria. Primary three pupils constituted the subjects for the study during the period of the research. Questions for data collection covered only the content area of numbers and numeration derived from the 9- years Basic Education Mathematics Curriculum Guide for Lower Basic Three Pupils.The study employed the cross- sectional survey research design because data was collected from the respondents only at a particular time. The population of the survey consisted of all the primary schools' pupils from the 17 LGAs of Plateau State. The target population was made up of primary three pupils from Pankshin LGA being the last class of the Lower Basic Education. The sample consisted of 235 pupils selected from 4 (1 public urban and 1 public rural, 1 Private urban and 1 Private rural) schools. The study adopted a simple random sampling technique of the heart and draw type to arrive at the required sample size of schools. All the pupils from these selected schools answered question on the Error Analysis of Lower Basic Education Numbers and Numeration Test (EALBENNT.

The instrument for data collection was called Error Analysis of Lower Basic Education Numbers and Numeration Tests (EALBENNT). The instrument consisted of section A and section B. Sections A contained the biodata of the respondents while section B contained the items. The biodata included gender (male or female), school type (private or public) and school location (urban or rural). The items in Section B were made up of 10 essay questions arranged in order of difficulty, from easy items to difficult items starting with addition, subtraction, multiplication and division.

The face validity of the items was established by two experts. One was a primary school mathematics teacher and the other was a research expert from Federal University of Education Pankshin. The content validity of the instruments was established through the use of a table of specifications. The reliability of the EALBENNT was established using the Cronbach Alpha reliability. A reliability coefficient of 0.78 was obtained indicating that the items were reliable. The simple percentage was used to analyze all the research questions and the results displayed using a bar chart that revealed clearly the types and percentage of errors that the pupils committed. All the hypotheses were tested at .05 level of significance using the student t-test of independent samples, P-values less than or equal to .05 indicated a significant difference while p-values strictly greater than .05 showed no significant difference and resulted in upholding a null hypothesis.

RESULTS

Research Questions One

To what extent will the pupils exhibit conceptual errors on the instrument?

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Table 1 Percentage of Conceptual Errors

Number of students	Sum of conceptual errors	Sum of all errors	Percentage
235	1330	1663	80

Table 1 shows that the percentage of conceptual errors committed by the pupils was 80%

Research Questions Two

To what extent will the pupils exhibit procedural errors on the instrument?

Table 2 Percentage of Procedural Errors

Number of students	Sum of procedural errors	Sum of all errors	Percentage
235	144	1663	9

Table 2 shows that the percentage of Procedural errors committed by the pupils was 9%

Research Questions Three

To what extent will the pupils exhibit computational errors on the instrument?

Table 3 Percentage of Computational Errors

Number of students	Sum of computational errors	Sum of all errors	Percentage
235	100	1663	6

Table 3 shows that the percentage of computational errors committed by the pupils was 6%

Research Questions Four

To what extent will the pupils exhibit careless errors on the instrument?

Table 4 Percentage of Careless Errors

Number of students	Sum of careless errors	Sum of all errors	Percentage
235	89	1663	5

Table 4 shows that the percentage of careless errors committed by the pupils was 5%

Table 5 Summary of percentage errors committed by the pupils

Types of Errors	Conceptual errors	Procedural errors	computational errors	Careless errors
Percentage	80	9	6	5

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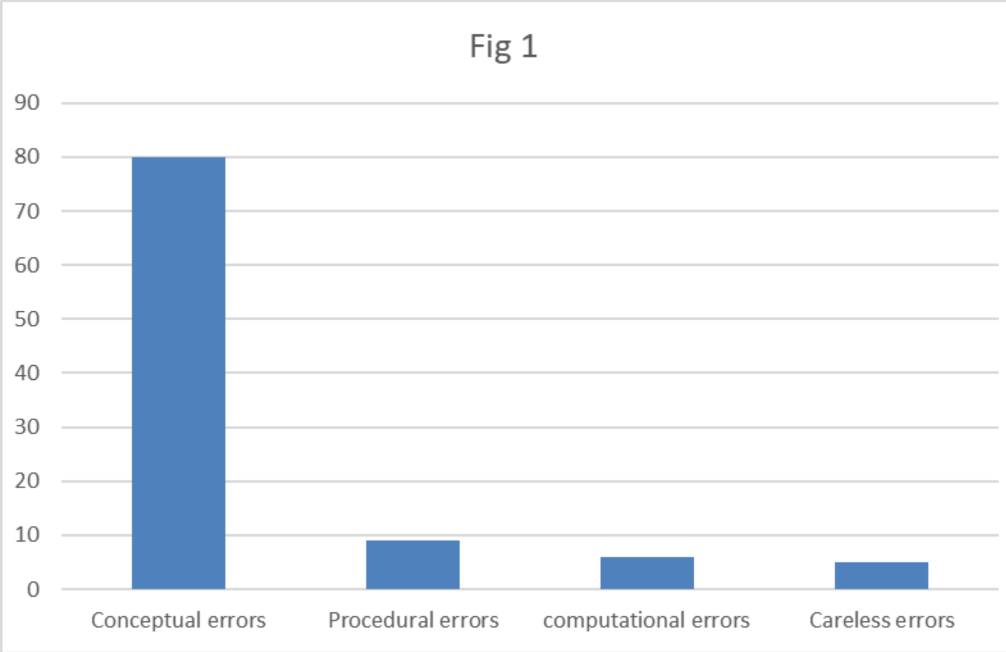

Figure 1: Bar chart for the percentage errors

Figure 1 shows that the pupils made 80% conceptual, 9% procedural, 6% computational and 5% careless errors on the instrument.

Hypothesis One

There is no significant difference in the error mean scores of pupils based on their gender on the instrument.

Table 6 Summary of independent sample t-test based on gender

Gender	N	Mean	SD	Df	T	Sif	Sig(2-tailed)
Male	113	6.99	1.66	233	-0.75	0.45	0.46
Female	122	7.16	1.72				

The independent samples t-test was conducted to compare the number and numeration mean scores of males and females. There was no significant difference in scores for males (M=6.99, SD=1.66) and females (M =7.16, SD= 1.72); T (233) = -0.75, p = .46. Thus, the null hypothesis was accepted and concluded that there was no significant mean difference in the error scores of the respondents on the instrument according to gender when tested at .05 level of significance.

Hypothesis Two

There is no significant difference in the mean scores of the students from public and private schools on the instrument.

Table 7 Summary of independent sample t-test based on School Type

School type	N	Mean	SD	Df	T	Sif	Sig(2-tailed)
Public	155	6.99	1.69	233	-2.21	0.65	0.03
Private	80	7.41	1.66				

The independent samples t-test was conducted to compare the number and numeration mean scores of public and private schools. There was a significant difference in scores for public (M=6.99, SD=1.69) and private (M=7.41, SD= 1.66); T (233) = -2.21, p = .03. Thus, the null hypothesis was rejected and concluded that there was a significant mean difference in the error scores of the respondents on the instrument according to school type when tested at .05 level of significance

Hypothesis Three

There is no significant difference in the error mean score of pupils from urban and rural schools on the instrument.

Table 8 Summary of independent sample t-test based on School Location

School Location	N	Mean	SD	Df	T	Sif	Sig(2-tailed)
Urban	179	7.20	1.71	233	1.94	0.18	0.054
Rural	56	6.70	1.59				

The independent samples t-test was conducted to compare the number and numeration mean scores of urban and rural schools. There was no significant difference in scores for urban (M=7.20, SD=1.71) and rural (M=5.70, SD= 1.59); T (233) = 1.94, p = .054. Thus, the null hypothesis was upheld and concluded that there was no significant mean difference in the error scores of the respondents on the instrument according to school location when tested at .05 level of significance.

DISCUSSION

The finding of research question one revealed that among the four types of errors, the lower basic education three pupils committed 80% of conceptual errors. This is more than three quarter of the percentage of errors committed on all the items. This finding is in tandem with that of Daymude (2010) who posits that most students commit errors as a result of not knowing how to solve the problem and forgetfulness. It corroborates the findings of Krishnasamy and Abdulla (2015) who found that 57% of students made conceptual errors which is more than half the percentage of the errors committed on the instrument they developed. This high level of conceptual errors might occur as a result of teachers' inability to cover the mathematics course contents before transiting to new classes after some period of industrial dispute commonly called "strike action" in Nigeria.

The findings from research question two showed that the pupils made 9% procedural errors. The finding is in line with that of Krishnasamy and Abdulla (2015) who found the percentage of procedural errors committed by students was 13%. In the same vein the findings from research question three revealed that 6% of the errors committed by the pupils where computational errors. This is similar to the findings of Krishnasamy and Abdulla (2015) who found that the computational errors committed was also 6%. Result of research question four revealed that 5% of the errors made were careless errors. This is in contrast with the findings of Krishnasamy and Abdulla who found that 24% of the errors committed by students was careless errors. The bar chart revealed a pictural representation of the percentage of errors indicating a serious gap in the conceptual understanding of numbers and numeration by lower basic three pupils in Pankshin LGAs, Plateau State.

The findings from hypotheses one and three when tested at .05 level of significance revealed that there were no significant differences that existed in the types of errors committed by the pupils based on their gender and their school location but a significant difference existed for the mean score error of the pupils based on their types of school whether public or private. The later finding is in contrast with that of Rushton (2018) and Adam, Mclaren, Durken, Mayer, Rittle- Johnson, Isotani and Velson (2014) who found that no significant difference existed in the error mean score of students in delayed post-test responses based on their type of school.

CONCLUSION

Based on the findings of the study it was concluded that the reason why pupils find mathematics difficult to understand is largely because of conceptual errors followed by procedural errors while computational and careless errors were minimal once the pupils understood the concepts and the procedure for solving the problems. This support the fact that most of the items were either left unanswered or responded to wrongly. The study has helped in identifying that error analysis can help greatly in ascertaining the major challenges faced by the lower basic pupils and thus pinpoint the types of error that need to be addressed quickly by educational stakeholders.

RECOMMENDATIONS

In the light of the findings above the following recommendations were made.:

1. Lower Basic Education mathematics teachers should include error analysis as a method of assessment.
2. Teachers should constantly assess pupils in various mathematics content areas to identify where they are weak.
3. Teachers should organize remedial classes for weak pupils that have been identified through error analysis
4. The TETFUND Centre of Excellent in Innovative Teaching and Learning in Primary and Early Childhood Education should collaborate with the Plateau State Universal Basic Education Board for training of primary and early childhood educators on how to conduct error analysis of their pupils' mathematics assessment.

Disclaimer (Artificial Intelligence)

Authors hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

I used Quillbot generative AI, Transformer-based Language Model (NLP) for writing assistant in paraphrasing and grammar correction

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Competing Interests

No competing interests exist in this study

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