

Improving Educational Quality (IEQ) Project

**INVESTIGATING PUPILS' PERFORMANCE ON MATHEMATICS
WORD PROBLEMS IN LOWER PRIMARY SCHOOL IN MALAWI**

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Table of Contents

INTRODUCTION	1
BACKGROUND TO CURRENT LANGUAGE POLICY ISSUE IN MALAWI	1
SAMPLE AND METHODOLOGY	3
SUMMARY OF FINDINGS	4
Differences in Performance between Chichewa- and Chiyao-Speaking Children	4
Difference in Performance on Mathematics Word Problems between Pupils who have Chichewa and Chiyao-Speaking Teachers	5
Pupils’ Performance on Word Problems Compared to Similar Problems in Numeric Form	6
Differences in performance between boys and girls	10
Overall Pupil Progress	11
STUDY INSIGHTS	13
CONCLUSION	14
REFERENCES	15

Introduction

The various studies that have been conducted on language in education have shown that children learn better during the early years of their primary education when the medium of instruction is in the language they speak at home (Andoh-Kumi, 1999). This is important because learning in unfamiliar language especially during these years of a child's education, entails learning two things, the language itself and the content of the subject being studied, all at the same time. This is not an easy task for most children unless the subject content is put in context or language that is familiar to children so that they are not disadvantaged in their studies at school.

Malawi has over 15 local languages (Mchazime, 1996, Kathewera, 1999). However, Malawi's national language, Chichewa, is the only local language that is used as a mandatory medium of instruction in standards 1 to 4 in all public primary schools, irrespective of whether or not children use it as their home language. This paper investigates findings on pupil performance in mathematics, particularly focusing on word problems that are assessing math skills in a context, using data from a longitudinal study on quality of education in Malawi conducted by the Improving Education Quality II (IEQ) Project in partnership with the Malawi Institute of Education and Save the Children Federation, Inc.

Previous studies on language and pupil achievement in mathematics at primary school in Malawi concentrated on senior classes (Kachaso 1988; Kaphesi 2000) where the language policy dictates that instruction should be in English. Kachaso's study compared standard 7 pupils whose math instruction had been conducted in either English or Chichewa. The results of this study showed that pupils performed better on mathematics word problems when instruction had been in Chichewa. Similarly, Kaphesi's study compared the effect on pupil achievement of using Chichewa or English as medium of instruction in mathematics. Kaphesi used standard 6 pupils as his subjects.

The effects of language on mathematics achievement using data from the IEQ study, however, were more ambiguous. Before we examine these findings, a review of the contextual framework that has given rise to teaching mathematics in Chichewa in all public schools is necessary.

Background to Current Language Policy Issue in Malawi

Some of the reforms that have been made in the education sector since Malawi got her independence in 1964 have been in the area of language education. In 1968 the government promoted Chichewa from amongst more than 15 other local languages as national language and school subject to be studied from standard 1 onwards in all public schools (Mchazime, 1996). Chichewa became the only local language that was used as a medium of instruction from standard 1 through to 4 in all public schools.

In 1989, the government established that all pupils' books (except those for English studies) for standards 1 to 4 should be written in Chichewa (Dunga et al, 1993; Chamdimba et al, 1994; Chilongozi et al, 1994). Thus, pupils in public schools system had to learn mathematics, general studies and other subjects through Chichewa irrespective of whether or not Chichewa was their home language (Chilora, 2000). In 1996, the language policy changed again, instituting pupils' mother tongue as the language of instruction for standards 1 to 4 (Ministry of Education, 1996). Despite this formal policy change, classroom evidence suggests that Chichewa remains the language that children learn mathematics and other subjects in grades 1 to 4 in the Mangochi and Balaka districts. This policy directive may have been difficult to implement in these districts because there was little support to teachers in the form of mother tongue training and development of mother tongue instructional material.

As a consequence of the policy changes, how do children whose home languages are not Chichewa perform in mathematics on the first day that they enter school and during the entire four years that they continue to learn in Chichewa? Do these children perform as well as Chichewa speakers do in mathematics? Or does learning mathematics in Chichewa, a foreign language, disadvantage these children? Does the performance in mathematics differ when presented as word problems in Chichewa compared to numeric representation. These are some of the questions raised in trying to understand the impact of Malawi's language policy on pupil performance in mathematics.

In an effort to unveil the mist that surrounds the quality of learning that children receive at classroom level, the IEQ Project, carried out a longitudinal study with financial support from United States Agency for International Development (USAID), in two multilingual districts in which both Chichewa and Chiyao (a majority mother tongue in the region) play important roles. One question raised during this study was the effect of learning mathematics through a language that children do not speak at home.

We hypothesized that because the majority of pupils speak a different language than the language of instruction, their performance on mathematics word problems would be negatively affected by differences in teacher and pupil language or the language status of the pupil. However, as will be discussed, the context of the mathematics word problems may positively influence pupil achievement, more than the potential negative influence from the mismatch between pupil and teacher language.

This paper explores the following questions in detail:

- What are the differences in performance on mathematics word problems between
 - Chichewa- and Chiyao-speaking pupils,
 - Pupils who have Chichewa and Chiyao speaking teachers,
 - Chichewa-speaking pupils who are in class with Chichewa-speaking teachers and Chiyao-speaking pupils who are in class with Chiyao-speaking teachers?

- How do pupils perform on mathematics word problems compared to similar problems in numeric form?
- What are the differences in performance on mathematics word problems between boys and girls?

The paper concludes with a discussion of some of the insights emerging from this study and the implications that these findings have for the policy makers, curriculum designers, instructional materials writers and the practitioners.

Sample and Methodology

The sample in this longitudinal study included standards 2, 3 and 4 pupils in 60 schools in Mangochi and Balaka districts, both of which are multilingual societies with Chiyao as the majority mother tongue language for children. In 1999 an equal number of boys and girls were selected from standards 2, 3, and 4 as follows: 16 pupils were selected from standard 2, 8 pupils were from standard 3 and standard 4, respectively. The data for standards 2, 3 and 4 were collected in February and October 1999 as well as in October 2000. The months selected are significant as February is the start of the school year in Malawi and October is the end.

The study included interviews of teachers, head teachers and community members (parents and local leaders in two separate groups of men and women). The February 1999 data for standards 2, 3, & 4 includes 1,855 pupils from 188 classroom teachers and head teachers from 65 schools, plus community groups of women and men. The October 1999 data includes 1,508 pupils (75 percent of the original). The October 2000 data includes 1210 pupils (60.5 percent of the original). During each of these data collection periods, among other things, pupils were assessed in Chichewa, English and mathematics skills, which included tasks on mathematics word and numeric problems.

For the mathematics assessment, the syllabus and textbooks were used to construct test items measuring crucial basic skills such as numbers, mathematic operations, and other numeracy concepts, including money and measurements. Pupils were assessed using a variety of numeric/symbolic representations as well as verbal contextual representations. The word problems were read out loud in Chichewa to the pupil while the pupil could read along using the card displaying the problem in front of them. If necessary, the math problems could be orally translated to Chiyao, if the teacher could speak it. All the instruments were curriculum-based; meaning all the mathematics items included came from or were adapted from the pupils' textbooks used in teaching mathematics.

The analysis in this study used a paired t-test to compare mean percent scores between groups and between math word problems and similar numeric math problems. The analyses took into account the nested sampling frame of pupils in classes used in the longitudinal study.

Summary of Findings

This study has unveiled interesting findings related to language and pupils' achievement in mathematics. In particular, when instruction is given in a context it may help improve pupil performance. These findings may provide practitioners insight into classroom practices that may help them understand pupil learning.

DIFFERENCES IN PERFORMANCE BETWEEN CHICHEWA- AND CHIYAO-SPEAKING CHILDREN

As discussed, we had expected pupil performance to differ when language of the pupil or the sharing of the language of the teacher and pupil was compared. This potential difference would be important to understand because pupils who speak languages other than Chichewa are in the same class with pupils who speak the national language. Children are required to learn all subjects in Chichewa, the national language, even if it is a language they do not understand. Hence, because not all children who are in school speak the national language in the early years of primary education, and they are often not matched with teachers who speak the same mother tongue, we expected significant differences in performance between those pupils whose mother tongue was Chichewa and those who spoke a different mother tongue.

Data from the longitudinal study suggest that 64 percent of learners speak Chiyao at home, whereas only 35 percent speak Chichewa (Namathaka et al, 2000; Chilora and Harris, 2001). In this analysis, comparisons in mathematics word problem achievement were made between Chichewa-speaking pupils and Chiyao-speaking pupils, between pupils taught by Chichewa-speaking teachers or Chiyao-speaking teachers, and between pupils who did and did not share the same mother tongue with the teacher.

The results were mixed, and it is difficult to determine the true source of the differences. There were a few statistically significant differences between Chichewa-speaking children and their Chiyao-speaking counterparts in their performance in mathematics word problems, particularly in standard 2, but there was no consistent pattern to the results. Where there were differences, Chichewa-speaking pupils tended to score higher in mathematics word problems, but not always. This raised questions about the source of the differences. Is the difference due to the language minority status? Is it because teachers and pupils share the same or different mother tongues? Are some teachers and learners bilingual? Or do teachers use learners' mother tongue to help them grasp mathematics concepts? Or does the context or story line of the mathematics word problem have a greater effect on performance, regardless of pupil or teacher language. These questions led to further investigation to find explanations for these differences.

DIFFERENCE IN PERFORMANCE ON MATHEMATICS WORD PROBLEMS BETWEEN PUPILS WHO HAVE CHICHEWA AND CHIYAO-SPEAKING TEACHERS

A classroom is an environment with various players, namely teachers and pupils, each playing important roles in the learning process. Wright (1987) argues that communication in the classroom environment must be clear and unambiguous throughout the teaching and learning process. However, clear and unambiguous communication only takes place when both the teacher and pupils understand the language of instruction. The IEQ/Malawi longitudinal study found a mismatch between the teachers and learners' home languages (Chilora and Harris 2001). That means some pupils in the sample were taught by teachers whose mother tongue is Chiyao, (33 percent) whereas teachers whose mother tongue is Chichewa taught the most pupils, including those whose mother tongue was Chiyao.

The IEQ researchers examined differences in performance on mathematics word problems between pupils who are taught by Chichewa- and Chiyao-speaking teachers, irrespective of pupil mother tongue or whether the pupil and teacher shared the same mother tongue. This investigation shows standard 2 pupils with Chichewa-speaking teachers scored higher on money-related word problems at the beginning of the year than the standard 2 pupils with Chiyao-speaking teachers did, but by the end of the year, the pupils who were with Chiyao-speaking teachers outperformed pupils of Chichewa-speaking teachers. However, this pattern only exists for standard 2. There are no consistent differences in performance by teachers' home language in either standard 3 or standard 4.

The same pattern prevailed when comparing teachers and pupils who shared the same language. At the start of the school year, standard 2 Chichewa-speaking pupils with Chichewa speaking teachers performed significantly better on the money word problems than Chiyao-speaking pupils with Chichewa-speaking teachers. By the end of that school year, however, the Chiyao-speaking pupils with Chiyao-speaking teachers performed significantly better on many of the same problems. Again, there are no consistent differences in performance by teachers' home language in either standard 3 or standard 4.

It appears language could have some effect, but it is unclear how. In standards 1 and 2, pupils are learning Chichewa as a subject, as well as the language of instruction for other subjects and are exposed to Chichewa in the general environment (e.g., radio broadcasts, market transactions). Also, Chichewa and Chiyao are both Bantu languages and due to their similarity coupled with extensive exposure to Chichewa, Chiyao speakers may be functioning more readily in both languages. Another explanation for the lack of difference in performance, at least within the realm of mathematics word problems, may be because the context of the word problems transcends language barriers. For example, in standard 4, there were no statistically significant differences between children taught by Chichewa- or Chiyao-speaking teachers, irrespective of pupil language or when compared with teacher language on any of the money word problems. This may be because older pupils have more exposure

to money, and that by standard 4, home language differences between teachers and pupils have less influence on pupil learning in this subject.

PUPILS' PERFORMANCE ON WORD PROBLEMS COMPARED TO SIMILAR PROBLEMS IN NUMERIC FORM

The idea that context could have more influence on performance than language in mathematics word problems was investigated in this study by comparing pupils' performance on mathematics word problems to similar problems in numeric form. Table 1 shows examples of the numeric and word problems that were considered similar for analytical purposes. Both, numeric and word problems were presented in written form and orally.

Table 1: Example Comparisons between Mathematics Word Problems and Similar Numeric Problems.

Numeric mathematics problems	Mathematics word problems
Multiply these two numbers: 4×3	You have 4 bottle tops. So do your two friends. How many bottle tops do you have together?
Add these two numbers: $27 + 67$	Lester has 66 pieces of chalk. He gathers 28 from the teachers in his school. How many pieces of chalk does he have altogether?
6 subtract 3	Joseph had 6 mangoes. He ate 3 of them. How many mangoes did he have left?

The results (see Chart 1) demonstrate that pupils scored better, on average, on mathematics word problems than they did on average for similar mathematics problems that were in numeric form. That is to say, a pupil was more likely to answer a word problem correctly than he/she would a simple numeric problem.

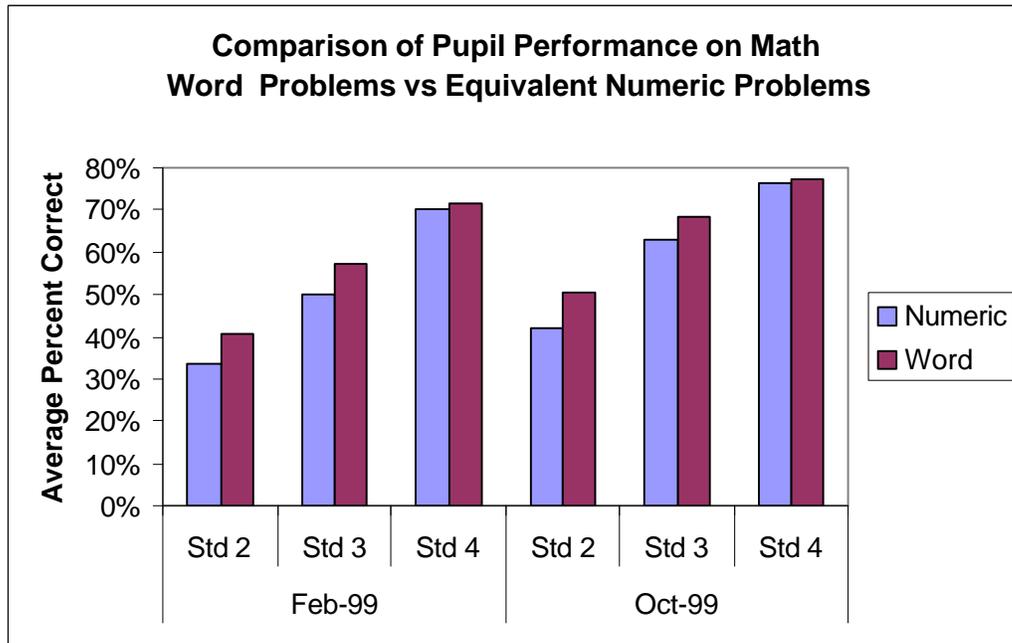
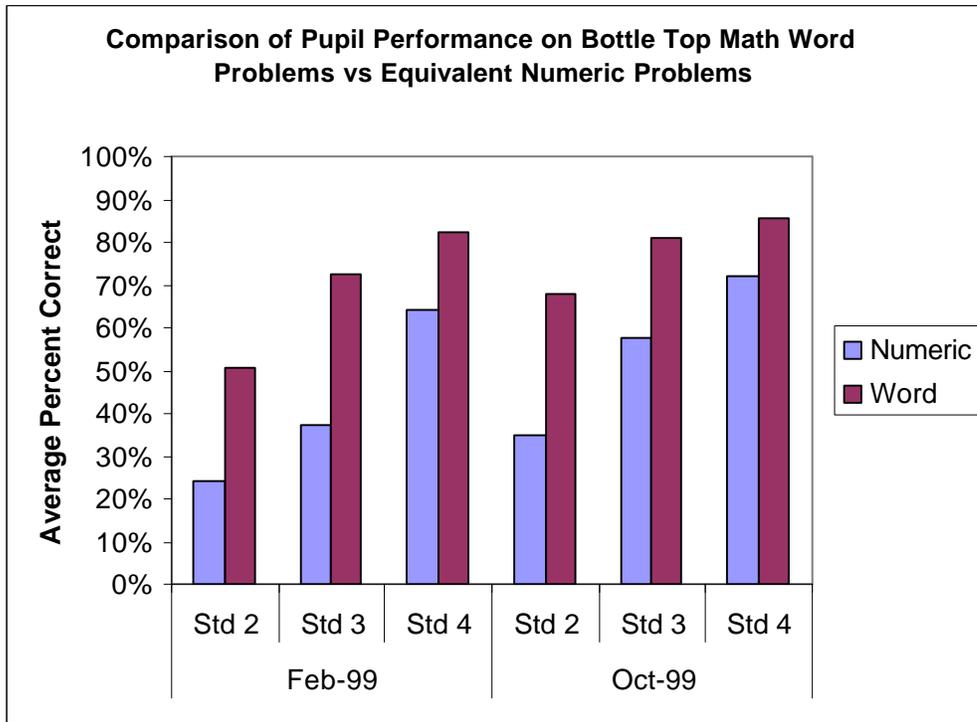
Chart 1: Pupil Performance on Similar Math Word and Numeric Problems.

Chart 1 also illustrates that differences between word and numeric scores for pupils in standards 2 and 3 are greater than in standard 4. This may be because pupils in standard 4 are more familiar with mathematic operator terms and symbols and less dependent upon contextual cues. The fact that children seems to be achieving more on mathematics word problem was surprising because we had thought that language differences would negatively affect achievement on word problems and that performance on numeric problems would be higher. However, it seems reasonable that word problems provide contextual clues to mathematical operations that particularly young children may have difficulty understanding, especially when questions are in abstract form such as symbols or operator terms.

Included in the problems were tasks that required learners to use certain familiar contexts, such as bottle tops, market goods or classroom materials to assess mastery of certain mathematic skills. As shown in Chart 2, this investigation also revealed significant differences in pupil performance in mathematics word problems that required the use of bottle tops compared to similar problems in numeric form. These differences suggest that learners understand more when the information is presented in a context that is familiar to them. Pupils performed much higher on the word problems that used the context of bottle tops to assess mathematics skills than other problems measuring the same mathematical skills. When framing mathematics word problems, it is, therefore, important to consider pupil familiarity with the context in which the question is being asked.

Chart 2: Comparison of Pupil Performance on Bottle Top Math Word Problems vs. Similar Numeric Problems.



Bottle tops are a common mechanism to teach pupils math skills and their familiarity with it highlights how context can aid understanding. Conversely, familiarity can also be a handicap if pupils are not able to generalize their knowledge to other situations. These statistically significant differences between numeric equivalents to bottle top word problems can also be interpreted as pupils understand mathematics problems in one context but are not able to generalize as readily to another context. Alternately, it could be that although pupils can compute mathematically with concrete objects, they are not as prepared to handle the same computation in a more abstract form.

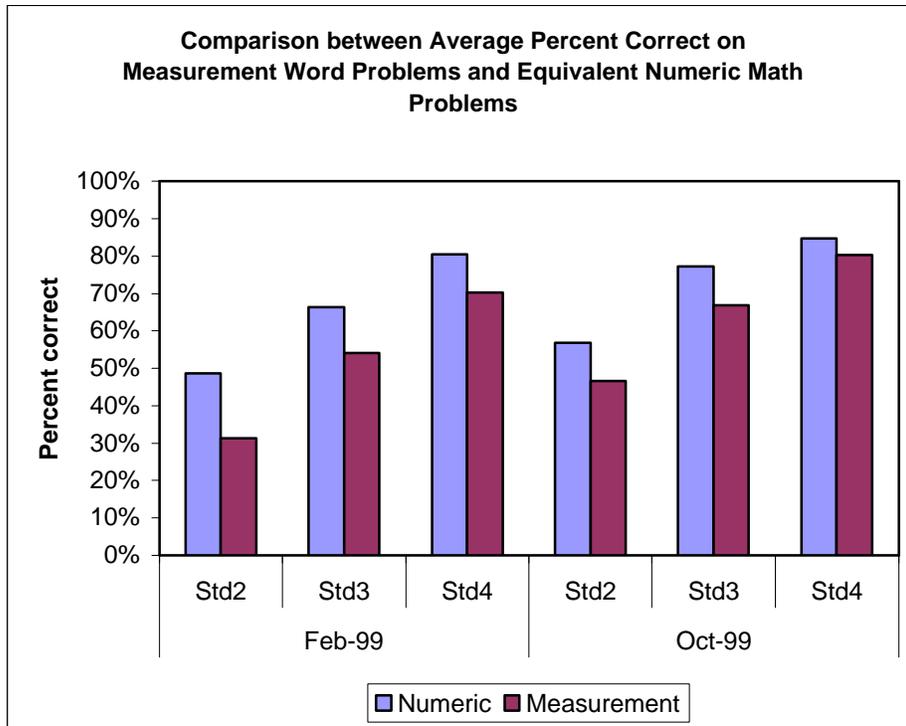
The one area that pupils performed better on tasks in numeric form compared to similar tasks in word was the word problems related to measurement (see Chart 3). The questions used in the assessment are in Table 2.

Table 2: Example Comparisons between Measurement Word problems and Similar Numeric Problems.

Numeric Mathematics Problems	Mathematics Measurement Word Problems
Subtract these two numbers: 8-3	ITEM 78. Mother has 8 liters of milk. She uses 3 liters of milk to cook soup for a celebration. How much milk does she have left?
Add 4 and 12.	ITEM 79. Mary travels 6 kilometers to school each morning and 6 kilometers back to her village each afternoon. How many kilometers does she travel altogether each day?
Multiply these two numbers: 34x2	ITEM 80. Andrew’s uncle lives 18 kilometers away from Andrew. How many kilometers would Andrew travel each time he visits his uncle?

One possible explanation for this difference could be the ambiguity of certain questions. Question 80, for instance, may be ambiguous to pupils. The question does not clearly say if Andrew’s visit includes him going and coming back. This may therefore create confusion for some learners, especially if the question is posed in a language other than their mother tongue. However, this does not explain why learners had problems with questions 78 and 79, which seem to be straightforward. Perhaps there are other explanations to this such as learners being less familiar with the concept of measurement or that the concepts are more abstract than numeric operators, especially at the lower grades. The differences between the numeric and measurement word problem diminish by standard 4 and pupils are performing better on the measurement word problems in standard 4 compared to standard 2. This is encouraging.

Chart 3: Comparison between Average Percent Correct on Measurement Word Problems and Similar Numeric Math Problems.



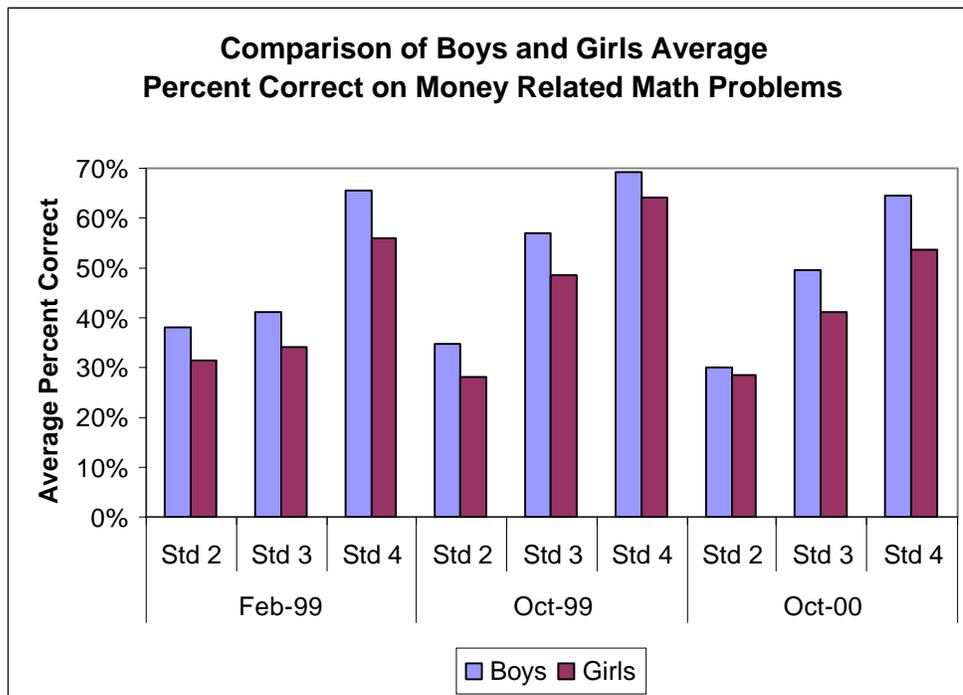
DIFFERENCES IN PERFORMANCE BETWEEN BOYS AND GIRLS

These other comparisons leads naturally to the query of gender difference in mathematics word problems and if their achievement varies based on the context of the questions. There is often an outcry in this country that girls are disadvantaged at school compared to the boys. For instance, it is argued that girls are given more chores at home, thus decreasing the amount of time to concentrate on school work whereas the boys are left with enough time to concentrate on their studies. This argument is backed up by research findings on chores that children do when they are at home (Namathaka et al, 2000). It is further argued that at school, girls are discriminated against, that they are not given an equal chance to take an active part in class, particularly in subjects such as mathematics (see Malawi Institute of Education, 1997: 34-35).

The results comparing girls' and boys' achievement show that significant differences exist for all the standards on money related word problems. Consistently, boys perform better than girls on problems related to money (see Chart 4). This may be because girls have less exposure than boys to money. In addition, in rural areas in Malawi boys are more likely than girls to be engaged in temporary

employment for money even when they are still at school whereas the girls' work is more likely to be centered around the home chores. Therefore, differences may be because girls are less familiar with the context surrounding money. The questions themselves may not measure what is intended, the mathematical skill, rather the question could be measuring their exposure to a context. A useful follow-up would be to see if girls would perform better if the same mathematical skill was contextualized in content more familiar to them.

Chart 4: Percent Correct on Money-Related Mathematics Word Problems, by Gender.



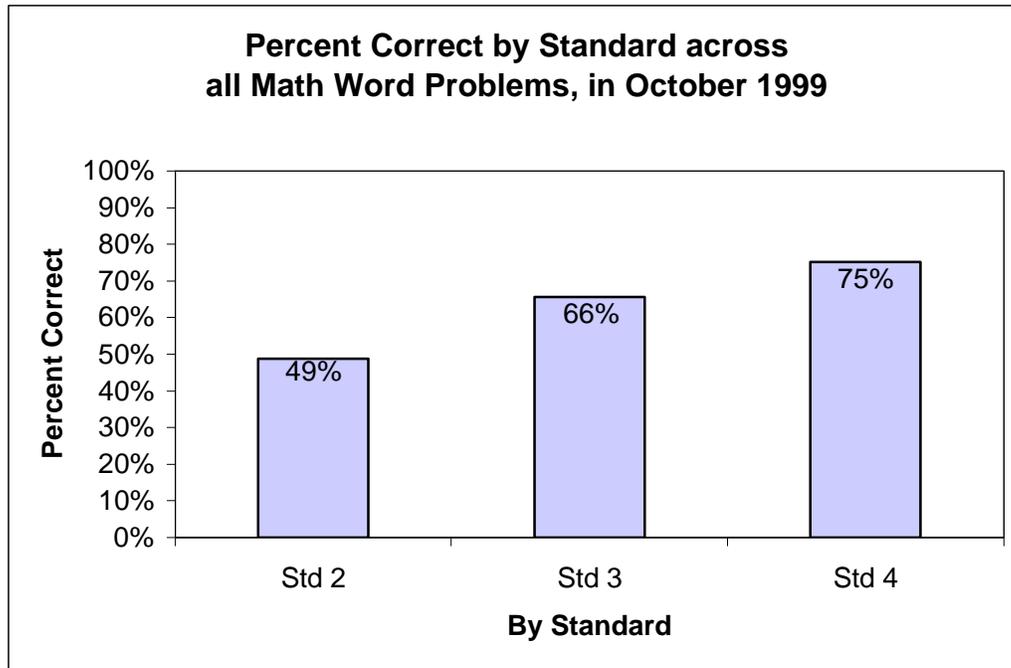
There were no other consistent differences between boys and girls. This may tentatively indicate that Malawi's attempts to improve girls' education could be having a positive influence because with one exception, girls are performing at the same level as boys. Of course, this is said with caution because we are not measuring the attribution of girls' achievement to policy and we do not have a previous baseline for comparison.

OVERALL PUPIL PROGRESS

Finally, it is important to note that despite crowded and under-resourced conditions, pupils are learning mathematics concepts as they progress through school. Pupils' scores are consistently higher with each standard. Chart 5 illustrates that pupils in standard 4 are, on average, achieving consistently

higher scores on mathematics word problems than those in standard 3, who are consistently performing better than pupils in standard 2.

Chart 5: Average Pupil Achievement on the Mathematics Word Problems, by Standard.



The study also revealed that pupil performance in mathematics word problems is related to pupil performance on various measures of Chichewa proficiency. We identified positive, statistically significant correlations between mathematics word scores and measures of Chichewa mastery, Chichewa achievement, and Chichewa learning gains over time for nearly all instances in all standards. This means those pupils who perform well in mathematics tend to be those pupils who also perform well in Chichewa.

Both of these general education findings are encouraging. Pupils are learning as they progress through school, and the rate and level of learning for mathematics and the national language tends to grow in tandem. The question for policymakers, however, is whether the rate of learning is fast enough: Are pupils learning as much as necessary in each standard to be prepared for the challenges of the next standard?

Study Insights

There are some expected and surprising insights related to mathematics achievement in lower primary school classes that we are learning from this longitudinal study. One affirming finding is that on average, children in lower primary classes in Malawi, irrespective of their gender and home language groups, are acquiring mathematics concepts and skills as they progress through school. However, what is not known is how fast children are acquiring these skills and whether or not policy makers and practitioners are satisfied with the levels of mathematics skills and concepts that children acquire during these early years of primary education.

A second important finding from this study is that the context in which mathematics problems are presented to learners matters. There is some evidence that learners are achieving more in mathematics when the problems are presented in contexts that are familiar to them, like bottle tops, unlike when they are presented in unaccustomed contexts, possibly measurement or money if you are a girl. This provides an important signal to curriculum designers, instructional materials developers and classroom practitioners about the classroom practices use of materials so that learners gain more in mathematics word problems.

Similarly, in standards 2 and 3 pupils are consistently achieving more on mathematics word problem than on analogous numeric problems, with this difference declining as pupils progress to upper classes. This finding also gives the practitioners a challenge to find appropriate classroom practices that can help learners to achieve equally in numeric and word mathematics problems in standards 2 and 3. Such practices may include use of familiar contexts and connecting the lessons to more abstract concepts, such as mathematic symbols, that are likely to assist the learners to achieve more in mathematics tasks in numeric form.

The familiarity of the mathematic word problems context may have a greater positive influence on pupil achievement in mathematics word problems than the potential negative influence of teacher and pupil language mismatch or the pupil language group. One reason could include the exposure of all pupils to Chichewa in society, the context most closely emulated in mathematics word problems. This further emphasizes the importance context can play.

Still another insight emerging concerns the performance of girls on mathematics word problems related to money. Compared to the boys, girls are consistently under performing on money-related mathematics word problems. Considering that girls play a crucial role in our societies, this finding challenges the practitioners to find appropriate strategies to use in class so that girls become equally proficient on money-related tasks in mathematics. The finding also sends important signals to parents and other stakeholders to find strategies for familiarizing girls with concepts about money, an

important skill for any member of society. All this said, there is some affirming evidence that except for money related problems; girls are performing on par with boys on mathematics word problems.

Conclusion

This paper compared pupils' performance in mathematics word problems across language groups and gender and to similar problems in numeric form. We learned that context makes learning meaningful and can both improve pupil performance when they are accustomed to the word problem's story line, but could hinder performance if they are not familiar to that context. As shown, pupils excelled in bottle top questions when compared to similar numeric problems because bottle tops are a familiar and commonly used teaching resource. Conversely, it has been demonstrated that in the context of money, girls are under performing compared to boys, possibly because they are comparatively less exposed to money.

Surprisingly, differences between Chichewa and Chiyao-speaking children, and between pupils who were taught by Chichewa and Chiyao-speaking teachers were not clearly attributed to a particular language interaction. However, it reasonable to think that the context of math word problems is more salient than differences in language, especially given the environmental exposure to Chichewa by all pupils, even those whose mother tongue differs. However, while language differences in this situation may not negatively affect pupil achievement, it is important to understand and recognize that language interactions may strongly affect other areas of learning.

This paper shared some insights that we are learning and the implications that these have on policy makers, curriculum designers, instructional materials developers and classroom practitioners, such as developing familiar contexts for teaching mathematics and using those contexts to make connections to more abstract concepts. The hope is that educators can now begin to think of appropriate strategic actions to take so that all children excel in mathematics.

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