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An Assessment of Students' Proficiency in Using Number Line to Solve Mathematical Problems

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Abstract

Number line is one of the efficient tools for solving mathematical problems; hence it becomes imperative that the proficiency of students in using it be investigated. The aim of this study is to investigate the proficiency of junior secondary school students in the use of number line in solving mathematical tasks. Majority (32.7%) of these students obtained D grade in their respective end of term examinations. The design for the study was quantitative in nature where the data on the students' proficiency on the use of number line to solve mathematical tasks was collected using questions adapted from [1]. The results from the study indicate that the students obtained an average percentage of success ranging from 45.8% to 50.2% across levels. There was no significant difference in the result obtained by the students across levels. The students performed better on paper and pencil computation at the expense of use of number line.

Keywords: *Assessment, mathematical problems, students, number line, proficiency.*

1 Introduction

Number line when properly learnt serves as an auxiliary means in solving mathematical tasks. It plays a very important role in early students' Mathematics. They are crucial elements of high quality Mathematics at all levels,[2];[3];[4]. They are used for effective Mathematics instruction, [5], [6]; [7]. They can also assist students to develop their own internal representations, [8]; [9].

Many studies have reported on the several uses of number line and the important role it plays in Mathematics education. The number line is used for estimation, [10]. It is used for multiplication,[11]; [12], for measuring length [13] and time , [14]. It can be used to extend students' knowledge, [15] and for giving access to possible solution strategies, [16]. It also serves for number representation [17]; [18] as well as forming geometric models for the operations of arithmetic,[19];[20].

Number line has the potential of producing a simple way to picture mathematical concepts. Many mathematical ideas and concepts require increasing complex language to describe and assess. So a representation like the number line can reduce the text that students need to be able to interpret in order to assess the mathematics in the question, [21]. The number line supports the students' performance as counting-type tasks, by offering a way of scaffolding with partial calculations and partial results [13].

Number line can be represented in various ways, structural and semi-structural, with or without numbers or other symbols, modelling the mathematical concept or solution. Another type of number line representations which is suggested in literature is the empty number line. This type offers the students the freedom to use it as they like for jotting or for working, [22].

Though many studies have mentioned the crucial role that the number line plays in organizing thoughts related to mathematical concepts and ideas, some have reported difficulties and limitations in its use. [23] reported that the number line caused some problems, possibly, because it was introduced in a measurement context. The number line does not model all equations successfully nor is intended to do so, [16].

In this work, the researcher studies how effectively students can use the number line in solving problems and to see if there is a significant difference across level in the score of students used for this study.

2 Objective of the Study

The improvement of mathematics education for all students requires effective teaching in the classroom. Assessing students' understanding and proficiency in the use of number line is the focus of this research. Determining what experience might be important to foster this understanding requires an analysis of students' proficiency in the use of number line. The objective of this study is to:

1. Assess students' achievement in a test involving use of number line across levels and in the stands of: (a) correct solutions with and without number line (b) correct solutions with number line only.
2. Analyze if there is any difference between male and female students achievement in the test.

3 Research Methodology

The methodology utilized in this study encompassed the quantitative methods where the data provided a bearing on how students responded to a given set of questions bordering on the use of number line for solutions. The tasks were designed to be slightly complex in order to engage the students in a thinking process and to avoid direct answers. Apart from addition and subtraction tasks, there were tasks which included two operations (addition and subtraction as well as multiplication and addition. The tasks were:

1. A frog is on rock number 16. It moves 12 rocks forward. What is number of the rock which it reached?
2. A butterfly is on flower 4. Each day it moves forward, 4 flowers. Which flower will it reach in 3 days?
3. An ant is on the number 9, and it moves 7 steps (each step is one number). Its hole is on number 21. How many steps remain before it reaches his hole?
4. A week ago the temperature was 23^0c. Today the temperature is 34^0c. By how many degrees has the temperature risen?
5. A book has 45 pages. John has already read 34 pages. How many pages remain unread?
6. A snail is on the number 3. Each day it moves forward 3 numbers. Which number will it reach in 6 days?

The subjects for this study comprised 300 students from of Junior Secondary One (JS1), Junior Secondary Two (JS2) and Junior Secondary (JS3) drawn from schools in Bwari Area Council of Federal Capital Territory (FCT), Abuja, Nigeria. These students were from the top classes for each of these levels. The compositions of the samples are shown in table 1.

Table 1: Demographics of respondents by grade levels and gender

Gender	JS 1	JS2	JS3	TOTAL	Percentage
Male	50	50	50	150	50
Female	50	50	50	150	50
Total	100	100	100	300	100
Percentage	33.3	33.3	33.3		

The composition of the samples is 33.3% in JS1, 33.3% in JS 2 and 33.3% in JS3. From this total, 50% of them is male students and 50% is female students.
Table 2 indicates the mathematics grades obtained in their respective end of term examination.

Table 2: Demographics of respondents by examination grades

Grade	Frequency	Percentage
A	40	13.3
B	73	24.3
C	89	29.7
D	98	32.7
Total	300	100

From the samples, majority 32.7% obtained D grade in their respective end of term examinations. This was followed by 29.7% with C grade, 24.3% with B grade and 13.3% with A grade. Approximately, 37.6% are above average considering their scores in their respective end of term examinations.

Instrument and Instrument Administration

All the students were given a 6- item paper and pencil test. The test items were adapted from Skoumpourdi [1]. They were given 3 minutes per question under thorough supervision of their teachers.

Analysis and Results

This section deals with the details of the findings of the students' performance based on the test conducted.

Analysis of the Test across Levels

Each of the test items is allocated a score of one (1) for a correct answer with or without a number line accompanying it, and a zero (0) score for an incorrect answer even when it is accompanied with a correct number line to restrict students to personal performance. As such, the total score for the test is 6 points. The average percentage of correct responses for the test with number line is less than 52% across levels. The least percentage of average score on the test is 45.8% (JS2) and the highest is 50.2%, which means that these students received a score less than 52% achievement in the test. Surprisingly, JS1 students performed better with an average percentage score of 50.2% than their seniors in JS2. The highest increase (44%) in the percentage of correct responses is in the transition from JS2 to JS3. This score is similarly represented in the mean score where JS3 students obtained the highest mean (3.01) as well as the JS1 students (3.01) and 2.75) for JS2 students. (See table 3 below).

Table 3: Descriptive statistics for the test by grade level with number line

Level	**N**	**Mean (max 6)**	**Percentage correct**	**Standard Deviation**
JS 1	100	3.01	50.2	17.61
JS2	100	2.75	45.8	14.02
JS3	100	3.01	50.2	20.86

Difference in Mean Score for the Test with Number Line

A review of table 3 shows that there was a difference in the Mean score between JS1, JS3 and JS2, in the test. In order to analyze if the mean difference was statistically significant, a t-test was done as shown in table 4 below.

Table 4: Comparing Means between levels in the test

	Sum of sequences	Df	Mean square	F-cal	F-tab
Between groups	4.507	2	2.255	0.027	19.49
Within group	25258.73	297	85.046		
Total	25263.24	299			

The calculated F-value of 0.027 is less than the tabulated F-value of 19.49 at $\alpha = 0.05$ level of significance. Therefore, there is no significant difference in the mean scores of the students used for the test.

Descriptive Analysis for the Test Strands across Levels

The following section details an analysis of the responses of the students across the strands performance (i) with and without number line and (ii) with number line only. The items in the test are analyzed with respect to each strand to find the percentage of correct responses for the items across levels.

Strand 1- Responses with and without Number Lines

This strand presents the performance of the students with correct responses with or without the number line. It indicates that the students performed better when compared with the result obtained with the number line.

Table 5: Item Analysis for Strand I across Levels

Item	Percentage			
	JS 1	JS 2	JS 3	Average
1	84	98	100	94.0
2	46	52	40	46.0
3	35	38	41	38.0
4	42	36	45	41.0
5	58	60	47	55.0
6	47	40	38	41.7
Average	52.0	54.0	51.8	52.6

The table shows that the students scored well on item 1 with an average of 94%. For items 2, 4 and 6, they scored an average percentage of 46%, 41%, and 41.7% respectively. Item 5 received an average score of 55%. They performed woefully on item 3 with an average of 38%. JS 1 students scored better than the JS 3 students on items 2, 5 and 6. Comparing JS1 scores with JS2, JS1 students are better at items 4 and 6. The comparison for JS2 and JS3 shows that the JS2 students performed better on items 2 and 5.
Generally, the average percentage scores are 52% for JS1, 54% for JS2 and 51.8% for JS3, implying that the JS2 students are better than the other levels. This could have resulted from the fact that the topic may have just been treated in their class.

Table 6: Item for strand 2 across levels

Item	Percentage			
	JS 1	JS 2	JS 3	Average
1	84	75	89	82.7
2	44	35	44	41.0
3	34	35	37	35.3
4	40	42	37	39.7
5	62	50	65	59.0
6	37	38	29	34.7
Average	50.2	45.8	50.2	48.7

Strand 2: Responses with Number Only

This strand is the focus of the study, to investigate the students' proficiency in the use of number line in solving mathematical tasks. Generally, the students scored an average percentage of 48.7%. JS1 and JS3 scored an average percentage of 50.2%, while JS2 students scored an average percentage of 45.8% when compared with the previous, it is seen that JS 1 and JS3 students are better at the use of number line. This could have resulted from the fact that the JS1 students might have just learnt the topic and the JSS3 did a revision on the topic since it is examination class. On the items, the students scored excellently on item 1 with an average percentage score of 82.7%. This is followed by 59%average score for

item 5, 41% for item 2 39.7% for item 4, 35.3% for item 3 and 34.7% for item 6. Overall, the students' proficiency in the use of number line is below average. Comparing the classes, JS1 students performed better than the JS2 students on items 1, 2, and 5 and better than JS3 students on items 4 and 6. This is surprising. Similarly, JS2 students performed better than the JS3 students on items 4 and 6. It is expected that the JS3 students should have been better considering their level and maturity. The factors leading to this disparity requires further investigation.

Comparison of the Test Result by Gender across Levels

An analysis was done to compare the difference in the test scores between gender in the respective levels, namely, JS1, JS2 and JS3. Table 7 below summarizes the result.

Table 7: Summary statistics for the number line test by gender and levels.

Level	Gender	N	Mean	Standard deviation
JS1	Male	50	26.0	12.2
	Female	50	24.2	6.4
JS2	Male	50	23.5	8.7
	Female	50	22.3	5.6
JS3	Male	50	26.3	11.9
	Female	50	23.9	8.8

Table 7 reveals that the mean score on the performance test (in the use of number line) in solving mathematical tasks is higher for male students than the female students across the three levels as shown in table 7. An independent samples t-test as shown in table 8, reveals that there is no significant difference in the mean score of the students used for the study.

Table 8: Independent samples t- test for the test by levels

Level	Test for equality of mean between gender (male/female)			
	t-cal	t-tab	Mean difference	St.error difference
JS1	0.923	1.984	1.8	1.95
JS2	0.262	1.984	1.2	4.58
JS3	0.477	1.984	2.4	5.03

4 Discussion and Conclusion

The aim of this study is to provide an answer to low proficient students on the use of number line in solving mathematical tasks by Junior Secondary School students. The result from this study has shown that students are not able to translate their solutions to the questions in number line. They have difficulty in interpreting the number line representation and in translating the problems to the number line. Students' inability to use the number line effectively could be due to several factors such as less emphasis on the ways the number line can function as auxiliary means in solving problems. Number line can be used to organize thought for giving answer to mathematical tasks in unskilled hands. The number line model remains' firmly in the "clue ideas file, [16]. Therefore, it is not just sufficient to recommend the use of number line as an auxiliary means for students' mathematical development. It should be properly included in mathematics textbooks. Teaching of the use of number line should be included in the curriculum and should begin with the teacher's scheme of work for the term.

This inability of students to creatively and successfully use number line can be overcome by designing a systematic teaching process in the use of number line. It is a developmental process that would support the familiarization of students and teachers with the various types of number line representations and their uses. If done, the number line would be a useful tool for every student and every teacher supporting the teaching and learning of Mathematics.

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