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ATTAINED MATHEMATICS CURRICULUM IN ZIMBABWE PRIMARY SCHOOLS

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ABSTRACT

This article presents a research on the attained mathematics curriculum in Zimbabwe primary schools conducted in 1981. The major findings are that:

(i) The majority of Grade Seven pupils proceed into the secondary school level with very limited mathematical background, especially in those areas that constitute the foundation for secondary school mathematics.

(ii) The majority of Grade Seven pupils show very weak understanding of key mathematical concepts such as number, fraction, place value, perimeter, area, and volume.

(iii) The Grade Seven pupils' levels of competence in the key processes of addition, substraction, multiplication and division are very low especially in problems involving combinations of whole numbers, proper and improper fractions, decimals and mixed numbers.

(iv) Most Grade Seven pupils show very low ability to apply mathematical ideas to real life problems even those involving practical concepts such as gain, loss, interest, discount and sales tax.

(v) Key geometry concepts are almost nonexistent in the majority of Grade Seven pupils.

(vi) The majority of Grade Seven pupils have a very weak knowledge of the important concepts of rounding and estimating.

(vii) The data collected suggested that primary school teachers make very little use of practically based approaches in developing mathematical ideas but rather employ rote learning strategies. This observation clearly needs further research.

RATIONALE

The attainment of independence in 1980 resulted in a vast expansion in primary school education. This vast expansion resulted in a wide spectrum of pupils proceeding through the primary school grades with very limited opportunity for any pupil to repeat a given grade. Furthermore, many curricular changes took place in the primary school system. For example, all Grade Seven pupils have a right to proceed into the secondary school system. The main assumptions of such a policy are that all primary teachers implement the intended curriculum equally well and that all primary school pupils benefit equally well from the implemented curriculum. This study was conducted to determine the outcomes of mathematics education through the primary school years and to find out the focus of teaching with respect to understanding and application of mathematics. The study should prove helpful for those at the secondary school level who have the responsibility of providing appropriate programmes for incoming students from the primary school. The findings of the study should also prove useful to those in the primary school whose task is to provide a solid foundation to the students as they progress through the primary school years. It is also viewed that the study should prove important for those in primary teachers colleges who have the responsibility of producing primary mathematics teachers.

METHODOLOGY

In conducting the investigation, a stratified random sample of 10 secondary schools was drawn by school type. The sampling design consisted of five categories, namely Group A schools (formerly all White, Asian and Coloured), Group B schools (formerly all Black), Upper Top schools (extensions of primary schools), former F2 schools (formerly all Black with emphasis on practical subjects) and Mission Secondary Schools.

The stratification was to afford a fair follow-up of 1980 Grade Seven graduates who had proceeded into Form one. All Form one classes at the nine participating schools (one school dropped out) provided an overall sample of 1869 pupils.

Five major clusters of topics were tested:

- Number Concepts and Place Value Concepts (Test 1)
- Computations on Whole Numbers (Test 2)
- Rational Numbers (Test 3)
- Indices, Statistics, Graphs (Test 4)
- Measurement and Geometry (Test 5)

The areas covered in the tests were the major curriculum topics for the primary school mathematics. Test 1 was based on the Stanford Diagnostic Test while Test 2 was based on the Mathematical Insight Test (14+). Tests 3, 4 and 5 were designed and pilot tested for reliability by the investigators. Using the split-half method, the determined reliability coefficients for the five tests were as follows:

Test	1	2	3	4	5
Reliability	0.88	0.96	0.98	0.98	0.84

Time constraints made it necessary to test pupils at the beginning of the third term of 1981 instead of in the first term, as would have been more desirable. This may have influenced some of the results but the overall picture still remains essentially clear.

DATA ANALYSIS

Pupil responses to the items on the tests were analysed. The outcomes are presented here as percentages of pupils giving correct responses to the items.

Of the 1853 pupils who took Test 1, only 49% could interpret the number line for whole numbers and only 20% could do the same exercise for fractions. Fractional relationships when shown diagramatically could only be understood by 60% of the pupils. Betweenness of wholes (e.g. the whole numbers between 5 and 9 are ...) was understood by 64% of pupils and that of fractions (e.g. the number at the point halfway between 1/2 and 3/4 is ...) was understood by only 16% of the pupils. For determining a fraction of a million only 13% were able to understand the problem. Turning to the pupils' understanding of number properties, 80% of the pupils could work with the additive and multiplicative identities, inverses and commutativity. On simplifying operations of the same order, 83% of the pupils were able to do the problems while only 21% were able to do items with operations at different levels (e.g. 3+5x2 = ?).

Only 11% of the pupils were able to do the item on balancing equations. For multiplication and division relationships dealing with fractions and decimals, e.g. which one of the following has an answer smaller than 1?

(3/4)/(1/2); 3/4 -(-3/4); 0,1 x 5/10 ; 0,6 x 5,0.

Only 33% were able to answer this item.

While place value forms a basis for the understanding of the arithmetical operations and of the concept of logarithm and hence is a very important part of the curriculum, only 43% of 1853 pupils could read a number on the abacus with only 12% being able to read a picture using place value blocks (this is in spite of the availability of such pictures in the primary school mathematics textbooks).

Regarding understanding of different ways of presenting denary numbers, 86% of 1,853 pupils responded correctly for the expanded notation in the form 300 + 50 + 5, only 30% could deal with the power form, e.g.,

$$4 \times 10^3 + 3 \times 10^2 + 5 \times 10^1 + 5 \times 1, \text{ and}$$

43% were able to respond correctly for numbers in the mixed form (e.g. 7 tens and 15 = ?). On an item regarding the change in value of a digit under movement to the left only 41% responded correctly while 31% responded correctly when a digit was moved to the right. Only 37% of the pupils tested showed understanding of a number presented in the standard notation, e.g. 1.6×10^4.

While it is expected that all pupils have developed full mastery of basic arithmetical algorithms, only 87% of 1,869 pupils who took Test 2 demonstrated mastery of the addition algorithm, 86% for the subtraction algorithm, only 62% showed sufficient mastery of the multiplication algorithm, 95% showed mastery of the division algorithm for single digit divisors where no remainder was involved but only 61% could deal with problems involving single divisor with a remainder, e.g., 200 divide by 6. When a two digit divisor giving a remainder was used only 28% of the pupils responded correctly with the percentage dropping to 15% when a three digit divisor and a five digit dividend were used.

On the practically based problems involving multiplication and division from pictorial data, only 47% of the pupils could identify product or factor, and only 39% could match an operation to a data picture.

While fractions constitute a very important subset of the real numbers, only 43% of 1,465 pupils who took Test 3 showed an understanding of the meaning of "action", 74% responded correctly on equivalence of fractions and 55% were able to compute the fraction of a given quantity. Interpretation of the numberline was an area of little understanding with only about 14% being able to do most of the items. Skills for reducing proper fractions to simplest terms was shown by about 80% of the pupils but only about 54% could do this when a mixed number was involved.

While the majority of the pupils tested showed some skills with computation involving fractions the percentage apparently possessing this skill was still quite low in certain areas. Seventy-three percent of those tested could add fractions with the same denominators. Whereas only 58% could add fractions or mixed numbers with unlike denominators, a similar picture obtained when subtraction was the operation. Seventy-six percent of the pupils got the items correct when the fractions were multiplied by whole numbers but only 50% got the items correct when the multiplier was a fraction or mixed number. A curious reverse took place when it came to division. When the divisor was a whole number only 31% could get the items correct but when the divisor was a fraction or mixed number 54% were able to answer correctly, suggesting that children only rotely applied the invert and multiply rule with little understanding of what was taking place in the division of fractions.

Seventy-one percent of those tested responded correctly to items involving the addition and subtraction of decimal numbers. Similar results were obtained for multiplication. For division involving a whole number divisor 70% got the items correct but when the divisor was a decimal the percentage responding correctly dropped to 33%.

When it came to percentage calculation which is an area where we daily are called upon to use percentages in real situations, pupils showed little skill. Only 22% were able to find the percentage of a whole such as "4 is what percent of 12". Only 18% were able to find percentage of whole numbers such as 6 is 20% of what number. When the item involved a decimal the percentage responding correctly dropped to eight percent. With the exception of finding single digit percentages of money items (30%), about 50% got these items (such as 25% of 40) correct.

In relation to rounding which is essential to estimation, with the exception of being able to round the nearest million (46%), less than 20% were able to respond correctly to such items.

Sixty-five percent responded correctly to the items on tenths and around 50% got the items correct when the fraction denominator was a factor of 10 or 100 but only 31% got the item correct when the denominator was not a factor of 10 or 100 and only 21% got the item correct when a mixed number was involved.

While 50% of those tested responded correctly to the item involving perimeter calculation only 34% responded correctly when they were required to measure as well. Only 24% correctly measured the perimeter of an irregular shape. While 58%

responded correctly to the item on the concept of area, only around 35% got the items on calculation of area correct. When it came to volume only 27% got the item on concept correct yet 40% were able to calculate the volume of a triangular prism. Forty percent got the item on mass correct.

While 81% were able to read time from a clock, only 28% got the item on the 24 hour system correct. Twenty-eight percent responded correctly to the item on calendars and a mere 13% were able to read the timetable correctly.

Around 30% got the items on the relationship of metric units correct. Money and time relationships surprisingly proved more difficult with only about 20% getting these correct. Capacity units involving calculation were responded to correctly by only 25% of those tested. Items involving money combinations proved very difficult with only six percent getting these correct and only 26% were able to correctly respond to the item on change.

While over 60% were able to correctly identify shapes only around 30% were able to correctly answer the items on shape properties. Over 80% of those tested responded correctly to the items on parallel lines and curve properties but only around 40% correctly answered the items on perpendicular lines and symmetry. About 50% correctly answered items on angles, about 40% got the item on circle properties and 62% the items on region property.

Observations from an International Perspective

About the same time as the study of Form I competencies was carried out in Zimbabwe, a much more comprehensive study of mathematics achievement and instruction (1985) was carried out in some twenty-one countries (the Second International Mathematics Study). A number of items were similar in both studies and it is interesting to compare the results.

One item (on the meaning of a million) was almost identical. The international mean achievement was 69% whereas in Zimbabwe the achievement was only 13% On reading a number line for whole numbers, Zimbabwe's achievement (49%) was higher than the international mean achievement (40%), yet on reading number line for fractions the international mean (35%) was higher than the Zimbabwean level (20%). In terms of using the associative property and the distributive property for multiplication the international mean was only 49% whereas the percentage for Zimbabwe was 87%.

On many items such as Operations with integers (Z=32, I=42)[1]; zero property of multiplication (Z=45, I=45); subtraction algorithm (Z=85, I=78) multiplication (Z=74, I=85); addition of fractions (Z=70, I=63); subtraction of fractions (Z=42, I=56); ordered pairs of points on coordinate graphs (Z=34, I=37); multiplication of fractions (Z=61, I=72), division of fractions (Z=55, I=36); multiplication of decimals (Z=66, I=56); percentage of a number (Z=47, I=55); reading a graph (Z=43, I=49), number as a percentage of another number (Z=34, USA=34); the results were quite similar. On the other hand, for some items the results were quite disparate; for example, division of decimals (Z=15, I=39), equivalent fraction (Z=21, I=44), and number which is what percent of another number (Z=23, I=48).

It can be seen that achievement in mathematics is of concern worldwide and that for the most part Zimbabwe's problems are neither unique nor in many instances more severe than those elsewhere. It is of concern that items which involve greater con-

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1 I refers to international mean percentage and Z refers to Zimbabwean mean percentage, and USA refers to the United States of America.

ceptualization seem to be the ones where Zimbabweans students fare the worst and that Zimbabwean students only seem to hold their own on those which are of a rote nature. This suggests our teachers do a good job on drill and practice but need to do much more in developing understanding and problem solving skills.

DISCUSSION OF RESULTS

First it should be noted that there are very few items where less than ten percent of those tested got the items correct and for the most part these items were items within the area which is taught as new material in the secondary school. Therefore, it immediately emerges that there is a small percentage of pupils for whom there is no need for concern. These pupils appear to have mastered the primary school syllabus and give every indication of being completely ready for, and capable of, coping with secondary school work. In many instances that percentage is far greater than ten percent but the performance as a whole indicate that there are areas of weakness which must be addressed.

It should also be noted that there is no item on the test where more than 95% of those tested got the item correct. This suggests that there may be a very small core of pupils who have not grasped any of the mathematics taught in the primary school and who need very serious remediation. Such remediation should be begun in primary and teachers need to be aware of such pupils and be able to identify them and provide appropriate remedial activities.

Of concern is the low percentage of pupils showing real understanding of number and in particular fractional numbers. Such an understanding is essential to further work in mathematics and may underline much of the problem seen in other areas that were tested. While a fairly high percentage (80%) of the pupils understood the properties of the number system it can be seen that understanding does not transfer to the solving of equations nor to the order of operations when they are of differing levels such as combining multiplication and subtraction in a single mathematical expression. Yet these are quite basic to understanding and performance in mathematical at the secondary level.

Another area of very grave concern is the overall poor performance of the pupils on place value. Place value understanding is essential to the understanding of the operations algorithms and the inadequacies displayed here lead to the problems which show up on the items on the basic algorithms particularly multiplication and division. Lack of multiplication and division reasoning ability, as shown in the items on reasoning from pictorial data, may also be contributing factors to the poor performance on the algorithms. All the items point to the likelihood that the emphasis in the primary classroom is on the rote acquisition of mechanical skills without an adequate conceptual framework.

The difficulties displayed in terms of understanding of the meaning of fractions and pupils' somewhat better performance on computational items also suggest this emphasis on the mechanics and underscores the danger of such an approach.

In a separate study conducted by Shumba (1988) in the Gweru schools it was found that teachers in fact did emphasize mechanics and the rote acquisition of skills without adequate conceptual frameworks. Yet those few teachers who used more discovery – oriented, meaning–centred approaches appeared to also produce pupils who achieved greater understanding of fractions while still possessing computational skills.

Decimals and percentages are areas for special concern as both show overall low attainment. Percentage calculations are especially worrying as there are so many occasions in our daily lives where percentage calculations are used; for example; taxes, interest, profit and loss to mention only a few. And pupils' inability to round numbers also shows that the key daily use of estimation would not be available to many of these pupils.

When we look at pupils' understanding of measurement and shape we again see serious deficiencies in key areas of mathematics useful to the daily life of the pupils.

It would seem that more attention needs to be given to the use of the numberline in many different ways, use of many embodiments of place value and sufficient conceptual development of multiplication and division algorithms along with practice for skills development. Time and money as well as other areas of measurement such as area and volume will also need greater emphasis and development and more consistent attention to real understanding. Fractions and decimals and percentages must be covered in practical ways so that pupils actually grasp the essential concepts.

RECOMMENDATIONS

Based on the findings of this study it is recommended that:

(1) The following topics need greater experiential and conceptual development for all pupils: place value, number line, multiplication and division algorithms, measurement, fraction and decimals.

(2) The following topics need to receive remedial attention for weaker pupils: addition and subtraction algorithms, place value, multiplication and division algorithms, time, number properties, fractions, decimals, indices and statistics.

Implications for Teacher Training

The results presented here have a number of implications for teacher training programmes. Firstly it must be determined that the teachers themselves thoroughly understand the processes which have been identified in this study as problem areas. This would be particularly true for primary teachers as they are the very ones who initially teach the material examined here. Secondly, effective methods of getting the material across must be thoroughly inculcated in the teachers. This will need to include both developmental methods and remedial methods for teachers. Thirdly, teachers will need methods of identifying pupils who have not understood particular topics so that remedial measures can be taken.

Additionally, while this study did not look particularly at problem solving abilities, there are some indications that pupils are not acquiring these abilities. Note that Zimbabwean pupils when compared with others internationally did better on the rote items while the international mean for conceptual items was higher than the mean on these items for Zimbabwe. Less than half the pupils were able to reason from pictorial data: this suggests that problem solving is not being adequately developed in the schools and that therefore teachers need to develop greater skills in teaching problem solving.

CONCLUSION

It would seem that not only is there a need for a thorough grounding of pre-service teachers in both mathematics and the methods of teaching it effectively, but there is also a need for in-service courses so that teachers in that field might also improve their teaching skills.

All these issues need to be seriously considered as the teacher is a key factor in how well pupils learn mathematics. Teachers will need all the help they can get if the problem is to be remedied as a thorough grounding in mathematics is essential to the growth of a technological society and for a quantitative control of one's environment.

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