Student Performance in Mathematical Tasks on IEA Literacy Study

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ABSTRACT

This study was carried out in 1991 as part of the International Reading Literacy Study. A stratified random sample of 2749 pupils in 143 schools in Form II during 1991 were administered the tests and questionnaires. Their teachers(143) and the heads of their schools also completed background questionnaires. A number of the items in the tests were concerned with the reading of tables, including timetables and graphs, which is a specifically mathematical reading skill. These items were analyzed to gain an overview of the reading skills in mathematics possessed by Zimbabwean pupils. On the whole less than half the pupils and in some cases less than one-third of the pupils were able to perform these tasks. Thus Zimbabwean pupils are not acquiring mathematical reading skills inspite of these skills being specifically provided for in the primary and lower secondary school mathematics syllabuses. Further it was found that better resourced, particularly in terms of textbooks and library books, schools performed better than poorly resourced schools. Additionally, schools with more experienced heads showed better levels of performance.

Introduction

One of the more important skills both in language and in mathematics is the ability to read mathematics materials. The ability to read mathematical material is a very necessary skill. According to Posamentier and Stepelman (1986) the ability to read a mathematics textbook with confidence is the most valuable skill a mathematics teacher can provide. Uprichard in the Foreword to *Teaching Reading and Mathematics* (Earle,1976) points out that "the mathematical development of children correlates highly with their ability to read mathematics. Further, the more

meaningful the approach taken in learning mathematics the more important reading ability becomes."

Involved in the reading of mathematics are the perception of symbols, the attaching of literal meanings, the analysis of relationships and the solving of word problems. Among the mathematical reading skills listed by Earle (1976) are the reading of graphs, reading of statistical tables, recognition of length and the relationship of time periods. Being able to read timetables, ready reckoners, tables and graphs are all seen as aspects of reading mathematics (Jaji,1991).

Included in the Zimbabwe primary school mathematics syllabus (Min.Educ., 1984) are the reading and use of bus and train timetables, ready reckoners, tables and graphs. Similar mathematical reading skills are included in the lower secondary mathematics syllabus (Min.Pri.& Sec.Educ., 1989). These aspects of the reading of mathematics are specifically catered for in the primary and lower secondary school mathematics syllabuses. This paper is directed to the extent to which the objectives of teaching these skills is attained in Zimbabwe.

The Study

The study was conducted under the International Association for the Evaluation of Educational Achievement (IEA) which is a network of national educational research organizations in some 50 countries (the number varies somewhat from study to study) and was created in order to carry out comparative surveys of schooling in its member countries. The decision to carry out a literacy study was made in 1986. The formal survey of scientifically selected national samples of 9- and 14-year-olds and their teachers was carried out in 1990-1991. Zimbabwe only carried out the study on 14-year-olds (Form II's). The aim of the study was to survey the achievement levels of students at this level. For the purposes of the study, reading literacy was defined as:

> ...the ability to understand and use those written languate forms required by society and/or valued by the individual. (Elley,1992,p.3)

There were three major domains or types of reading literacy materials included in the tests: Narrative prose, Expository prose and Documents. This particular paper only concerns itself with Documents and in particular those documents which are of a mathematical nature. Documents for the study were defined as:

> Structured information displays presented in the form of charts, tables, maps, graphs, lists of sets of instructions. These materials were organized in such a way that students had to search, locate and process selected facts rather than read every word of continuous text. In some cases, students were required to follow detailed instructions in responding to such documents. (Elley,1992 p.4)

Method

A multi-stage random sample of 192 schools was selected. Only 74,5 percent of these schools returned the tests and questionnaires. Thus the achieved sample was 143 schools with 2749 pupils. The sample was relatively balanced with regard to sex of the pupils with 52% boys and 48% girls. Sixty-five percent of the schools were classified as rural, a further 14% were from small towns and the rest were urban schools. The majority of the schools were rural or council schools(RDS) (69%) with the rest being private, government or mission (P or G) schools. Only 10% of the sample were English first language speakers with the rest being English second language speakers.

A test consisting of narrative, expository and documentary items in English was given mostly in multiple choice format. Additionally Student Quesionnaires designed to obtain information on students' home and school circumstances; a Teacher Questionnaire designed to obtain information on each teacher's background, instruction practices and beliefs; and a School Questionnaire designed to obtain information on the school circumstances and policies as viewed by the head of school were administered.

For purposes of analysis only those items which had mathematical content were selected for this particular discussion which focuses upon the extent to which the pupils had been taught to read material which is specifically mathematical in nature.

Findings and Discussion

Table 1
Rasch Ability Score for Reading Documents by percentiles

Percentile								
1%	5%	10%	25%	50%	75%	90%	95%	99%
164	246	282	325	375	421	471	500	573

Mean = 375; Min = 33 and Max = 692

The overall performance of Zimbabwean students in terms of reading documents is more than one standard deviation below the international mean (500). An examination of table 1 shows that 95 percent of Zimbabwean students fall below the international mean (500) for reading documents. This is cause for great concern.

A more indepth analysis shall now be made of the percentages of Zimbabwean students who can perform specific mathematical reading tasks.

Table 2
Reading Mathematical Materials

Task	Level	Percentage (Students Obtaining Correct Answers)				
Bus Timetable		All	Gender		School Type	
			M	F	RDS	P orG
	Direct	49	52	49	47	58
	Inference	30	34	27	26	41
	Conclusion	22	27	20	21	31
Directions						
	Reading Number	44	48	43	44	47
	Sum of Numbers	44	47	42	42	50
	Difference of Numbers	35	37	31	33	38
Chart						
	Direct	36	40	33	36	37
	Direct,count	35	37	37	35	42
	Inference	66	66	68	64	70
	Conclusion	25	29	22	25	28
Temperature Chart						
	Identify	75	75	74	72	77
	Inference	37	41	31	33	43
	Interpret	33	38	29	33	36
	Conclusion	44	50	41	43	51
	Direct	75	72	65	66	73
Graph						
	Interpret Graph	53	55	48	53	56
	Inference	29	32	29	30	31
	Conclusion	26	30	22	25	29

Only 49 percent of Form II pupils can read information directly (finding the bus which leaves a point first in a particular direction) from a bus timetable. When it comes to making inferences such as deciding the next bus after missing a particular bus only 30 percent of the pupils responded correctly to this item. Still fewer responded correctly when the item called for making a conclusion such as deciding the lastest bus you could take to arrive by a specified time (22%). These are all skills called for in the primary mathematics syllabus and the lower secondary mathematics syllabus and specifically practiced in at least some of the textbooks in use in the schools. This, then, is cause for concern as less than half of the pupils are achieving the lowest level of this skill area and fewer than one-third of the pupils achieve the somewhat higher level calling for a type of decision. Clearly these skills are not being achieved by the majority of our pupils. Contrast this with the pilot findings (Jaji, 1991) using a preferred stratified sample of Form II's from schools selected on the basis of being in the upper 10% and the lower 10% of schools in terms of 'O-level' results from 1987 from Harare and Mashonaland East on the basis of ease of access where the results reflected only 25% were failing to achieve the objectives. Clearly when the sample is random and includes a majority of rural schools as opposed to selected urban schools the numbers of pupils failing to achieve the objectives increases to a startling degree.

Less than half of the pupils responded correctly to the items related to reading and following directions. This reading task is of the type that is commonly used in textbooks and everyday classroom activities and suggests that pupils may not be able to follow directions given in written form in their day to day classroom experience.

When it comes to reading tabular chart information only about one-third of the pupils were able to do this task correctly. Though it is interesting to note here that two-thirds of the students were able to make a correct inference from the chart information. This inference type item, however, had the required information first in the chart and this in itself may have aided many pupils and thus perhaps accounts for the seeming inconsistency in the findings.

Being able to read temperature chart information presented a somewhat mixed picture. Seventy-five percent of the pupils appear to be able to pick out highs and lows from the chart. They, however, find it much more difficult to make inferences, interpretation and draw conclusions based on the data in the chart with again far less than half the pupils being able to perform these tasks competently.

With graphs the pupils again showed poor performance. Only about half the students were able to interpret a graph and less than one-third were able to make inferences or draw conclusions from the graph.

When we look at the performance of the pupils on these tasks by the gender of the pupil we see that while the performance is fairly similar boys tend to slightly outperform the girls consistently. The greater ability of the boys in reading tasks is contrary to the international picture where girls outperform boys. This difference in performance suggests that there are environmental factors which need to be examined affecting the performance of girls in Zimbabwe in all school related tasks.

When the data is again examined this time by school type it is seen that private, government and mission school performance is consistently higher than the performance of pupils in rural day schools. Again it would be important to try to examine the factors contributing to this difference in performance. But this is beyond the scope of this paper.

Table 3
School Factor Correlations: School Factors Correlated with Document Reading Performance

Factor	Pearson Correlation Coefficient	p value
Instructional Time (Hours)	-0.0146	0.4936
Teacher-Pupil Ratio	0.3036	0.0001*
School Resources	0.1882	0.0001*
Library Books Added Per Student	0.2832	0.0001*
School Library Books per Student	0.3870	0.0001*
Community Type (Urban-Rural)	0.2295	0.0001*
Years School Head/Total Career	0.2176	0.0001*
Years School Head/Present School	0.0923	0.0001*

School Factors which appear to have greatest effect on the performance of pupils are school resources; teacher-pupil ratio, school library books, school library books added per student, the type of community (this has been classified on the basis of density of population from rural to small town to urban to big city), and the total career experience of the head of the school. Clearly the factors of better school resources which include better teacher-pupil ratios, library books, etc. correlate quite highly with performance and it would seem that if the performance of the pupils in terms of reading documents is to be improved then it will be necessary to improve access to these resources. An interesting aspect is the high correlation between the total career experience of the head with performance. There is evidence in the school effectiveness literature that the quality of leadership of a school affects performance and the findings here certainly support that idea and suggest that for better quality the heads of schools need to be experienced educators.

Table 4
Home and Student Factor Correlations: Home and Student Factors Correlated With Document Reading Performance

Factor	Pearson Correlation Coefficient	p-value
Frequency Voluntary Newspaper Reading	0.1749	0.0001*
Meals Per Week	0.1831	0.0001*
Pupils Age in Years	-0.2714	0.0001*
Frequency of Use of Language of Test at Home	-0.0848	0.0001*
Years Fathers Education	0.1536	0.0001*
Years Mothers Education	0.0989	0.0001*
Parental Education	0.1465	0.0001*
Time Watching TV Outside School	0.0479	0.0150*
Frequency Voluntary Book Reading	0.0359	0.0725
Frequency Reading Document/Diagrams	0.0966	0.0001*
Home Possession Score	0.3171	0.0001*
Student Possession Score	0.1727	0.0001*
Frequency Asked at Home About Reading	0.0259	0.1875
Frequency Getting Homework	0.1731	0.0001*
Hours Homework Per Week	0.0321	0.1029
Hours Reading Homework Per Week	0.0168	0.3936
Time Spent on Test Language Homework	0.0043	0.8313
Reading Silently (Hours)	-0.0177	0.3734
Frequency School Reading	0.1485	0.0001*
Time Spent on Job/Family Responsibilities	-0.0541	0.0177*

Home and pupil factors which appear to have effect on the performance of pupils are the age of the pupil (with greater age having a negative effect on performance), parental education, home possessions, meals eaten per week, frequency of voluntary reading of newspapers,frequency of school reading, number of books in the home, the pupils own possessions, and whether English (the language of the test) is used in the home. In general it would seem that pupils coming from circumstances of greater wealth performed better. This finding is consistent with the overall international findings and with findings of other studies conducted in Zimbabwe.

Table 5
Teacher Factor Correlations: Teacher Factors Correlated with Document Reading Performance

Factor	Pearson Correlation Coefficient	p-value
Number of Years Teacher Education	0.0387	0.0553
Professional Reading	-0.0776	0.0001*
Frequency Teaching/Documents	-0.1176	0.0001*
Instructional Time (Hours)	0.0754	0.0003*
Proportion Student Needing Help	-0.1197	0.0001*
Proportion of Class Not Test Language	-0.0741	0.0004*
Proportion Language of Instruction Time	-0.0291	0.1614
Teaching Test Language (Hours)	0.0685	0.0006*
Proportion of Teacher Training	-0.0246	0.2371

Teacher factors and activities which affected performance were: the frequency of teaching the reading of documents, instructional time, and time spent teaching English. Pupil performance seemed to be affected by

opportunities to read silently in class, do comprehension test, read in the library, be listened to by their teachers, have systematic work on vocabulary, learn vocabulary from test, learn library skills, read other subject areas and participate in student discussions. It must be noted, however, that in the case of reading other subject areas, participating in student discussion, comprehension tests, and systematic vocabulary activities that the effect was negative and not positive. Teaching strategies which had an effect on pupil performance were thinking about topic knowledge, remember related things on same topic, prediction, writing notes, and remembering similar things they have read. Again note that prediction, writing notes and remembering similar things they have read had a negative and not a positive relationship with performance.

Conclusion and Implications

All of the mathematical reading tasks included in the test are tasks which are specifically included in the syllabus for mathematics in the primary school. Thus it could be expected that pupils would in general perform well on these tasks. However, the findings that less than half the pupils and in some cases less than one-third of the pupils are able to do so clearly indicate that there is a problem in learning these tasks. First, we are led to wonder how much time is being spent on these tasks at the primary level. An examination of the textbooks in use in the schools shows that the tasks do appear in the books. It is possible that the amount of practice provided for is insufficient and thus this might be part of the problem.

When we consider the place of these topics in the lower secondary school (Forms I and II),a look at the ZJC Mathematics syllabus shows that one of the aims of the syllabus is to enable pupils to understand, interpret and communicate mathematics information in everyday life. A specific topic under content objectives is the ability to read, interpret and use data presented in charts, tables, maps and graphs, e.g. ready reckoners, road maps, charts and graphs in newspapers. Therefore, we see again that there is specific provision for mathematical reading tasks at the lower secondary level. An examination of the most commonly used Form I and II textbooks show that this is included in the textbooks but only on a limited scale. Again the amount and type of practice provided may be insufficient for mastery of this important skill.

Additionally, it is of concern that when it comes to interpretation and problem solving greater difficulty is experienced by pupils. It appears that about half the pupils can read the material at the lowest level of knowledge but only about one third can do so when the skill called for is of a higher order such an interpretation, extrapolation or problem solving. Note that this achievement of the mechanics of a mathematical process without sufficient understanding of the underlying concepts to be able to use the iadeas in problem solving has been a recurrent problem in the research on the mathematical knowledge of pupils in Zimbabwe (see Jaji & Nyagura, 1989 & Jaji, 1990).

It might be argued that the tasks may appear simple to teachers and thus not enough time is spent teaching the skills. Clearly the skills are not being mastered. There is evidence that some of the methods commonly used in the schools are not very effective, for example having pupils make notes.

Schools which are better resourced particularly in terms of textbooks and library books perform better. It would seem then that performance of pupils can be improved by better provision of these resources. More experienced heads seem to have pupils who perform better and this suggests that attention needs to be paid to the experience of the school head.

It would seem that the following need urgent attention:

- Methods used in teaching reading at both primary and lower secondary levels need to be examined.
- Sufficient practice of tasks for mastery must be given at both the primary and lower secondary levels.
- More books are needed in schools at all levels.
- Heads of schools need to be more experienced.

An important question not addressed by the present anyalysis is: Which factors/variables need to be "controlled" in order to reduce variability in mathematical reading skills between-schools, between-classes and between- students? In order to formulate policies we need to know the impact of each of the determined significant factors on the distribution of reading performance. We need to know which schools are least effective and most effective. This then becomes the basis of needed further analysis and research in this important area if we are to see the mathematical and even general reading skills of pupils improved.

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