HEART
HIGH-QUALITY TECHNICAL ASSISTANCE FOR RESULTS

RESEARCH TO INVESTIGATE LOW LEARNING ACHIEVEMENT IN EARLY GRADE NUMERACY (STANDARDS 1–4) IN MALAWI

The victory of form over substance

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Executive summary

Malawi is a poor country. Improving education is one of the Malawi Government's priority areas in its Growth and Development Strategy (2017–2022). The government wants more children to progress through and succeed in their schooling, so they graduate with the right skills to enable them to participate in and contribute to Malawi's workforce.

The UK is providing funding to support the Malawi Government to improve the quality of early grade numeracy teaching, so all children are supported to learn more effectively. To better understand the best approach to improving numeracy outcomes, the Ministry of Education, Science and Technology (MoEST) and the UK determined that there was a need to conduct a scoping exercise to better understand the key bottlenecks that are inhibiting student learning. This report is the outcome of that scoping study.

The research study set out to answer the question: What are the key success elements of a programme designed to improve early grade numeracy? In order to develop a response to the main research question, the research team set out to investigate: what the existing assessment data say about early grade numeracy performance; what the dominant enacted pedagogy in early grade numeracy classrooms is; how the existing curriculum defines expectations, standards, and pedagogical approaches for early grade numeracy; how the general learning environment supports (or does not support) effective learning; and, how the existing CPD addresses teacher licensing and in-service training expectations.

To investigate what the existing assessment data say about early grade numeracy performance the researchers studied a range of reports and, where available, the associated data and survey instruments. The surveys, reports, and assessments all confirm the view that students in Malawi are struggling with mathematics and lagging behind where they should be, both in terms of their own learning and in relation to neighbouring countries. The purpose of this aspect of the research was, however, not to reiterate the findings of these studies but rather to establish what further information can be gleaned from these studies to identify the key characteristics of the items that students struggled with. The item performance data indicate that when an item is presented in a less-standard format the experienced difficulty increases and learners are not confident in applying their mathematical knowledge. Students rely on rote learnt methods that are only applicable in limited and familiar situations. The analysis of assessment data has shown that the Malawian assessments have, at best, a limited (and by extension, limiting) expectation of what students should be able to do. When compared with the benchmarks set by international assessments, the expectations of the Malawian assessments (in particular, the MLSS and MLA) fall well below the benchmarks. The way in which students are being taught and assessed mathematics does not foster understanding or encourage them to apply their knowledge in unfamiliar contexts.

To investigate the dominant enacted pedagogy in early grade numeracy classrooms, the research team conducted classroom observations in 51 classrooms across the performance spectrum in 16 schools from urban to rural and remote. For each classroom observation the researchers used a standard observation tool developed specifically for this study that captured data on: the classroom facilities; the availability and use of student resources; the evidence and use of teacher planning materials; and, the classroom culture (including: cognitive demand of the classroom activities; evidence of differentiated instruction or lack thereof; use of teaching resources; general classroom atmosphere; and language use). In addition, the researchers collected data at three-minute intervals throughout each lesson to develop a description of the 'typical' Malawian early grade (Standards 1 to 4) numeracy lesson.

Based on the observations recorded every three minutes a clear image of the 'typical' Malawian early grade (Standards 1 to 4) numeracy lesson emerged. Lessons all followed a very similar pattern across classes and grades. Typically: the lesson started with the teacher writing the lesson title in full on the chalk-board; next, the teacher explained the meaning of the lesson title and asked students to repeat in chorus (chanting) after the teacher; the teacher then explained or demonstrated a procedure, leading students to contribute chanted responses (answers) to questions about each of the steps within the procedure; the teacher then set a similar example for the students to complete – either individually or in 'groups'; after reviewing the example with the whole class, the teacher then set two or three examples for the students to complete individually. Students worked on these examples in their workbooks and the teacher walked around the class, monitoring the students working and marking their work.

On account of the curriculum sequencing, all of the lessons observed in the research dealt with the same content area: calculations with numbers. This coincidence allowed for an interesting insight into the way in which students are being taught to calculate with numbers across Standards 1 to 4. Throughout the observations, irrespective of standard, the researchers observed how teachers uniformly demonstrated a calculation strategy that involved the use of counters. Lesson by lesson and calculation by calculation the researchers observed the same script (procedure) playing out in each of the classes with the key implication of this script being that students in Standards 2 to 4 are not, in reality, calculating with two-, three- and four-digit numbers, but are, in effect, performing two, three and four sets of single-digit arithmetic. The above noted, the energy and enthusiasm with which the script/routine was carried out was striking to the researchers. When asked what the number the teacher was pointing to was, at least 70% to 80% of the students in the class would enthusiastically put their hands in the air hoping to be the one selected to answer the question. And when a child was selected and they answered the question correctly the whole class would typically clap or sing a chant to praise the student. The atmosphere was striking in terms of the energy that the teacher used and that the students echoed.

The classroom observations demonstrated quite clearly that there is a dominant enacted pedagogy in early grade numeracy classrooms. The positive point to take away from this is that teachers follow the curriculum and teacher guides: they all appear to follow a standardised classroom routine and do so very faithfully. This is positive in as much as it suggests that if there were a change in curriculum and/or shared understanding of the optimal classroom routine, then teachers, with appropriate training and support, might be able to respond and implement the new vision. However, it is the opinion of the researchers that the current dominant enacted pedagogy and learning environment does not support effective learning. The focus on routines and procedures without any attention to understanding, application, and reasoning is of concern. That Standard 4 students are in effect performing calculations in the same way as Standard 1 students is inappropriate. It is this focus on teaching procedures that gives rise to the observations made in the analysis of the assessment data – in particular, that students are not able to apply their mathematical knowledge in a meaningful way. Of equal or greater concern is the calculation strategy that students are using when performing the addition and subtraction procedures. Irrespective of the number of digits in the numbers involved in the addition and subtraction calculations, the calculations are reduced to multiple single-digit calculations and those single-digit calculations are, in turn, performed using counters and a 'counting all' strategy. While a counting all strategy is an important foundational strategy appropriate for, say, Standard 1, it is not appropriate for the number ranges associated with Standards 2 and beyond. Students need to be developing more efficient age, grade (standard), and number range appropriate ways of calculating – and more generally of working with numbers.

To understand how the existing curriculum defines expectations, standards, and pedagogical approaches for early grade numeracy, the researcher team conducted a review of: the mathematics syllabus for Standards 1 to 4; the mathematics teacher's guides published by MIE; and, the student textbooks for Standards 1 to 4 published by MIE. This review of the curriculum has revealed that the curriculum is over-designed and over atomised, and does not take into account the interrelated nature of mathematical concept development. At the same time, review has also uncovered that the expectations of the curriculum are rather unambitious – as opposed to being challenging, or even too challenging.

The impact of this unambitious and ineffectively structured curriculum, with its low expectations, is seen in the observations of the classroom study described earlier in this report and in the performance characteristics of students described in the analysis of assessment data.

To better understand the general learning environment and how it does or does not support effective learning, the research team conducted interviews with a range of key informants in different regions. The interviews were organised using prompts from a semi-structured interview designed for this activity and focused on: the respondents' perceptions of mathematics performance in the early grades in Malawi and their explanations for the state of mathematics performance; the respondents' sense of what it means to do mathematics and their expectations of the elements of a good mathematics lesson; how teachers are expected to monitor the progress of their students and to cater for the range of needs of the different students in their classes; the NRP, in terms of key strengths and achievements to date; and, the strengths and challenges of the recently introduced 2-2-2 model in Teacher Training Colleges (TTCs).

That mathematics performance is not what it could/should be is well accepted among the key informants who participated in the scoping study. In the main, language issues and large classes were suggested to be the most significant explanatory factors for this poor performance. However, what was striking about the interviews was how respondents struggled to answer the question(s): '*What, in your words, does it mean to do mathematics? And, what mathematical skills and/or knowledge do you think Standard 1 to Standard 4 students should develop?'* In describing an effective mathematics lesson, much was made of the need for teachers to demonstrate the process of calculating practically using locally available resources. It is clear that for most respondents the learning of mathematics is understood to be procedural (see instrumental vs relational understanding (Skemp, 1986)) and that teaching mathematics is about teaching procedures to complete tasks. Notwithstanding the efforts of the TTC to focus on what it means to teach mathematics, the student teachers revert to 'telling' as soon as they get to the classroom. Nether differentiated instruction nor continuous assessment, although acknowledged as important, are implemented and this too is explained in terms of large classes. It is clear that any national programme designed to improve early grade numeracy will need to address the reality of very large classes and the effective implementation of the proposed methodologies in this context.

Possibly the most striking observation that emerges from the key informant interview component of the study is that the respondents expressed surprise at how well the Standard 1 students are able to read on account of the National reading Programme (NRP) activities. This is striking in as much as it reinforces an emerging theme in the scoping study – low expectations. That respondents can be so impressed (and surprised) by Standard 1 students' success with reading reinforces the notion that 'the system' has limited, and hence limiting, expectations of what students are capable of.

Taken together there are two overriding themes that emerge from all the study elements: the Malawian mathematics/numeracy environment is characterised by limited and limiting expectations of students; and the focus of teaching is on form over substance.

This has profound implications for the success elements of a programme designed to improve early grade numeracy. In particular, the programme will need to shape a modernised vision of what it means to do and teach mathematics. To do so the programme will need to address expectations of what students are capable of at all levels of the education system; modernise the curriculum, assessment, and teaching practices; and, involve stakeholders from all sectors of the education system (curriculum, assessment, pre- and in-service teacher training and supervision, teachers, and school leaders). This involvement from the start will be key to the institutionalisation of the programme methodologies.

In accepting the above, it should be noted that there are also many positives that the study has revealed: classrooms are safe and happy spaces in which students are enthusiastic to participate; teachers work hard to make lessons interesting; teachers uniformly follow the teacher's guides, with the dominant pedagogy being very similar from one class to the next. This is positive in as much as it suggests that if teachers are introduced to a different methodology and provided with sufficient support, they may well be able to adapt their practice and implement the approach with enthusiasm; and, the education system is highly functional, with each directorate committed to the success of the students.

The study has also revealed that there are a number of significant structural issues that hamper progress and success. The implication of these issues needs to be considered in the development and implementation of any programme designed to improve early grade numeracy. These include, but are not limited to the following: class size and resourcing – the programme should include innovative practicable teacher management strategies to support learning in oversize mixed-ability classes; language – it is clear that having early grade students learning in Chichewa, where Chichewa is not their home language and their teacher does not speak their home language, creates challenges; textbook and exercise book provisioning -- as the programme develops teaching and learning materials, care needs to be taken to provide each student in every class with the necessary learning materials for them to be able to participate effectively in learning; and, absenteeism – as the programme develops and implements a more ambitious curriculum, measures to address persistent absenteeism will be required. Additionally, it is also recommended that effort is devoted to the setting of increased expectations, possibly in the form of clearly articulated standards/benchmarks that are grade aligned for each of the key concepts and skills in the mathematics curriculum. The setting of these standards/benchmarks should provide a clear developmental learning trajectory for students from Standard 1 through to the end of primary school and possibly beyond.

As the MoEST (with support from DFID) contemplates a programme designed to improve early grade numeracy, a key question from the outset needs to be whether this programme will focus on doing better what is currently being done – i.e. developing confidence in using the computational procedures of arithmetic more effectively. Or whether such a programme provides the opportunity of developing a modernised vision of what it means to do mathematics for Malawi: a vision of mathematics in which students experience mathematics as a meaningful, sense-making, problem-solving activity; and a vision of mathematics teaching and learning that expects students not only to know mathematics, but also to understand the mathematics they know, be able to apply the mathematics they know to solve unfamiliar problems, and be able to reason (argue) with the mathematics that they know. It is the view of the authors of this report that it would make sense to use the opportunity of an intervention programme to set a 21st Century vision for mathematics in Malawi and then to use the programme to achieve this.

The authors anticipate that a programme designed to improve early grade numeracy will include the following stages: the identification of a core group who with appropriate technical assistance and support will lead the programme; setting the vision; developing pilot materials; rigorous piloting; programme refinement; and. taking the programme to scale and institutionalisation.

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List of abbreviations

CERT	Centre for Educational Research and Training, University of Malawi
CPD	Continuing professional development
DEM	District Education Manager
DFID	UK Department for International Development
DIAS	Directorate of Inspection and Advisory Services
EGMA	Early Grade Mathematics Assessment
GDP	Gross domestic product
MIE	Malawi Institute of Education
NRP	National Reading Programme
PEA	Primary Education Advisers
PSLCE	Primary School Leaving Certificate Examination
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
TALULAR	Teaching and Learning Using Locally Available Resources
TTC	Teacher Training Colleges
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
MANEB	Malawi National Examinations Board
MoEST	Ministry of Education, Science and Technology
USAID	United States Agency for International Development

1 Background, terms of reference, and research methodology

1.1 Country context and impetus for the research

Malawi is a poor country in the world. Achieving faster economic growth in Malawi requires a stronger human capital base and a better skilled labour force to promote private sector development. Evidence suggests that the development of cognitive skills can drive individual earnings and lead to the fairer distribution of income, promoting equity, while also improving national economic growth.

Improving education is one of the Malawi Government's priority areas in its Growth and Development Strategy (2017–2022). Getting children into school is not enough: the school system needs to support children to master basic skills. The government wants more children to progress through and succeed in their schooling, so they graduate with the right skills to enable them to participate in and contribute to Malawi's workforce.

The proportion of government budget spent on education is high. Over the past five years, spending on education averaged 7% of gross domestic product (GDP), which is higher than the average for sub-Saharan Africa. The education sector in Malawi has also received the highest share of the government budget (approximately 18%) for the past three years. However, in absolute terms, government spending on education is still low: just $33 per child in primary school and $129 per child in secondary school.

The Malawi Government's investment in education is having some of the desired impact. In 2017, 89% of boys and 95% of girls enrolled in the first year of primary school, compared with just 20% in 1994. This pleasing improvement is, however, offset by significant levels of absenteeism (estimated at 35%) (Asim, S., Ravinder, G., and Wang, X., *forthcoming*); repetition (it is estimated that only 19% of students get to Standard 8 without repeating at least one year); and high dropout rates (retention for the full primary cycle was only at about 38% in 2013) (World Bank, 2016). Correspondingly, students' learning outcomes are low.

With funding from the United Kingdom and the United States, the Malawi Government is implementing the National Reading Programme to improve early grade literacy. A new curriculum has been developed and every lower primary school teacher in the country has been trained. All students in Standards 1–4 are now benefiting from a new phonics-based approach to developing literacy. This is the government's flagship programme, aimed at improving the quality of teaching.

The UK is providing funding to support the Malawi Government to improve the quality of early grade numeracy teaching, so all children are supported to learn more effectively.

To better understand the best approach to improving numeracy outcomes, the Ministry of Education, Science and Technology (MoEST) and the UK determined that there was a need to conduct a scoping exercise to better understand the key bottlenecks that are inhibiting student learning. This report is the outcome of that scoping study.

The findings of this scoping study will inform the focus of a new programme to improve numeracy outcomes for lower primary school students in Malawi.

1.2 Terms of reference

The scoping exercise intended to identify the key challenges and bottlenecks that are preventing satisfactory student performance and the improvement of teacher quality in numeracy in lower primary school (Standards 1–4).

It was recommended that the scoping work would consider the following components:

- Curriculum review of the primary school mathematics curricula and syllabuses. It was recommended that the review focus on the content and expected competency levels for learners in lower primary (Standards 1–4), and how this prepares students for upper primary (Standards 5–8) and lower secondary (Forms 1 and 2).
- Classroom observations of mathematics lessons in a range of primary schools to see the typical learning environment and teaching practices for early grades in Malawi. It was recommended that these observations focus on the pedagogical approaches used for numeracy instruction, including how teachers use teaching aids to improve students' understanding of mathematical concepts, and how teachers differentiate students and support all children, regardless of ability, to learn.
- Review of student achievement, to include an analysis of results from mathematics learning assessments, tests, and examinations conducted over the past 10 years (e.g. Monitoring Learning Achievement (MLA) tests, Primary School Leaving Examinations (PSLCEs), Early Grade Mathematics Assessments (EGMAs), and mathematics assessments from the Malawi Longitudinal Student Survey baseline).
- Review of professional development and support structures for primary school teachers, both (pre-service and in-service), to understand the current opportunities for training and upskilling teachers. It was recommended that the review also include school-based continuing professional development (CPD), coaching, and mentoring opportunities, including support offered by the inspection and advisory service. It was recommended that the review outline the remit of different professional development and support structures, and how these work in practice to improve the capacity of teachers to deliver quality mathematics lessons.
- Learning environment assessment, through school visits, lesson observations, and stakeholder interviews. It was recommended that the research assess the typical learning environment for students, including: availability of textbooks and teacher guides; classroom setup (size, pupil–teacher ratio, etc.); resources, etc. It was recommended that the assessment consider how the learning environment impacts student learning.
- Policy review of relevant MoEST policy frameworks, outlining opportunities to improve the teaching of mathematics in primary schools in Malawi. It was recommended that the study include a review of the new Student Promotion Policy (which references improving the quality of remedial education in primary schools) and the Medium of Instruction policy (and how this impacts students' learning of mathematics).

1.3 Research question(s)

The research study set out to answer the main question:

What are the key success elements of a programme designed to improve early grade numeracy?

In order to develop a response to the main research question, the research team set out to investigate:

- what the existing assessment data say about early grade numeracy performance;
- what the dominant enacted pedagogy in early grade numeracy classrooms is;
- how the existing curriculum defines expectations, standards, and pedagogical approaches for early grade numeracy;
- how the general learning environment supports (or does not support) effective learning; and
- how the existing CPD addresses teacher licensing and in-service training expectations.

1.4 Research methodology

This section describes briefly how each of the sub-questions were tackled:

What do the existing assessment data say about early grade numeracy performance?

It is generally accepted that early grade numeracy performance in Malawi is poor. There was no need to re-establish this fact. However, it was considered necessary to catalogue the assessment data that are routinely collected in Malawi and to determine the performance profiles of early grade students as revealed by in the existing data.

What is the dominant enacted pedagogy in early grade numeracy classrooms? And how does the general learning environment support (or not support) effective learning?

Notwithstanding the intentions of the curriculum, the learning that takes place in classrooms is a function of how teachers structure learning opportunities, what learning they value, and how students experience numeracy/mathematics. The research to answer this question took the form of classroom observations in a mix of urban, rural, and hard-to-reach schools.

How does the existing curriculum define expectations, standards, and pedagogical approaches for early grade numeracy?

For the purpose of this research study, ‘curriculum’ was taken to mean the various MoEST documents used to communicate the content, extent, and pedagogical and assessment approaches to be used in the teaching of early grade numeracy. In addition, the researchers also investigated how the intended curriculum is manifested in printed teaching and learning materials (e.g. textbooks etc.).

How does the general learning environment support (or not support) effective learning?

Key informant interviews were conducted with (among others): the Malawi Institute of Education (MIE), the Directorate of Inspection and Advisory Services (DIAS), the Department of Teacher Education, the Directorate of Education Planning, the Directorate of Basic Education, selected District Education Managers (DEMs), Primary Education Advisers (PEAs), Primary Inspectors of schools, deputy principals, heads of section (maths), lecturers at Teacher Training Colleges (TTCs), Chancellor College (Faculty of Education), teachers, and selected development partners (in particular Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)).

How does the existing CPD address teacher licensing and in-service training expectations?

It is expected that by far the largest component of the intended intervention programme will involve in-service teacher training for early grade numeracy teachers. Furthermore, it is also anticipated that improved pedagogy will rely on school-based support and mentoring – ideally by senior teachers and/or school leaders. Given the fact that the National Reading Programme (NRP) has already grappled with this issue, interviews with the implementers of the NRP provided insight into this question.

2 Research activity

This section of the report discusses the research activity and findings with respect to each of the guiding questions.

2.1 What do the existing assessment data say about early grade numeracy performance?

To investigate what the existing assessment data say about early grade numeracy performance the researchers studied the following reports and, where available, the associated data and survey instruments:

- Malawi Longitudinal School Survey (MLSS) Assessment (2016);
- Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) III report;
- Malawi EGMA: National Baseline Report 2010, Mathematics Education in Sub-Saharan Africa: Status, Challenges, and Opportunities;
- 2015 MLA report; and
- the Primary School Leaving Certificate Examinations from 2014 to 2018, as well as the examiners' reports for the last three years.

All these surveys, reports, and assessments confirm the view that learners in Malawi are struggling with mathematics and lagging behind where they should be, both in terms of their own learning and in relation to neighbouring countries.

The SACMEQ III data[1] show that Malawian learners perform well below the regional average, with only 1.7% of Standard 6 learners achieving ***competent numeracy*** (Level 5) and 59.9% failing to achieve even ***basic numeracy*** (Level 3).

The 2010 EGMA[2] data strongly indicate that learners are behind in their learning, with most Standard 4 students (61.8%) being confident only with Standard 2 numeracy (e.g. addition and subtraction).

The MLSS assessments were administered to Standard 4 students, and contained a mixture of items ranging from Standard 1 to Standard 4. The overall average score for mathematics was 43%, with the average score for the Standard 1 items being 50% and the average score for the Standard 4 items 33%. Of the Standard 4 students only 33% of the students could add simple two- and three-digit numbers correctly.

The purpose of this aspect of the research was not to reiterate the findings of these studies but rather to establish what further information can be gleaned from these studies to identify the key characteristics of the items that students struggled with.

Item level data were available for both the 2016 MLSS and the 2015 MLA studies. The analysis of this data is discussed in the next sections.

[1] SACMEQ III Malawi Report 2008.
[2] USAID EGMA 2010.

2.1.1 Review of the MLSS assessment data

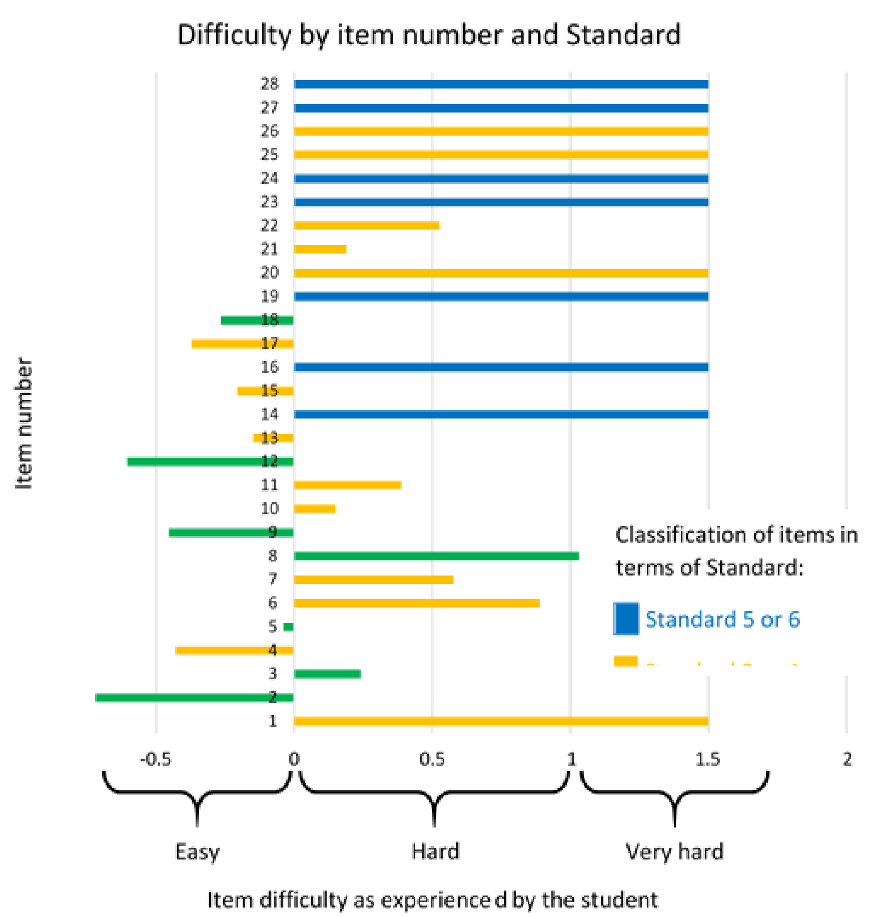
MLSS is a nationally representative survey of schools in Malawi, overseen by the World Bank. Among other things, it includes assessments of a random sample of Standard 4 students in mathematics, English, and Chichewa.

Figure 1 illustrates the experienced item difficulty for the MLSS items. Items are displayed vertically, with the first item in the test (item 1) at the bottom and the last item in the test (item 28) at the top. Items to the left of the vertical axis (i.e. those with a negative difficulty index) are items that an average Malawian student has a high probability of answering correctly; those to the right of the vertical axis are items that the average learner experiences as challenging. The items are also colour-coded by the standard[3] at which they were pitched, green for Standards 1 and 2 content, yellow for Standards 3 and 4 content, and blue for Standards 5 and 6 content. To allow all the data to be presented on a single graph the horizontal scale is truncated at +1.5[4], a value which indicates that the item is effectively beyond the ability of an average learner and even the very best learners struggle to answer the item correctly. A difficulty of zero means a question is at the ability level of the average student: that is, the average student has an even likelihood (50/50) of answering the question correctly.

[3] As defined by the original World Bank test developers in the item data, note that even though the items cover some higher (Standard 5 and Standard 6) content, the items are still only concerned with basic/emergent mathematics – presumably to check if learners could apply mathematical concepts to new situations.

[4] The MLSS data give difficulties in standard deviations rather than the more usual probability of an average learner getting the item correct. In this example, a learner has to be 1.5 standard deviations above the mean ability (i.e. in the top 6.7% of the cohort) in order to have even a 50/50 chance of getting the item correct.

Figure 1 **Analysis of MLSS items in terms of experienced difficulty and standard level of the items**



While **Figure 1** confirms, as expected, that all the Standards 5 and 6 items are outside the comfort zone of the average Malawian Standard 4 student, only four of the Standards 3 and 4 items – items 4, 13, 15, and 17 – are comfortably accessible by the average learner. Of concern is the realisation that four of the 14 (29%) Standards 3 or 4 items (yellow) – items 1, 20, 25, and 26 – are well beyond the comfort level of the average Standard 4 student. Also of concern is that one of the Standards 1 or 2 items (item 8) is beyond the average student's confidence level.

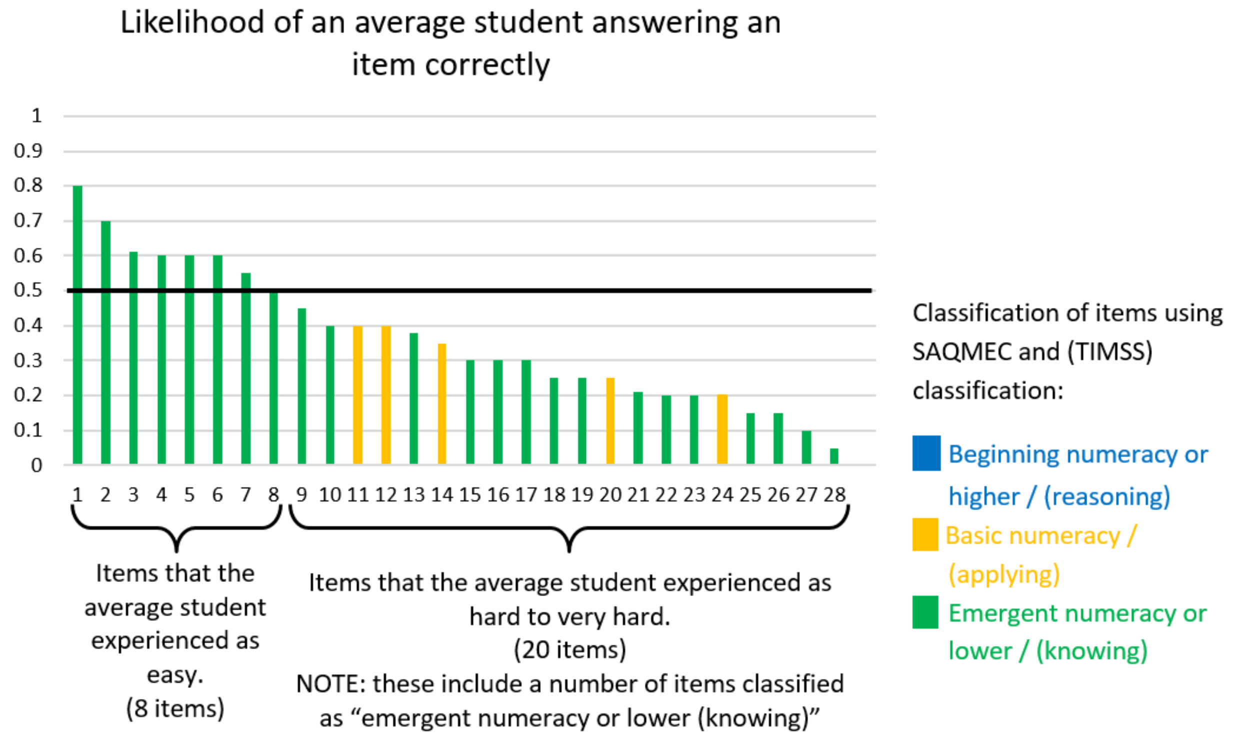
Even the very best of the students struggle to answer the Standards 3 and 4 questions correctly. Also noteworthy is that one of the Standards 1 or 2 items (item 8) is beyond the average Malawian student's confidence level.

To summarise, the data indicate that, although the majority of the items at the Standards 1 and 2 level and a few of the simpler Standards 3 and 4 items are accessible to the average Standard 4 pupil, the majority of the Standards 3 or 4 items – and, unsurprisingly, all of the Standards 5 or 6 – items are inaccessible to the average Standard 4 student.

Figure 2 provides an alternative way of looking at the item data. The graph plots the items in order of item difficulty (note: the horizontal axis shows the item difficulty ranking, not item number) against the likelihood of an average learner answering the question correctly. The items are colour-coded based on SACMEQ and Trends in Mathematics and Science Study (TIMSS) classifications[5]. The horizontal black line represents the likelihood of an average student having a 50% chance of answering the item correctly (the equivalent of 0 on the horizontal axis of **Figure 1**).

[5] Discussed later in the report.

Figure 2 Analysis of MLSS items in terms of experienced difficulty and SAQMEC/TIMSS classification



As with the **Figure 1** analysis against standard level, **Figure 2** indicates that of the 28 items only eight were accessible to the average learner (at or above the black line). It also indicates that all the items beyond the emergent numeracy classification were experienced as from 'hard' to 'very hard', and there were no items in the assessment at the higher 'beginning numeracy (reasoning)' level.

To better understand the experience of the average student, we now examine a few of the assessment items.

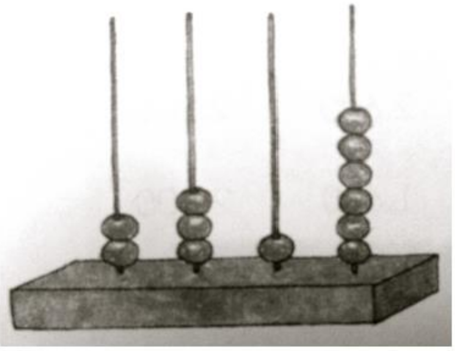
In some cases students may be struggling on account of language issues or because of the way that the question is phrased. To illustrate this, items 1 and 17 are shown in **Figure 3**. Item 1 is intended to be a simple question assessing knowledge of place value and yet students experience this item as difficult (with an index ≥ 1.5 [see **Figure 1]**), in contrast to item 17 (with an index = 0.37 [see **Figure 1**]) that uses an abacus and in so doing presents the same question in a way that is more familiar to students.

Figure 3 Items 1 and 17 of the MLSS assessment

1) Which digit is in the hundreds place 2,345? Circle the correct answer

A) 2 B) 3 C) 4 D) 5

17) Circle the answer that represents the number in the abacus below.



A) 2124 B) 1143 C) 3142 D) 2316

The item performance data indicate that when an item is presented in a less-standard format, for example as a word problem[6], the experienced difficulty increases and learners are not confident in applying their mathematical knowledge. By way of illustration, **Figure 4** compares items 2 and 11 from the assessment.

Figure 4 Items 2 and 11 of the MLSS assessment

2) Circle the result of subtracting the given numbers.

$$\begin{array}{r} 7 \\ -\ 4 \\ \hline \\ \hline \end{array}$$

A) 3 B) 5 C) 2 D) 7

11) Olive had 19 sweets and has given Kisa 6. How many sweets are remaining with Olive? Circle the correct answer.

A) 6 B) 13 C) 19 D) 25

Item 2 is experienced as very easy, with a difficulty index of -0.72. However, if the format of the question is changed, despite requiring the same mathematical operation, then the experienced difficulty increases. For item 11, the difficulty is +0.39, with only approximately 35% of average students being able to answer it correctly. There is the confounding fact that item 11 involves a two-digit number, whereas item 2 did not, but this should not be enough to increase the experienced difficulty to the extent that it does.

Overall, the pattern which emerges is that, where items go beyond procedural mathematics and where they expect students to engage with more complex expectations (for example, in Standard 4 items, such as multiplying or dividing a three-digit number or using applications), these items are

[6] This is despite the fact that the Malawian curriculum, in common with other countries, expects teaching to include the application of calculations to 'working out practical problems' and textbooks, including word problems, as a means of applying numerical calculation skills.

beyond the confidence levels of all but the very best students – and even these students find the items challenging.

2.1.2 Review of the MLA assessment data

The MLA is a national survey conducted by Malawi National Examinations Board (MANEB), DIAS and the Centre for Educational Research and Training (CERT), University of Malawi, in the subject areas of English, Chichewa, and mathematics at Standards 2, 4, and 7, designed to help policymakers determine what learners know and can do at each level, as against the expectations of the curriculum.

While the items in the MLA assessment have different score values, for the purpose of this study all items were treated as single mark items, this means that the analysis developed here may not replicate the MLA findings exactly. That said, the findings will nonetheless be broadly similar and this approach allows for better comparison with the MLSS data.

Figure 5 Analysis of MLA items in terms of experienced difficulty and SAQMEC/TIMSS classification

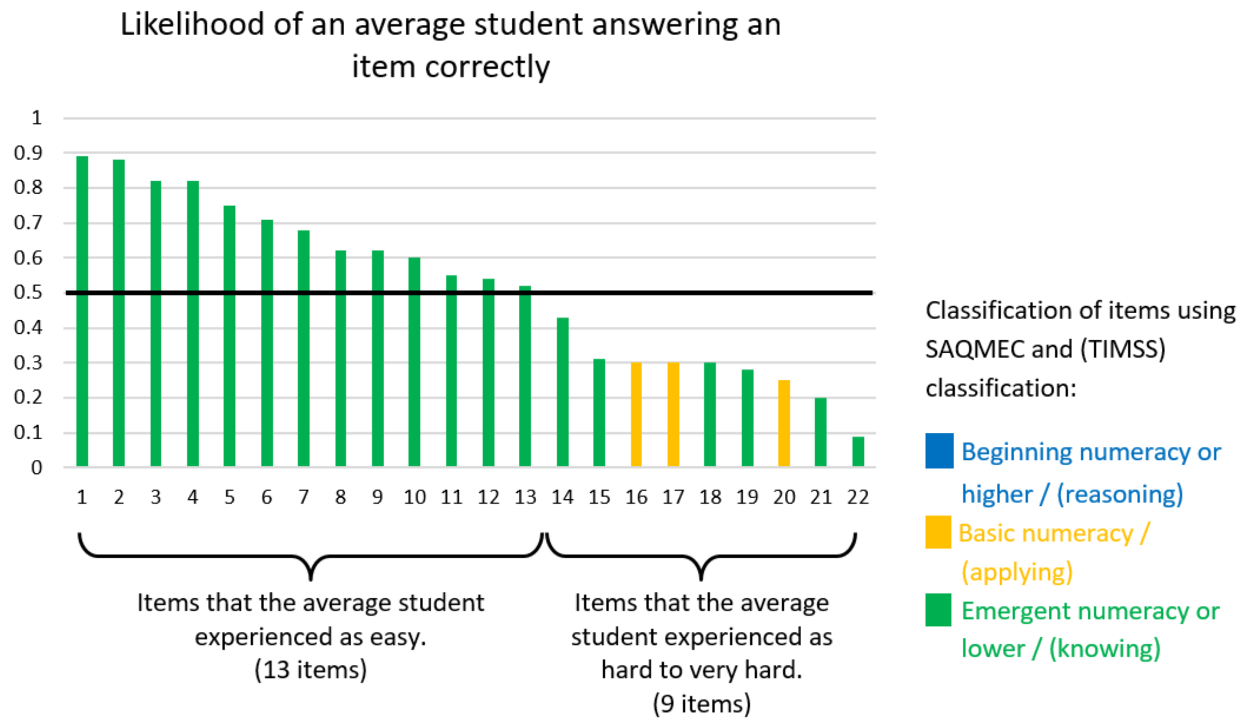


Figure 5 plots the MLA items in order of item difficulty against the likelihood of an average student answering the item correctly. The items are also colour-coded based on the SACMEQ and TIMSS classifications. In the case of the MLA assessment, the items seem well matched to learners' capabilities, with a good spread of difficulties and no items being beyond the capability of the highest performing students.

On the surface, the MLA data look more positive than the MLSS data, with 13 of the 22 items being accessible to the average student. Students, in general, seemed to perform better on the MLA items, confidently adding two three-digit numbers involving bridging (carrying) and even adding four four-digit numbers. The MLA data also suggest that 55% of students were able to perform simple multiplication involving a four-digit number (which the MLSS data suggested as being well beyond the capabilities of most students).

As with the MLSS data, studying the actual assessment items provides insight into student performance patterns. One of the reasons that students seem to score more highly on certain items of the MLA assessment is that they are highly structured and, presumably, in a familiar format (compared with some of the classroom examples later), allowing the student to apply standard well-known procedures to achieve the correct outcome. Items that require deeper understanding or application increase the experienced difficulty and appear to confuse the students.

Figure 6 Items 1, 5, and 11 of the MLA assessment

1. Wonkhetsa Nambala izi (Malikisi 6)

	H	T	O
	5	3	7
+	2	8	4
	___	___	___

5. Wonkhetsa ndalama izi (Malikisi 4)

K75 + K13 = ☐

11. Wonkhetsani nambala izi (Malikisi 6)

	TH	H	T	O
	1	4	5	1
	3	2	3	9
	2	3	2	4
+	1	9	7	1
	___	___	___	___

To illustrate the point, **Figure 6** compares items 1, 5, and 11 from the assessment. When an item is presented in a familiar way (e.g. items 1 and 11), in the case of item 1, despite the item involving three-digit addition with bridging (carrying), 75% of the Standard 4 students answer the question correctly. Even in the case of item 11, which on the surface of it appears to be harder – involving the addition of four four-digit numbers with bridging (carrying) – 70% of the Standard 4 students answer the question correctly. However, even if the item is structurally simpler in terms of mathematical demand but presented in a less familiar format, the experienced difficulty increases dramatically, and many students struggle to answer the question correctly. For example, item 5, which involves the addition of two two-digit numbers (without bridging/carrying) should, when compared with the mathematical demand of items 1 and 11, be accessible to the majority of Standard 4 learners. However, only 54% of students answer the question correctly.

This brief item analysis clearly illustrates that students are not able to apply their mathematical knowledge in a meaningful way and rely on rote learnt methods that are only applicable in limited and familiar situations.

2.1.3 PSLCE

The PSLCE is the main high-stakes school examination. Unfortunately, no data were available (and there were no average scores or percentage pass rates) and so comparable quantitative item analysis could not be performed. Only the qualitative information from the examiners' reports was available, alongside the items themselves.

Each of the annual examiners' reports for the PSLCE studied state that candidates can only cope with questions concerning recall, and they fail to answer questions that rely on applying mathematical concepts. All the reports also say that students demonstrate poor mastery of the curriculum. Furthermore, they also report that learners struggle to understand mathematical language: for example, knowing that *lustrum* refers to a period of five years[7].

The examiners' reports also provide some insight into how and why students are struggling. For example, in a question requiring learners to find the highest common factor many candidates found the lowest common multiple, suggesting that they are unsure of which mathematical knowledge to use and, unless they are clearly told, they guess at the appropriate procedure needed to answer a question – in this instance, knowing that the three numbers have a commonality and then guessing which process to apply, rather than understanding the mathematics. Similarly, in some of the questions involving fractions it would seem that candidates apply a random assortment of procedures in the hope of producing an answer, rather than demonstrating any understanding the mathematics.

In terms of question demand, these papers seem much more balanced than the other assessments, asking a higher proportion of application questions but still no reasoning. For example, the 2018 paper has 17 questions assessing knowledge and 21 assessing application. The absence of any higher order skills is unsurprising as the examiner reports state that the intention is only to assess knowledge and application.

When analysed in terms of the SACMEQ classification it is encouraging to see items assessing beyond the basic numeracy level, with some items assessing at the 'mathematically skilled' level. However, the reports indicate that these items are beyond the performance levels of most candidates and are rarely answered correctly.

2.1.4 Discussion

The analysis has shown that the Malawian assessments have, at best, a limited (and by extension, limiting) expectation of what students should be able to do. If we compare these assessments with the benchmarks set by two international assessments, the expectations of the Malawian assessments (in particular, the MLSS and MLA) fall well below the benchmarks.

SAQMEC and TIMSS

SACMEQ describes mathematical competency in terms of eight levels. Given that SACMEQ is designed specifically for the region and that Malawi participates in SACMEQ, the assessment

[7] This does, however, seem to be a strange example of specific mathematics language to examine as the word is not expressly included in the Malawian syllabus, although it is mentioned (albeit misspelled) in the Standard 7 Teacher Guide.

framework provides a relevant basis for analysis. In an effort to provide a wider international comparison, TIMSS, which also assesses at the equivalent of Standard 4, is also included here as a basis for analysis.

In terms of the content expectations both SACMEQ (Ross *et al*. 2004) and TIMSS (Mullis 2013) broadly align with the curriculum content of the Malawian curriculum. In the case of SACMEQ this is no surprise as part of SACMEQ's development involved a curriculum mapping exercise with all member states (of which Malawi is one). A review of the TIMSS content shows that all the items on the MLSS and MLA Standard 4 assessments are listed in the TIMSS content framework.

The issue with the Malawian assessments is not so much what is covered in terms of content, but rather how it is covered, and what is expected of the learners.

In addition to describing content expectations, the SACMEQ assessment framework describes various levels of mathematical competency in terms of what students are able to do with the mathematical content (knowledge), including the flexibly and confidence with which they can do it. **Table 1** sets out the SACMEQ achievement levels and the associated description.

Table 1 SAQMEC achievement levels

Level	Skill/ competence	Description
1	Pre-Numeracy	Applies single-step addition and subtraction.
2	Emergent Numeracy	Applies two-step addition and subtraction involving carrying.
3	Basic Numeracy	Translates verbal information into arithmetic operations using one arithmetic operation.
4	Beginning Numeracy	Translates verbal information into arithmetic operations and uses multiple mathematical operations in the correct order.
5	Competent Numeracy	Translates verbal, graphic, or tabular information into an arithmetic form in order to solve a given problem.
6	Mathematically Skilled	Solves multiple-operation problems (using the correct order) involving fractions, ratios, and decimals.
7	Concrete Problem-Solving	Extracts and converts information from tables, charts, and other symbolic presentations in order to identify, and then solve, multi-step problems.
8	Abstract Problem-Solving	Identifies the nature of an unstated mathematical problem embedded within verbal or graphic information and then translates this into symbolic, algebraic, or equation form in order to solve a problem.

Neither of the Malawian assessments analysed (MLA or MLSS) assess above Level 3 Basic Numeracy on the SAQMEC scale. The PSLCE does have some items assessing Levels 4 to 6 (Beginning, Competent, and Skilled Numeracy) but the examiners report that very few students are able to respond successfully to these items.

The TIMSS Assessment Framework also helps to define what it means to achieve in mathematics. It does so not only in terms of the content domain but also in terms of what students should be able to do with that content. TIMSS defines three cognitive levels: knowing, applying, and reasoning.

Knowing is defined as '*a facility in applying mathematics, or reasoning about mathematical situations, depends on familiarity with mathematical concepts and fluency in mathematical skills*'. The important part of this definition is that knowing also covers basic applying of mathematics in a rote manner. Being able to use a mathematical concept in a familiar context counts as knowledge rather than applying.

Applying involves '*the application of mathematics in a range of contexts. In this domain, the facts, concepts, and procedures as well as the problems should be familiar to the student. In some items aligned with this domain, students need to apply mathematical knowledge of facts, skills, and procedures or understanding of mathematical concepts to create representations. Representation of ideas forms the core of mathematical thinking and communication, and the ability to create equivalent representations is fundamental to success in the subject. Problem-solving is central to the applying domain, with an emphasis on more familiar and routine tasks*.'

While some of the MLSS and MLA items analysed could be classified as 'applying', they do so, at best, at the lower end of the spectrum.

In TIMSS, reasoning mathematically involves '*logical, systematic thinking. It includes intuitive and inductive reasoning based on patterns and regularities that can be used to arrive at solutions to problems set in novel or unfamiliar situations. Such problems may be purely mathematical or may have real-life settings. Both types of items involve transferring knowledge and skills to new situations; and interactions among reasoning skills are usually a feature of such items*.'

None of the MLSS and MLA items analysed could be classified as 'reasoning'.

In most cases the SACMEQ levels and the TIMSS cognitive domains represent similar expectations, albeit that they are phrased differently. Very roughly, *Beginning Numeracy* in the SACMEQ levels reflects *Reasoning* in the TIMSS framework. While this is not a precise match, because each of these is a multi-dimensional construct, it is sufficiently close for the purpose of this report. The correlation between basic numeracy and applying is less clear in as much as some of the expectations for basic numeracy (e.g. the ability to translate written or verbal information into arithmetic operations) only require the use of one arithmetic operation in a familiar context, and so would be considered knowing under TIMSS. However, in this sample of items only two items fall into this borderline category so they are still grouped together here to aid easy interpretation.

Table 2 maps the MLSS and MLA items against the item distribution proposed by TIMSS. What is clear from the MLSS and MLA assessments is that, when the items are mapped onto the TIMSS (or SACMEQ) framework, the expectations fall well below the expected distribution for Standard 4 students.

In all the items (both from MLSS and MLA) less than 20% of items are assessing at or beyond either basic numeracy (SACMEQ) or applying (TIMSS), and none of the items are assessing any form of competent numeracy or even beginning numeracy (SACMEQ), i.e. reasoning skills (TIMSS).

Table 2 Comparison of the cognitive demand of the MLA and MLSS item distribution with the TIMSS expectation for Standard 4 students

Level	TIMSS	MLA	MLSS
Knowing	40%	86%	82%
Applying	40%	14%	18%
Reasoning	20%	-	-

To illustrate how learners respond to items that are at the knowing and applying levels, we can consider items from both the MLA and MLSS assessments that deal with number sequences and illustrate how, as the complexity increase, the students' ability to respond correctly decreases.

Completing missing numbers in a number sequence is an item type that is often used to explore understanding of numeracy and allows an element of problem-solving to be introduced. Can students recognise patterns and determine the mathematical relationship(s) between the elements of the sequence? In the MLSS and MLA assessments only basic numerical sequences are assessed. Even so, even where the pattern is still simple, most of the students are not able to apply their mathematical knowledge. **Figure 7** illustrates three items from the MLSS and MLA assessments. The first and third items are from the MLSS assessment, while the second item is from the MLA assessment.

Figure 7 Pattern completion items from the MLSS and MLA assessments

9) Circle the missing numbers.

9	**8**			**5**	**4**

A) **10, 11** B) **7, 6** C) **7, 2** D) **11, 10**

9. Lembani nambala zoyenera m'malo momwe mulibe. (Malikisi 2)

4500, 5000, ________, 6000, 6500, __________

26) Circle the missing number in the following pattern.

30		90	120	150

A) 50 B) 60 C) 600 D) 40

The first item in **Figure 7** requires students to recognise the numbers 1–10 in reverse order. 61% of the learners in the sample could answer this question correctly. Although the result is encouraging, it should be noted that for Standard 4 students this item should be very accessible. The next example could at first seem to be harder because the numbers involved are four-digit numbers. That said, in reality the pattern is very obvious and there is no real need for understanding or reasoning and it follows that the majority of the sample, 62%, could answer this question correctly.

In both these cases it could be argued that students have to apply some reasoning to identify the missing numbers, but in reality this is simple application of mathematics or reasoning about mathematical situations and would still be classified as knowing within the TIMSS classifications.

When in the third item (in **Figure 7**) the sequence expects student to determine the mathematical relationship between the elements of the sequence, even though the relationship is relatively obvious (a step size of 30) the experienced difficulty increases significantly. Less than 25% of the sample could correctly determine the missing number.

Even though this item is essentially testing 'knowing' for students who are confident with and can apply their mathematical knowledge, it could also be argued that when students are unfamiliar with this type of item they first need to decode the information to understand the question, and then, depending on how they approach the question, apply several mathematical operations to get to the answer. It is probably for this reason that many of the students struggled with this item.

> The way in which students are being taught mathematics does not foster understanding or encourage them to apply their knowledge in unfamiliar contexts.

2.1.5 Conclusion

A key question raised by this analysis is whether these assessments determine the expectations or reflect them. If the monitoring assessments have such low expectations, it is unlikely that teaching and learning will progress beyond these limited aspirations.

2.2 What is the dominant enacted pedagogy in early grade numeracy classrooms? And how does the general learning environment support (or not support) effective learning?

To investigate the dominant enacted pedagogy in early grade numeracy classrooms, the research team conducted classroom observations in 51 classrooms across 16 schools over a period of two weeks. The school districts were identified in cooperation with DIAS and the schools in each district with the support of the DEMs. The aim was to select a broad range of schools from urban to rural and remote, and across the performance spectrum (as determined by the DEMs). **Table 3** summarises the characteristics of the schools and classrooms observed

Table 3 Profile of schools and classrooms visited during the classroom observation study

		School performance		
		Low	Average	High
School location	Urban	4 schools 2 × Std. 1; 2 × Std. 2 2 × Std. 3; 2 × Std. 4	-	2 schools 3 × Std. 1; 1 × Std. 2 3 × Std. 3; 1 × Std. 4
	Rural	2 schools 2 × Std. 1; 2 × Std. 2 2 × Std. 3; 2 × Std. 4	4 schools 3 × Std. 1; 3 × Std. 2 3 × Std. 3; 2 × Std. 4	-
	Remote	4 schools 3 × Std. 1; 5 × Std. 2 4 × Std. 3; 4 × Std. 4	-	-

For each classroom observation the researchers used a standard observation tool developed specifically for this study (see **Annex A**) that captured data on the following:

- the classroom facilities, including the number of students (present and enrolled) and desks;
- the availability and use of student resources (notebooks, pens/pencils, and textbooks);
- the evidence and use of teacher planning materials (lesson plans, teacher guides, and textbooks); and
- the classroom culture:

  - cognitive demand of the classroom activities (computing, understanding, applying, and reasoning);
  - evidence of differentiated instruction or lack thereof;
  - use of teaching resources;
  - general classroom atmosphere; and
  - language use.

In addition, the researchers collected data at three-minute intervals throughout each lesson. The purpose of the observations was to develop a description of the 'typical' Malawian early grade (Standards 1 to 4) numeracy lesson. These regular observations focused on:

- teacher activity;
- student activity;
- teacher questioning;
- student questioning;
- cognitive demand; and
- language use patterns.

2.2.1 Summary of classroom observations

Class size

In the interviews with stakeholders much was made of class size and the teacher–student ratio (see Section 2.4). **Table 4** summarises the class sizes observed in terms of three categories determined in relation to the reported national average class size of 70 students per class (*Type 1*: up to 70 students; *Type 2*: 71 to 140 students; and *Type 3*: more than 140 students). The table also reports on the number of each of the classes that had adequate seating and/or no seating or inadequate seating for the number of students in the class.

Table 4 School performance by class size by type

			School performance		
			Low	Average	High
School location	Urban	Type 1: (students ≤ 70)	-	-	3 (3;0)
		Type 2: (70 < students ≤ 140)	2 (0;2)	-	5 (2;3)
		Type 3: (students >140)	6 (0;6)	-	-
	Rural	Type 1: (students ≤ 70)	5 (4;1)	1 (1;0)	-
		Type 2: (70 < students ≤ 140)	3 (2;1)	5 (3;2)	-
		Type 3: (students >140)	-	5 (0;5)	-
	Remote	Type 1: (students ≤ 70)	8 (1;7)	-	-
		Type 2: (70 < students ≤ 140)	8 (2;6)	-	-
		Type 3: (students >140)	-	-	-
Key: a (b;c) a = the number of classes in the category					

b = the number of classes with adequate seating
c = the number of classes with no seating or inadequate seating

Availability of resources

Table 5 summarises the observed availability of student resources, while **Table 6** summarises the observed availability of, and use of, teacher's teaching and planning materials.

Table 5 Resources available to the students in observed classes

	All/nearly all students in the class	> 50% of the students in the class	< 50% of the students in the class	None of the students in the class
Textbook	-	8%	14%	78%
Exercise book	73%	17%	10%	-
Pen/pencil	75%	17%	8%	-

Table 6 Use of teaching resources in observed classes

	Evident and used	Evident	Not evident
Teacher guide	-	-	100%
Textbook	18%	6%	76%
Lesson plan	43%	39%	18%

Classroom management and atmosphere

Table 7 summarises the observations with regard to classroom management and atmosphere for the 51 classrooms observed.

Table 7 Classroom management and atmosphere characteristics for the observed classes

With regard to the students, the teacher:	
Treats all the students the same	98%
Provides differentiated support according to student needs	2%
Provides different explanations for different groups of students	-
With regard to teaching resources (teaching aids), the teacher:	
Does not use resources	30%
Uses resources effectively to support concept development	28%
Uses resources but the link to concept development is unclear	42%
With regard to classroom atmosphere:	
The teacher creates a calm and safe space for learning	90%
A lot of time is spent on disciplining students	2%

When a student makes a mistake, the teacher reprimands or punishes the student	2%
When a student makes a mistake, the teacher encourages the student to try again and/or moves on to another student	73%
When a student makes a mistake, the teacher asks a clarifying question or breaks down the task as appropriate	2%

Lesson characteristics

Based on the observations recorded every three minutes a clear pattern of the ‘typical’ Malawian early grade (Standards 1 to 4) numeracy lesson emerged. **Figure 8** provides a summary of the teacher actions, student actions, and teacher questioning patterns based on the observations made in the 51 classrooms during this research activity. The bold lines represent the dominant observed activity at each time interval, while the faint lines represent the next most frequently occurring activity (provided that the activity was observed in at least 25% of the lessons in that time interval).

The detailed three-minute observations also recorded student questioning patterns, the cognitive demand of the lesson activity, and the language being used. In the case of student questioning, the pattern was very clear: students did not ask questions. With regard to the cognitive demand of the lesson, all lessons focused on low cognitive-demand activities (typically calculating). Finally, in terms of the language use pattern, in general all of the lessons observed were in Chichewa, with teachers and students typically switching to English for number names and some of the arithmetic operations (e.g. the words ‘add’, ‘subtract’, ‘equals’ etc.).

What is evident from **Figure 8**, and what was striking throughout the observations, is that the lessons all followed a very similar pattern across classes and grades. Typically:

- The lesson started with the teacher writing the lesson title in full on the chalk-board – the title linked the lesson to the national curriculum. During this time the students sat still and watched.
- Next, the teacher explained the meaning of the lesson title and asked students to repeat in chorus (chanting) after the teacher.
- The teacher then explained or demonstrated a procedure, leading students to contribute chanted responses (answers) to questions about each of the steps within the procedure.
    - Throughout the observations and across the grades, students were noticeably eager to contribute answers to the teacher’s questions. Typically, 70% to 80% of students raised their hands and pleaded enthusiastically for the opportunity to answer the question.
- The teacher then set a similar example for the students to complete – either individually or in ‘groups’.
    - In the observations where the question was set as a group task (irrespective of group size [five to six students or 20–25 students]), only one student in each group wrote the question down, and while one or two other students occasionally commented on what was written, in general, the majority of the group observed what the lead student was doing, making no meaningful contribution to the group task.
- After reviewing the example with the whole class, the teacher then set two or three examples for the students to complete individually. Students worked on these examples in their workbooks and the teacher walked around the class, monitoring the students working and marking their work.

- During this time students did not collaborate. They worked individually and did not compare their work with others.
- Teachers marked students' work with a large red tick, often writing '*Good*' if the student's answers were correct. While some of the teachers marked questions one at a time, enabling the teacher to pick up errors/misconceptions as they occurred, the vast majority of the teachers only marked a completed set of questions. Typically, students' exercise books were returned to the student unmarked if the student's work was not correct, with only a very small proportion of the teachers observed offering any guidance or further explanation if a student had made an error.
- In each observed class there were a significant proportion of students who did not participate in this part of the lesson.

Figure 8 **Teacher actions, student actions, and teacher questioning patterns observed in the early grade (Standards 1 to 4) numeracy lessons**

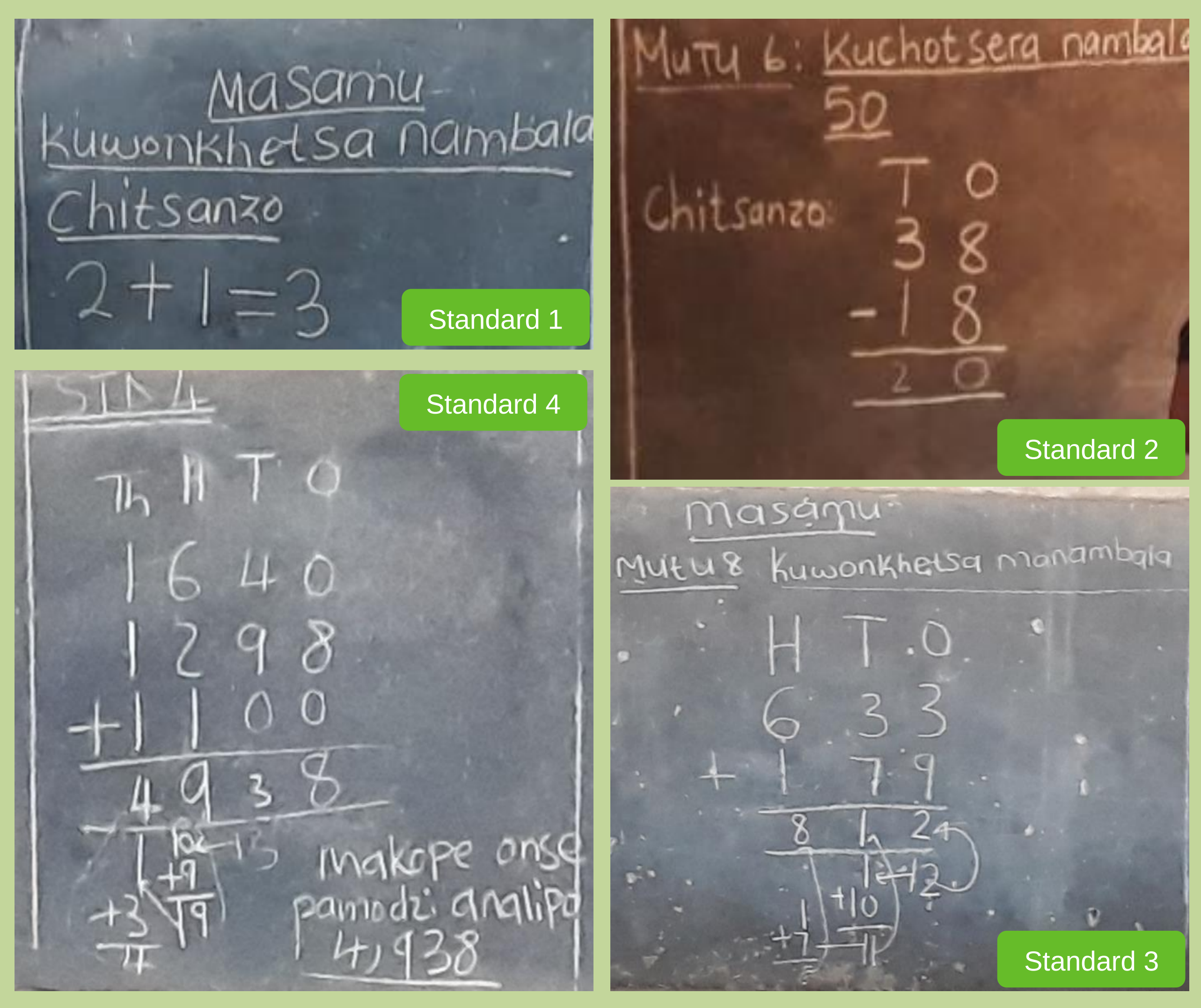
Lesson content and methodology

The Malawian national curriculum teacher guides sequence the mathematics content in units for each standard. The order of each of the mathematical topics for each standard is very similar. On account of this sequencing, and because all of the observed teachers were keeping pace with the sequence and timing of the units in the guides, all of the lessons observed in the research dealt with the same content area: calculations with numbers. In almost all of the cases the calculations were either addition or subtraction, although in a few of the Standard 4 classes division and multiplication were also observed. This coincidence allowed for an interesting insight into the way in which students are being taught to calculate with numbers across Standards 1 to 4.

Figure 9 illustrates the teachers' demonstration of the calculation that was the subject of an observed lesson for each of the four standards. The curriculum focus of the lessons, by standard, was:

- Standard 1: 'Addition with numbers not exceeding 5';
- Standard 2: 'Addition and subtraction of numbers within the range of 0 to 50 without regrouping';
- Standard 3: 'Addition and subtraction of three-digit numbers with regrouping'; and
- Standard 4: 'Addition and subtraction of four-digit numbers with regrouping' (The reader will notice that there is an error in this calculation).

Figure 9 Calculation strategies across the standards



What **Figure 9** is unable to convey is the calculation strategy used to complete the calculations across the standards. Across the observations, irrespective of standard, the researchers observed how teachers uniformly demonstrated a calculation strategy that involved the use of counters. Lesson by lesson and calculation by calculation the researchers observed the same script (procedure) playing out in each of the classes:

- For each column in the calculation, the teacher would point at the number in the top row of the column and ask: ‘What is this number?’ This was followed by some interaction between the teacher and the class that involved chanting the number.
- Next the teacher would use resources (stones, leaves, twigs, bottle tops, spike abacus, place value box, etc.) to count out (with the students chanting in unison) the number of counters that correspond to the number in the top row.
- Then the teacher would point at the number in the next row of the column and ask: ‘What is this number?’ This was again followed by some interaction between the teacher and the class that involved chanting the number.
- Next, the teacher would use the same resources to count out the number of counters (with the students chanting in unison) that correspond to the number in the next row. In the case of addition the teacher would make a new pile, in the case of subtraction the teacher would count

the counters from the pile of counters that had already been counted (for the number in the top row).

- Then the teacher would, in the case of addition, count (with the students chanting in unison) the number of counters in the two piles, and, in the case of subtraction, count (with the students chanting in unison) the remaining counters in the pile.
- Finally, the teacher wrote the counted out number at the bottom of the column and (in the case of Standards 2 to 4) moved to the next column in the calculation whose numbers were added or subtracted in the same way without regard to their values as 'tens' or 'hundreds'.

At the risk of highlighting what may already be self-evident, the key implication of this script is that students in Standards 2 to 4 are not, in reality, calculating with two-, three- and four-digit numbers, but are, in effect, performing two, three and four sets of single-digit arithmetic. Granted, in Standards 3 and 4, they need an additional procedure for bridging tens (more colloquially referred to as 'carrying' or 'borrowing' or regrouping). That said, the bridging procedure taught in Standards 3 and 4 in effect reduces the situation to single-column arithmetic.

What the description of the script does not convey is the classroom atmosphere. The energy and enthusiasm with which the script/routine was carried out was striking to the researchers. When asked what the number the teacher was pointing to was, at least 70% to 80% of the students in the class would enthusiastically put their hands in the air hoping to be the one selected to answer the question. And when a child was selected and they answered the question correctly the whole class would typically clap or sing a chant to praise the student. When the teacher was demonstratively counting out the counters, the whole class enthusiastically counted along in unison. The atmosphere was striking in terms of the energy that the teacher used and that the students echoed.

2.2.2 Discussion

The classroom observations have demonstrated quite clearly that there is a dominant enacted pedagogy in early grade numeracy classrooms. The positive point to take away from this is that teachers follow the curriculum and teacher guides: they all appear to follow a standardised classroom routine and do so very faithfully. This is positive in as much as it suggests that if there were a change in curriculum and/or shared understanding of the optimal classroom routine, then teachers, with appropriate training and support, might be able to respond and implement the new vision. However, it is the opinion of the researchers that the dominant enacted pedagogy and learning environment does not support effective learning.

Focus on procedures and use of inefficient calculations strategies

The focus on routines and procedures without any attention to understanding, application, and reasoning is of concern. That Standard 4 students are in effect performing calculations in the same way as Standard 1 students is inappropriate. It is this focus on teaching procedures that gives rise to the observations made in the analysis of the assessment data – in particular, that students are not able to apply their mathematical knowledge in a meaningful way. If the assessment item does not conform to the students' standard representation of the mathematical concept they are unable to apply what they do know to make sense of the unfamiliar situation.

Of equal or greater concern is the calculation strategy that students are using when performing the addition and subtraction procedures. As has been clearly demonstrated, irrespective of the number of digits in the numbers involved in the addition and subtraction calculations, the calculations are reduced to multiple single-digit calculations and those single-digit calculations are, in turn, performed using counters and a ‘counting all’ strategy.

The Early Numeracy Research Project (Australia) Learning and Assessment Framework (Gervasoni *et al*. 2002) describes expectations (‘Growth points’) of students in terms of increasingly sophisticated calculation strategies for performing addition and subtraction. **Table 8** lists the different levels and provides a brief description of each level. These levels apply to students in Standards 1 to 4. What is of striking concern is that Standard 4 students in Malawi are only using one of the lowest-level strategies for performing addition and subtraction – the Level 1 **counting all** strategy. While the Level 1 **counting all** strategy is an important foundational strategy appropriate for, say, Standard 1, it is not appropriate for the number ranges associated with Standards 2 and beyond.

Table 8 Strategies for addition and subtraction

Level	Name	Description
0	**Not apparent**	Not yet able to combine and count two collections of objects.
1	**Count all** (two collections)	Counts all to find the total of two collections.
2	**Count on**	Counts on from one number to find the total of two collections.
3	**Count back/count down to/count up from**	Given a subtraction situation, chooses appropriately from strategies including count back, count down to, and count up from.
4	**Basic strategies** (doubles, commutativity, adding 10, tens facts, other known facts)	Given an addition or subtraction problem, strategies such as doubles, commutativity, adding 10, tens facts, and other known facts are evident.
5	**Derived strategies** (near doubles, adding 9, build to next ten, fact families, intuitive strategies)	Given an addition or subtraction problem, strategies such as near doubles, adding 9, build to next 10, fact families, and intuitive strategies are evident.
6	**Extending and applying addition and subtraction using basic, derived, and intuitive strategies**	Given a range of tasks (including multi-digit numbers), can solve them mentally, using the appropriate strategies and a clear understanding of key concepts.

In all the classrooms observed, there was no evidence of students being encouraged to develop mental arithmetic skills for addition, subtraction, multiplication, or division. There was no evidence that students are expected to develop familiarity with or knowledge of number bonds (within a number range appropriate to their standard). The researchers witnessed no instances of completing and bridging tens; doubling and halving; adding to or subtracting from multiples of 10; adding and subtracting 10; and/or using 10 - 1 or 10 + 1 to support calculations involving 9 and 11 respectively. Even in the case of calculations involving counters and counting all, students were not even encouraged to ‘count on’.

Students need to be developing more age, grade (standard), and number range appropriate and efficient ways of calculating – and more generally of working with numbers.

Teachers' lesson plans

The teachers' lesson plans, where available (in more than 80% of observed lessons – see **Table 6**), indicated conformity with the format of the national curriculum documents and teacher's guide. They uniformly outlined the lesson and lesson stages; these included: defining the topic to be addressed; the success criteria; and the teaching strategies to be adopted. All of the plans reviewed by the researchers included a declaration of the learning objectives in terms of the curriculum but not in terms of the student skills which would be necessary for students to be able to participate in the lesson.

The lesson methodology was expressed in the same terms as the national curriculum and often repeated the guidance suggested in the guidelines. The phrase '*Discuss with pupils* …' under the column for methodology was universally included but none of the observed lessons included any discussion or negotiation about meaning. The time allocated in the lesson plan for '*Discuss with pupils* …' was used by the teachers to explain and/or demonstrate to students the way to perform the procedures needed to complete the calculation.

In summary, teachers seem to be preparing lesson plans for review by their head teachers or section heads, albeit that these lesson plans are more formulaic than thoughtful – much in the same way that students are performing calculations by following procedures, without much thought regarding the meaning of what they are doing. That said, glancing through the lesson plan books there was some indication that teachers are not preparing lesson plans for every lesson, but rather for those occasions when they need to hand in their planning books for inspection and/or when a visitor comes to the school.

Student exercise books

As **Table 5** reports, the vast majority of students in almost all of the observed classes had exercise books in which to write. When asked to take out their exercise books to complete the calculations set by the teacher almost all of the students were able to take out a book and writing implement and to do the work set by the teacher.

In many classes a lot of time was lost with students first copying out the lesson title and curriculum objective from the board before they started working on the work set by the teacher. Of course, it could be argued that the lesson title and curriculum content are important if students are to review the work in their exercise books. Nevertheless, closer inspection of the workbooks revealed that the workbooks are, in the main, not a systematic record of work completed by the students. When asked to work in their workbooks students typically searched in the exercise book for any available blank area to write on and completed the task there, with the consequence that the workbooks are not a useful record of activities and work. To add to this inefficiency, and possibly on account of exercise books and writing materials being costly items for some parents, many pupils were observed using old exercise books obtained from older siblings. By way of illustration, a set of Standard 3 addition calculations could easily be bookended by lesson notes on the human reproductive system on one side, and a list of countries of the world on the other.

Having exercise books is necessary but not sufficient: the exercise books need to provide a record of learning that can be used by the student to reflect on and revise from.

The impact of the TALULAR policy

The Teaching and Learning Using Locally Available Resources (TALULAR) policy encourages teachers to use locally available resources to support teaching and learning. This policy has been well adopted by teachers. In almost all of the lessons observed (70% see **Table 7**), the researchers witnessed teachers using resources (stones, leaves, twigs, berries, bottle tops, spike abacus and place value boxes etc.) for making the numbers in the calculations and counting, etc. In many lessons it was also clear that teachers deliberately used a range of different resources in the lesson. In one lesson in particular, the teacher was observed using small stones to count out the numbers in, and to perform, the first calculation. For the second calculation she used bottle tops and for the third calculation she used leaves.

In the opinion of the researchers, however, in almost one-half of the lessons in which resources were used as described, they detracted from the subject of the lesson rather than adding clarity or facilitating understanding (42%, see **Table 7**). During one particular Standard 3 lesson in which the teacher was demonstrating a three-digit subtraction problem, she pointed to the 7 in the top row of the tens column and, with all the customary associated student chanting, counted out seven bottle tops; she then pointed to the 3 in the bottom row of the tens column and removed three bottle tops from the pile of 7. She then asked 'How many remain? How many bottle tops remain?' Many students in the class shouted out 'four' and it was clear that most if not all of the students in the Standard 3 class knew that the answer was four, but still the teacher said 'let us check'. Then, with the students chanting along in unison, she demonstratively counted out the remaining counters: 'one … two … three … four' and wrote the numeral 4 below the 3 in the bottom row of the tens column, before proceeding to the hundreds column.

In the case of the Standard 3 class, and for most (if not all) of the Standards 2 to 4 classes, we would expect students to know that 3 subtracted from 7 leaves 4. This should be a well-established mathematical object for students: there should not be a need to reconstruct this from first principles using counters. That said, the researchers got a strong sense that teachers felt pressured, first, to use physical (concrete) objects to reconstruct the calculation and, second, to use a wide range of objects/resources. In short, the impression was that the teachers were more concerned with performing the procedure rather than the value (if any) of doing so.

Inclusion

All classes are typically expected to have students at different developmental levels. In general, the larger and the more senior the class, the greater the developmental range of the students in the class. Of the classes observed in this research more than 65% had more than 70 students in a class and one-third of these had more than 140 students in the class (**Table 4**). Furthermore, it was observed that in general the larger classes were also the classes with no or inadequate seating. What is quite clear is that long before they can address the range of developmental levels among the students in their classes, Malawian teachers face significant logistical challenges with large classes, which in many cases do not have adequate furniture for the students in the class.

Against this background, and aware of the challenges faced by teachers, it seems almost inappropriate to draw attention to the lack of differentiation and/or inclusion that was evident in most (if not all) classes. That said, it cannot be ignored that there were many students who were not participating in class at anything beyond the teacher-student chanting level.

In the case of exercise books, it was observed that if students did not have an exercise book, the teachers simply ignored them during the 'individual' work stage of the lesson and they sat doing nothing. As already described, in those classes where 'group work' was used by the teacher to have students do a parallel problem to the one demonstrated by the teacher, typically only one student in each group wrote down and did the calculation, while the others sat around doing nothing. All this is to report that, quite apart from their ability to participate or not on account of their developmental levels, there were many instances of a sizeable number of the students in a class sitting and doing nothing for substantial portions of each lesson.

In addition to the above, it should also be noted (**Table 7**) that in 50 of the 51 classes observed teachers treated all of the students the same and the researchers saw no evidence of teachers making any attempt to provide differentiated support according to the developmental needs of the students.

While providing differentiated instruction in large classes is indeed a challenge, there is nonetheless a need for teachers to be able to identify the students requiring remedial support, and mechanisms to provide this, even if those mechanisms involve exploring the use of outside of class opportunities (e.g. afternoon classes; holiday camps etc.). There is a need to provide support for teachers to adopt an inclusive approach that uses simple strategies to ensure all students are participating.

Classroom atmosphere

Notwithstanding the concerns raised about the pedagogy and lack of cognitive demand that characterised the majority of lessons observed, there were a number of features of the lessons that are deserving of mention. When asked to describe the classroom atmosphere, it is noteworthy that the researchers in all but one case indicated that the ‘teacher creates a calm and safe space for learning’ (**Table 7**), and in that other case they observed that the teacher spent a lot of the lesson ‘disciplining students’. This is significant. In all the classroom observations there was no evidence of teachers performing corporal punishment on the students, or of the presence of any instruments (canes, sticks or belts) that might have been used in the execution of corporal punishment. The researchers have experience of classroom observations in other African countries and this is not the norm.

In reporting how teachers dealt with student errors – a potentially powerful indicator of classroom culture – the researchers noted only one instance of a teacher who reprimanded the student(s) and in the vast majority of cases noted that the teacher either ‘encouraged the student to try again and/or moved on to another student’ (**Table 7**). Sadly, there were also few instances where the teacher responded to a student’s mistake by ‘asking a clarifying question or breaking down the task as appropriate’. While it would have been good to see more of the latter, the generally supportive classroom atmosphere is encouraging.

This generally supportive classroom atmosphere was also manifested in the enthusiasm with which students responded to the teachers’ questions and participated in the lessons, as previously mentioned.

Clearly, a supportive classroom atmosphere is not enough to ensure success and performance in numeracy, but it is a necessary prerequisite for a productive learning environment.

2.2.3 Conclusion

The classroom observations have demonstrated quite clearly that there is a dominant enacted pedagogy in early grade numeracy, which is delivered in classrooms that are safe and have the potential to support effective learning by students who are in the main enthusiastic to be in the classes and to participate in the lesson. That said, much of what happens in classes is procedural, at a low level of cognitive demand and not supportive of developing understanding, reasoning, and/or the ability to apply learning in unfamiliar situations.

The French didactician Guy Brousseau wrote in 1984: '*The more explicit I am about the behaviour I wish my students to display, the more likely it is that they will display that behaviour without recourse to the understanding that behaviour is meant to indicate; that is, the more likely that they will take the form for the substance*.' (Brousseau, G., 1984).

The classroom observations give a strong sense that form is more important than substance:

- The standardised teaching of calculating from Standard 1 to Standard 4 noticed throughout the classroom observations is entirely about the mechanical steps of the procedure. It relies on primitive calculation strategies ('counting all') and is unconcerned with performing addition or subtraction with two- three- or four-digit numbers and producing a meaningful answer to a problem. To make the point more explicitly, it was possible to observe teachers and students perform several n-digit addition and subtraction calculations without ever saying the number names of the n-digit numbers in the calculation and/or the number name of the number that is the result of the calculation.
- The teachers' lesson plans are formulaic, conforming to a standardised layout and structure, and using language from lists of desirable behaviours (e.g. discussion etc.) – and yet the lessons proceed without any meaningful manifestation of the behaviours that are listed in the plans.
- In line with the TALULAR policy and approach, teachers use a wide range of resources in their lessons, with little or no reflection on whether or not the resources are needed at all and/or on whether the resources selected by the teacher are the most appropriate to support the development of the concept that is the focus of the lesson.
- Many teachers follow their initial explanation/demonstration of the procedure that is the subject of the lesson with an example that students must complete in groups. The students appear to know what groups they belong to and they turn to sit in these groups. However, there is no discussion or group work to talk of: one 'lead' student does all the work while the others sit and watch.

2.3 How does the existing curriculum define expectations, standards, and pedagogical approaches for early grade numeracy?

To understand how the existing curriculum defines expectations, standards, and pedagogical approaches for early grade numeracy, the researcher team conducted a review of the following documents:

- the mathematics syllabus for Standards 1 to 4;
- the mathematics teacher's guides published by MIE; and
- the student textbooks for Standards 1 to 4 published by MIE.

This section will not provide a detailed analysis of the documentation that was reviewed but rather a broad analysis that attempts to problematise the current form of the curriculum (taken to mean syllabus, teacher guides, and textbooks), and to use this characterisation as a way of explaining the classroom practices observed in the classroom observation component of the study.

2.3.1 Curriculum overview

The Malawian mathematics curriculum consists of six core elements:

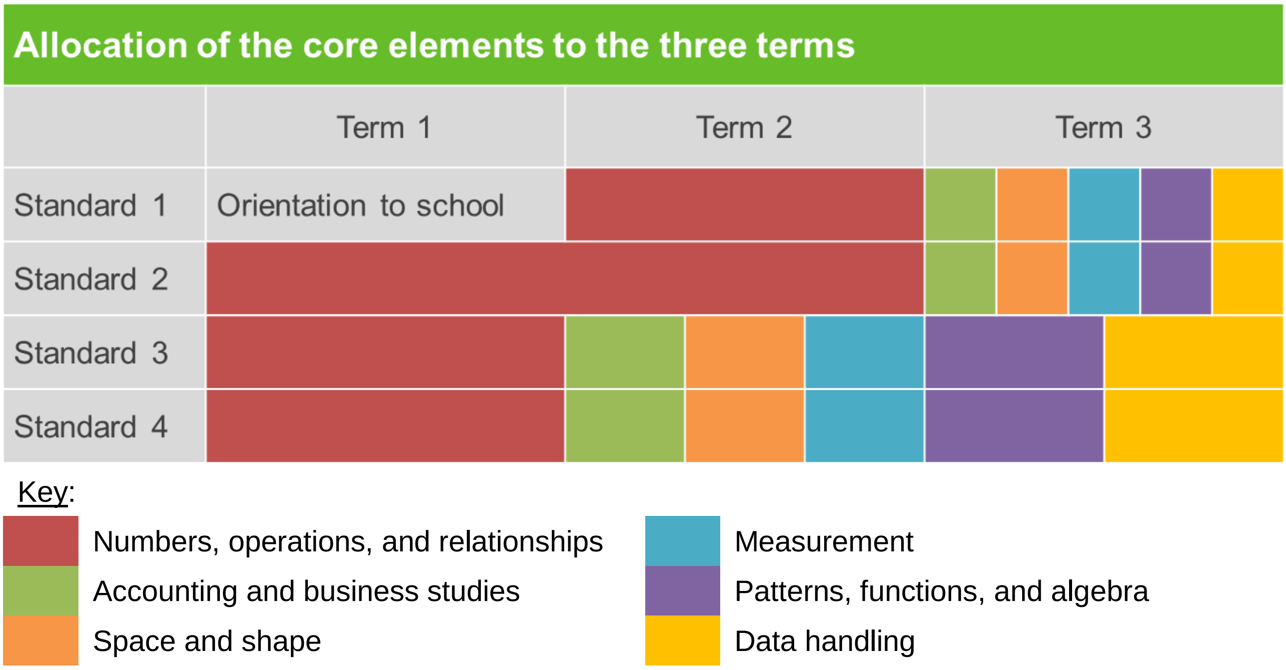
- numbers, operations, and relationships;
- accounting and business studies;

- space and shape;
- measurement;
- patterns, functions, and algebra; and
- data handling.

With the exception of accounting and business studies, which is a uniquely Malawian element, the other five core elements correspond to the core elements or outcomes of the mathematics curricula of many/most countries.

In addition to defining these core elements, the syllabus documents also define how and when the core elements with be taught. **Figure 10** illustrates how the core curriculum elements have been allocated to the school terms for each of Standard 1 to Standard 4.

Figure 10 The allocation of mathematics core curriculum topics to school terms by standard



The key observation to be made about the allocation of the core curriculum elements to the school terms for Standards 1 to 4 (**Figure 10**) at this stage is that the allocation is in blocks. While allocation by blocks makes good sense from an organisational point of view, this approach is unresponsive to the way that children learn. To illustrate: under this system, a Standard 3 student would study *Numbers, operations and relationships* for the first term of the school year. In the second and third terms they would focus on the other five core curriculum elements, returning again to *Numbers, operations and relationships* in the first term of Standard 4. In practical terms it would mean that these students would not work with *Numbers, operations and relationships* for up to 10 months between the end of the first term of Standard 3 and the start of the first term in Standard 4. Students who do not continuously practice and use concepts that they have learned about are likely to forget about them and lose confidence in working with them.

A sequencing of topics that has students visit and revisit topics throughout the year, and that links related topics to one another, is likely to be more responsive to students' needs and learning styles.

2.3.2 Concept development

The mathematics syllabus defines expectations for each standard by means of assessment standards and success criteria for each assessment standard. For each concept within each core element there are clear specifications of what students should be able to do in each standard. **Figure 11** illustrates the expectations for addition and subtraction from Standard 1 to Standard 4.

Figure 11 The development of addition and subtraction from Standard 1 to Standard 4

	Standard 1	Standard 2	Standard 3	Standard 4
Assessment Standard	Learners must be able to add and subtract numbers up to 9	Learners must be able to add and subtract numbers up to 99	Learners must be able to add numbers with sum not exceeding 999 and subtract numbers within the range of 0 to 999	Learners must be able to add and subtract numbers within the range of 0 to 10,000
Success criteria	First: Learners must be able to: • add any 2 numbers with sum not exceeding 5 • subtract any 2 numbers within the range of 0 – 5 Then: Learners must be able to: • add any 2 numbers with sum not exceeding 9 • subtract any 2 numbers within the range of 0 – 9	First: Learners must be able to: • add numbers with sums not exceeding 20 without regrouping • write addition sentences • subtract numbers within the range of 0 to 20 without regrouping • write subtraction sentences Then: Learners must be able to: • add numbers with sums not exceeding 50 without regrouping • write addition sentences • subtract numbers within the range of 0 to 50 without regrouping • write subtraction sentences Then: Learners must be able to: • add numbers with sums not exceeding 99 without regrouping • write addition sentences • subtract numbers within the range of 0 to 99 without regrouping • write subtraction sentences	Learners must be able to: • add three digit number to one digit number without regrouping • add three digit number to two digit number without regrouping • add two digit numbers with 3 digits without regrouping • add three digit numbers without regrouping • add two numbers with regrouping • subtract one digit number from three digit number without regrouping • subtract two digit number from three digit number without regrouping • subtract a three digit number from a three digit number, without regrouping • subtract numbers with regrouping	Learners must be able to: • add numbers up to 4 addends with sum not exceeding 3000 without and with regrouping • add numbers up to 4 addends with sum not exceeding 6000 without and with regrouping • add numbers up to 4 addends with sum not exceeding 9,999 without and with regrouping • subtract numbers within the range of 0 to 3000 without and with regrouping • subtract numbers within the range of 0 to 6000 without and with regrouping • subtract numbers within the range of 0 to 9,999 without and with regrouping

What is striking about the development of addition and subtraction across the four standards is how the topic has been organised in number ranges, in what can at best be described in an arbitrary way. The developmental trajectory for addition and subtraction, broadly speaking, flows as follows:

- Standard 1:
  - Addition and subtraction
    - first, in the range 0 to 5;
    - then, in the range 0 to 9.
- Standard 2:
  - Addition and subtraction <u>without bridging</u> (regrouping, or more colloquially ‘carrying and borrowing’)

    - first, in the range 0 to 20;
    - then, in the range 0 to 50; and
    - finally in the range 0 to 99.
- Standard 3:
  - Addition and subtraction
    - Initially without bridging (regrouping, or more colloquially 'carrying and borrowing') for
      - first, three-digit numbers and one-digit numbers;
      - then, three-digit numbers and two-digit numbers; and
      - finally, three-digit numbers and three-digit numbers.
    - Then, with bridging.
- Standard 4
  - Addition and subtraction with bridging (regrouping, or more colloquially 'carrying and borrowing')
    - first, up to 3,000;
    - then, up to 6,000; and
    - finally up to 9,999.

What is striking about this trajectory is that students do not meet the concept of bridging (e.g. 7 + 8 = 15) until they are in the second half of Standard 3. By implication, the mathematical world of students does not include a wide range of calculations that they will meet in their daily lives. Also striking about this trajectory is how the number range is parsed: first till 5, then till 9, then till 20, 50, and 99, then to 999 without bridging, followed by addition and subtraction up to 999 with bridging, and then up 3,000, 6,000, and finally 9,999. The researchers were unable to establish how this progression had been determined in the writing of the syllabus, although one interviewee did mention that the team responsible for the development of the syllabus did not necessarily review syllabuses/curriculum from other countries, but instead did their best to create trajectories by applying their knowledge to the best of their abilities.

Similarly striking about the syllabuses for Standard 1 to Standard 4 is that all of the other *Number, operations, and relationships* concepts are developed within the same number range that is used for addition and subtraction. For example, counting, reading, and writing numbers, and comparing quantities etc. all happen in exactly the same number ranges as addition and subtraction, although multiplication and division, which are introduced in Standards 3 and 4, are introduced in a lower range and by means of strange multiplicands and divisors. For example, in Standard 3 students are only expected to divide numbers up to 99 by 2, 3, 4, and 5 (without remainder), while they must multiply numbers (in an unspecified number range) by numbers up to 7: in other words, 3 × 3, 9 × 3, and presumably 19 × 3 are acceptable, but 3 × 9 is technically not covered by the syllabus.

This report does not have the space to provide a detailed analysis for each assessment standard of each core curriculum topic but suffice it to say that the same arbitrary development of concepts permeates the syllabus documents.

It is notable that the situation in Malawi is different to that in some other countries, where curricula are overloaded and programmes, in an eagerness to improve standards, are too ambitious for the development level of the targeted age groups of students.

2.3.3 The role of the teacher's guides and textbook

While the syllabus outlines the curriculum contents in terms of assessment standards and associated success criteria, the teacher's guides for each standard allocate the contents of the syllabus to units of work, and each unit of work to numbers of lessons. **Figure 12** illustrates how the content of *Numbers, operations, and relationships* has been allocated to units of work, with the associated number of lesson for each unit, while **Figure** 13 lists the 27 activities (59 lessons) for the first unit *Counting up to 5*.

Figure 12 Standard 1 units for *Number, operations, and relationships*

Allocation of the core elements to the three terms

	Term 1	Term 2	Term 3
Standard 1	Orientation to school		
Standard 2			

Unit 1	Counting up to 5	59 lessons
Unit 2	Addition of numbers with sums not exceeding 5	12 lessons
Unit 3	Subtraction of numbers in the range 0 to 5	14 lessons
Unit 4	Counting up to 9	36 lessons
Unit 5	Addition of numbers with sums not exceeding 9	12 lessons
Unit 6	Subtraction of numbers in the range 0 to 9	12 lessons

Figure 13 Standard 1 activity and lesson allocation for *Unit 1: Counting up to 5*

Unit 1: Counting up to 5 — 59 lessons

Activity	Topic	# Lessons	Activity	Topic	# Lessons	Activity	Topic	# Lessons
1	Introducing the number 1	2	10	Recognising symbol 3	2	19	Tracing the number 4	1
2	Recognising symbol 1	2	11	Tracing the number 3	3	20	Writing the number 4	3
3	Tracing the number 1	3	12	Writing the number 3	2	21	Introducing the number 5	2
4	Writing the number 1	3	13	Introducing the number 0	3	22	Recognising symbol 5	2
5	Introducing the number 2	2	14	Recognising symbol 0	2	23	Tracing the number 5	2
6	Recognising symbol 2	2	15	Tracing the number 0	1	24	Writing the number 5	2
7	Tracing the number 2	3	16	Writing the number 0	2	25	Ordering the numbers 1 to 5	2
8	Writing the number 2	2	17	Introducing the number 4	3	26	Fill in missing numbers	2
9	Introducing the number 3	2	18	Recognising symbol 4	2	27	Review exercise	2

As we unpack the curriculum from the syllabus to the teacher's guide, and finally the textbook, it becomes quite apparent how atomised the curriculum and teaching approach is. Rather than recognising and building on the interrelated nature of the mathematical concepts, the syllabus, teacher's guide, and ultimately the textbook treat each number and what must be done with each number (knowing, recognising, reading, and writing) as separate and unrelated ideas. **Figure 14** shows the teacher's guide notes for Activities 1 to 4 and **Figure 15** shows the corresponding pages in the textbook.

In Activity 1 of Unit 1, the teacher spends the first two lessons 'showing the learners one object and asking them the number of objects being shown'. This presumably involves the teacher telling the student that she is showing them one object and asking them to chant after her that this is one object. Variation theory (Kullberg, A, Runesson Kempe, U., Marton, F., 2017) makes it very clear that children (people) are unable to appreciate the 'one-ness' of one without also knowing something that is not one. The next two lessons involve the same activity but this time the teacher holds up a card with the number one drawn on it. For the next three lessons the teacher provides the number one in the form of clay models or paper cut-outs etc., and the students are expected to run their fingers over the models, and finally for the remaining three lessons devoted to the number one the students must draw the number one. For each of these sets of lessons there is a corresponding page in the textbook. The teacher's guide and textbook then moves on to the number two and the same activities are repeated for nine lessons devoted to the number two.

It follows that Standard 1 students will not have been introduced to the number five by the middle of the school year, and yet during each and every break they go onto the playground and purchase goods from the vendors selling food, sweets, and cold drinks. In their interactions with the vendors they must estimate and/or calculate the total cost of the items they will purchase, offer the correct amount of money, and/or monitor that they receive the correct amount of change. For Standard 1 students the mathematics of the classroom has no relationship to the numbers in their day-to-day world and right from the beginning they are unlikely to see any relationship between the mathematics they learn in school and the enumerating they do with numbers as a matter of course on a daily basis. This lack of coherence contributes to students experiencing mathematics as a foreign and meaningless activity.

Figure 14 Standard 1 teacher's guide notes for Activities 1 to 4

which they are reciting the words while touching the objects. Your aim is to ensure that the quantity of objects is matched correctly for each number recited. During this stage learners must be able to count in sequence giving one number name to each object.

Activity 1 Introducing the number I

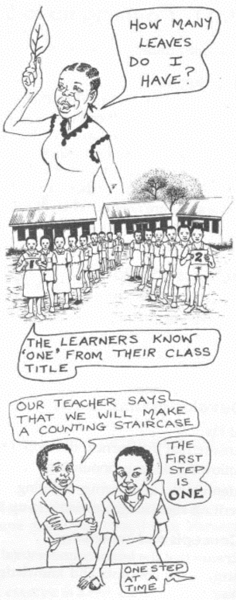
Time allocation: 2 lessons

Suggested resources

leaves, stones, maize seeds, bottle tops

Instructions

1. Ask the learners to mention the number of heads a dog or a chicken has.
2. Show the learners one object and ask them to tell the number of objects being shown (*chimodzi, limodzi,* etc)
3. Repeat with a variety of other objects.
4. Explain that *chimodzi* means one.
5. Help the learners to say **one** several times.
6. Write **1** on the board and ask the learners to read **1** after you.
7. Show the learners a number card containing **1**.
8. Let the learners read **1** after you.
9. Organise the learners into groups.
10. Give the learners a variety of materials such as leaves, stones, seeds, cards and bottle tops.
11. Let the learners show each other one object at a time.
12. Ask the learners to turn to the learners' book *Mutu* 1 and do *Ntchito* **1**.



Activity 2 Recognising symbol 1

Time allocation: 2 lessons

Suggested resources

number cards, bottle tops, leaves, wall charts, stones.

2

Instructions

1. Show an object in one hand and a number card in another with a symbol of **1**.
2. Let the learners say 'one' after you.
3. Repeat this activity with different objects.
4. Involve the learners by giving them objects and number cards in their groups.
5. Ask the learners to take out all cards labelled **1** and show their friends.
6. Let the learners match the number card labelled **1** with one object.
7. Use wall charts to show different objects depicting the number **1**.
8. Ask the learners to turn to the learners' book *Mutu* 1 and do *Ntchito* 2.

Activity 3 Tracing the number 1

Time allocation: 3 lessons

Suggested resources

The number **1** made from clay or carton, number cards, slates, sandy ground, notebooks

Instructions

1. Show the learners **1** made from clay or carton.
2. Demonstrate tracing **1** on the chalkboard.
3. Distribute the model of **1** to all groups.
4. Let the learners trace the number **1**.
5. Assist the learners who need support to trace the number **1**.
6. Ask the learners to turn to the learners' book *Mutu* 1 and do *Ntchito* 3.

Activity 4 Writing the number 1

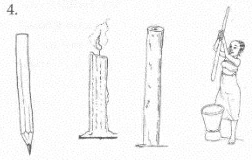
Time allocation: 3 lessons

Suggested resources

number cards, chalkboard, counters, sand, pencils. clay, seeds, stones

Instructions

1. Show the learners the number **1** on a number card.
2. Demonstrate to the learners how to write **1** on the chalkboard.
3. Demonstrate how to write **1** in the air while facing the chalkboard.
4. Let the learners write the symbol **1** in the air and on the ground several times.
5. Let the learners practise writing **1** on the ground, on slates, in exercise books and mould **1** using different objects.
6. Let the learners model the number **1** using different objects.
7. Ask the learners to turn to the learners' book *Mutu* 1 and do *Ntchito* 4.



There are examples of things representing the symbol one

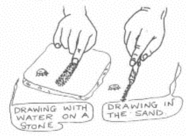


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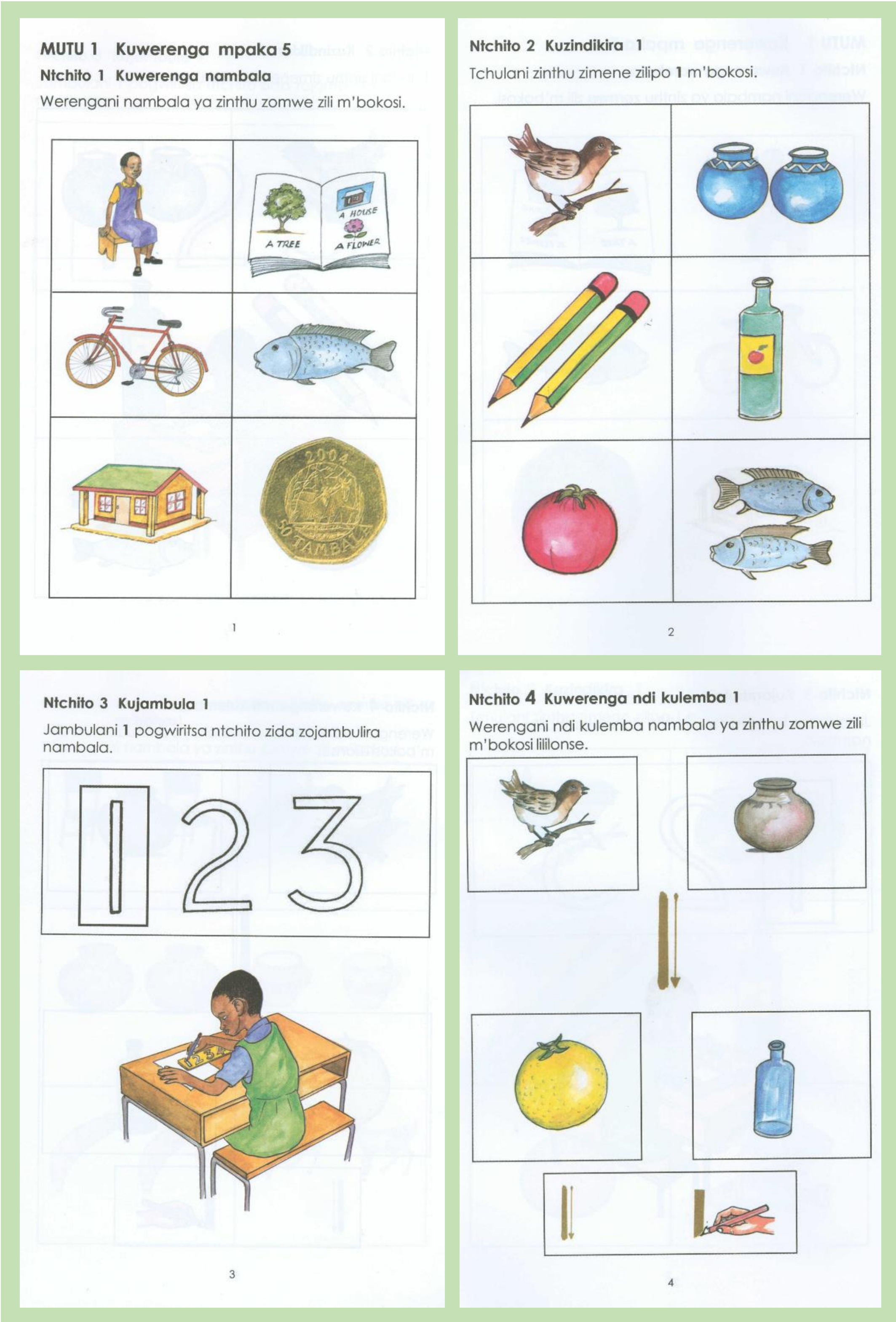
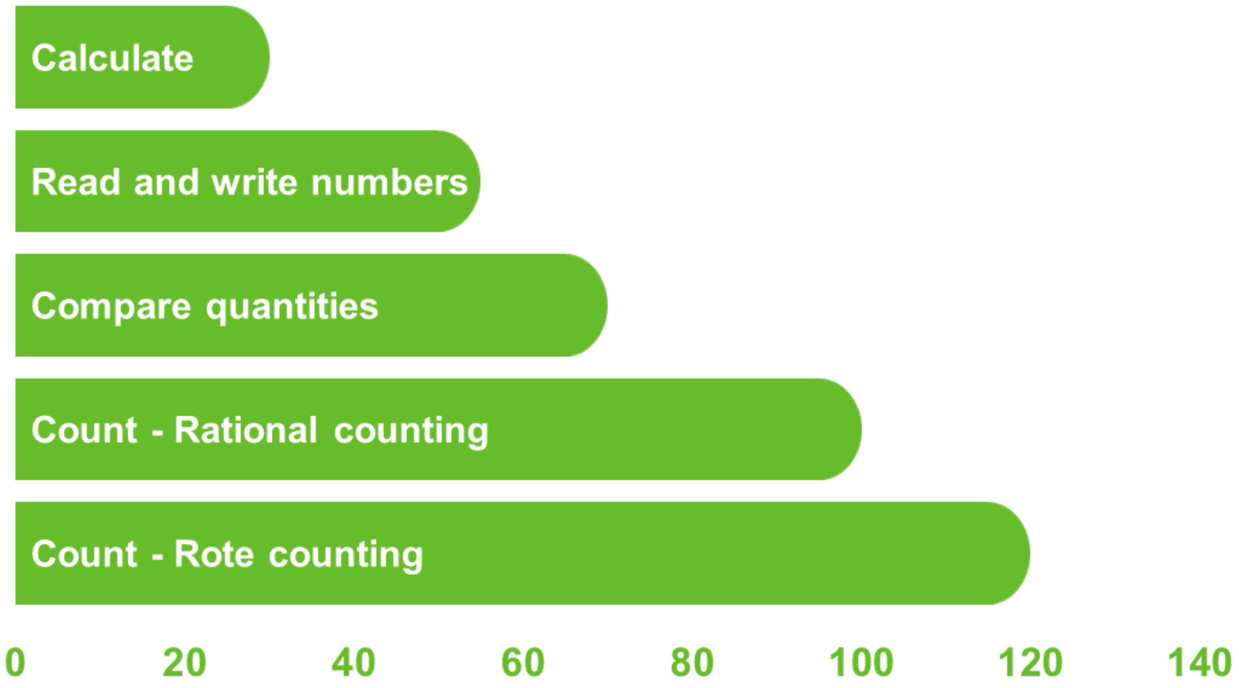
Figure 15 Standard 1 textbook pages for Activities 1 to 4



2.3.4 Discussion

The brief description and analysis of the curriculum has tried to convey how the curriculum is over-designed and over atomised, and does not take into account the interrelated nature of mathematical concept development. At the same time, the discussion has also tried to convey how the expectations of the curriculum are rather unambitious – as opposed to being challenging, or even too challenging. **Figure 16** illustrates how early students in Standard 1 can know different number concepts in different number ranges.

Figure 16 Early number concepts and associated number ranges



Beyond being able to know different number concepts in different number ranges, it is actually important for students to work with these concepts in different number ranges.

- Rote counting develops students' number vocabulary and they need to have a well-developed number vocabulary before they can start rational counting. So, students should be rote counting as far as possible.
- Rational counting (counting concrete objects) is important for three reasons: it gives meaning to the vocabulary developed during rote counting; it supports the development of students' sense of 'muchness' (numerosity); and it provides students with their first tool for calculating. That said, students can count rationally into high number ranges long before they can read or write numbers, and they should be encouraged to do so. However, they cannot count rationally in a number range that exceeds their rote counting number range.
- Comparing quantities is something that students can also do long before they can read or write numbers. When the quantities (piles of objects) are clearly dissimilar, students 'know' which pile has more objects and which pile has fewer. As the sizes of the piles become more similar, students are not easily able to look at the piles and know which have more and which have less: they must now count the objects in the piles and it follows that they can only compare piles of objects as long as the piles have numbers of objects that are within the number range of objects that they can count rationally.

- With time, students are exposed to, and need to learn how to read and write, numbers, and at first they will do so in a lower number range than the number range in which they are counting rational (concrete) objects and comparing quantities.
- As students start calculating with numbers they must be able to read the numbers that they are calculating with and it follows that they will perform calculations in a number range within which they can read and write the numbers.
    - Rational counting also provides students with their first tool for calculating. At first this will typically involve a *counting all* strategy. Asked to calculate how many sweets two children have altogether if one child has 8 sweets and the other child 7, a student will count out and make one pile of 8 counters and another pile of 7 counters and then they will count all the counters together and conclude that the two children have 15 sweets altogether. Students can make sense of the situation and easily solve the problem in a number range that exceeds the Malawian expectation for Standard 1, as long as they can count (rationally) up to 20 or more objects. Furthermore, they do not even have to be able to read or write the numbers in the problem (the teacher can tell them these) and/or write the problem as a column arithmetic addition calculation, the problem technically involves bridging (regrouping or more colloquially carrying) and, despite all of this, the problem is accessible.

What this discussion has tried to highlight is that the Malawian early grade mathematics curriculum is insensitive to the interrelated way in which students develop number concepts, and too atomised (insufficiently interrelated) to allow for students to experience mathematics as a meaningful activity. It is quite simply unambitious.

The impact of this unambitious and ineffectively structured curriculum, with its low expectations, is seen in the observations of the classroom study described earlier in this report and in the performance characteristics of students described in the analysis of assessment data.

2.4 How does the general learning environment support (or not support) effective learning?

To better understand the general learning environment and how it does or does not support effective learning, the research team conducted interviews with a range of key informants in different regions, selected in collaboration with DIAS. **Table 9** summarises the regions and the persons interviewed. In addition, the lead researcher also conducted interviews with the directors and/or senior management (in those cases where the directors were not available) of DIAS, Basic Education, Planning, DTED, MANEB, and MIE, as well as with staff members of GIZ who have played a role in the re-development of the pre-service teacher training programme, RTI International, the implementers of the NRP, and one of the lecturers at Chancellor College.

Table 9 Summary of interviews with key stakeholders

Region	District Education Office					TTC	
	DEM	PEA	Inspector	Desk officer	Head teacher	Principal or deputy principal	Head of mathematics department
Lilongwe	1	1	1			1	1
Mzimba		1		1			
Ntchisi	1						
Mangochi		1			1		
Machinga						1	2
Nsanje		1	1				
Blantyre	1		1			1	2

The interviews were organised using prompts from a semi-structured interview designed for this activity (see **Annex B**). The interviews focused on:

- the respondents' perceptions of mathematics performance in the early grades in Malawi and their explanations for the state of mathematics performance;
- the respondents' sense of what it means to do mathematics and their expectations of the elements of a good mathematics lesson;
- how teachers are expected to monitor the progress of their students and to cater for the range of needs of the different students in their classes;
- the NRP, in terms of key strengths and achievements to date; and
- the strengths and challenges of the recently introduced 2-2-2 model[8] in TTCs.

2.4.1 Findings

There was universal acceptance among the interview respondents that mathematics performance among early grade students in Malawi is poor and that it needs to be improved. While several respondents believed that the problem only starts at Standard 5, when students move from instruction to Chichewa to instruction in English, the vast majority agreed that performance across the early grades is poor.

Large classes

While the reasons provided by respondents for the poor performance varied, there was almost unanimous agreement that large classes contribute significantly to the state of affairs. Large classes prevent teachers from implementing expected practice (e.g. teacher's guide methodologies

[8] The trainee teachers complete two terms in college, two terms in practicum in schools, and a final two terms in college.

and assessments policy etc.), make it difficult for teachers to provide differentiated instruction, and make it difficult to source enough teaching resources (e.g. stones and leaves for counting).

Additionally, head teachers interviewed by the school observers acknowledged that the MoEST target of limiting pupil–teacher ratios of all classes to 60:1 is an unachievable target in the present circumstances.

Language of instruction

In addition to large classes, almost all of the respondents alluded to the ‘language issue’ – although their concerns around language varied. Respondents cited the language policy as contributing to the state of affairs. They explained that students are expected to study in Chichewa in Standards 1 to 4, but for many students Chichewa is not their home language and this makes it hard for them to understand the teacher and/or engage with the textbook. Teachers, they argued, are not necessarily posted according to the home language of the students and so there are many classes in which teachers cannot speak the language of the students. The respondents also explained how students start school knowing number names in English (in their communities people use the English terms for the number names) and struggle to make the transition to Chichewa – the language of instruction – in which there is a lack of vocabulary to express number concepts and related terminology, which means it quickly becomes very complicated to convey even simple terms. In the lessons observed by the research team, teachers and students almost universally expressed number names and other mathematical terminology in English, while speaking Chichewa etc.

Another language-related issue raised by the respondents was the fact that the teacher’s guides for Standards 1 to 4 are in English while the corresponding textbooks are in Chichewa. This, they argued, makes lesson delivery difficult, especially in those cases where neither English nor Chichewa is the home language of the teacher.

Attitudes toward and about mathematics

Some respondents argued that poor performance in mathematics can also, at least in part, be attributed to negative attitudes that prevail in the community and among teachers themselves. Respondents argued that these attitudes can be explained by the experienced disjuncture between ‘school mathematics’ and day-to-day use of mathematics and arithmetic. By way of illustration, respondents explained how school mathematics deals with the Tambala (1/100th of a Kwacha), in a world where students never see or use the Tambala in their daily lives – this currency unit is all but redundant.

Some respondents argued that teachers themselves struggle with mathematics and this struggle contributes to their perception of mathematics as a difficult subject, which they, in turn, convey in their teaching.

There is also a perceived gender issue, with mathematics being widely considered to be a ‘boy’s subject’, and girls are therefore not expected to do well in the subject.

Textbooks and other curriculum materials

With regard to the textbooks and other curricular materials, there was general agreement among respondents that the textbooks are appropriate and an effective resource. Some respondents argued that improvements could be made to the textbooks and, in particular, the link to the curriculum could be improved in places. However, in general, respondents did not explain poor performance in mathematics in relation to the textbook contents. Nevertheless, respondents did report that textbook distribution is uneven and not all students have access to a textbook. In this regard, respondents referenced the success of the NRP, saying how the NRP had been able to achieve universal distribution of learning materials so that each student has a book.

Effective mathematics teaching

In response to the question of what constitutes an effective mathematics lesson, respondents expect to see learners involved, attentive, and participating. Lessons, they argued, should be practical, with learners manipulating local, concrete objects to complete tasks. They expect teachers to prepare lesson plans that are linked to the syllabus, with clear objectives that are communicated to the learners at the beginning of each lesson. Furthermore, they expect that the lessons should be structured, with teachers demonstrating the process for calculating before students then practice the process first in groups and then on their own. Respondents expect to see students able to demonstrate key basic skills and able to complete activities. They expect that teachers check their students' understanding throughout the lesson, and set homework which is marked the next day. The homework, they felt, should encourage students to apply the lesson content to real life. With regard to monitoring student progress, respondents pointed out that the curriculum has assessment embedded into it and teachers are expected to use continuous assessment. There are review sections at the end of each unit in the teacher's guide, which provide opportunities to assess learners. Respondents explained that teachers are expected to use both formative and summative assessment, including verbal and written questions, on a regular (weekly or fortnightly) basis, and are encouraged by the PEAs to use the results to inform their lesson planning. However, respondents explained, continuous assessment is not practical in the large classes that prevail and teachers tend to rely on setting occasional tests (typically at mid-term).

Differentiated instruction and catering to the needs of students

On the question of catering to the range of students' needs in the classes and providing appropriate differentiated instruction, respondents explained that teachers are trained and encouraged to use a variety of methodologies and activities to meet different students' needs but that, in reality, very few adjust their teaching to the needs of their students or differentiate instruction in any way. The main strategy for providing support, they argued, remains the use of remedial classes after school, but they went on to say that this is seen as additional work for the teacher and a punishment for the learners, and accordingly is neither effective nor frequently used in reality.

Pre-service teacher training

The curriculum and organisation of the TTC teacher preparation programme has undergone significant changes in recent years. In terms of content, there has been a shift from teaching the mathematics that students need to know (which until recently involved prospective early grade teachers re-doing their secondary school mathematics) to how teachers teach and reflect on their practice – '*learning content by teaching it*'. There has also been a shift in the organisation of the programme to a 2–2–2 term model, with students spending two terms at college, followed by two terms working in schools and a final two terms back at college. In addition to discussing the standard questions of the semi-structured interview, the discussions with TTC personnel also focused on their experience of these changes. Respondents remarked enthusiastically on the new 2–2–2 model, arguing that the opportunity this provided for students to discuss classroom realities with their lecturers after their practicum is invaluable. In terms of the shift from content that previously focused on mathematical concepts and relied on memorisation to a focus on '*how do I teach mathematics*?' the respondents felt that, while it is valuable, student teachers nonetheless continue to use the 'old methods' in practice. The respondents also emphasised that TTC lecturer preparation to deliver the 2–2–2 curriculum is abstract rather than practical, and lecturers feel they should be trained in a more practical way. They felt that they should be conducting training to reflect the way trainee teachers are expected to deliver the school curriculum to learners in the classroom but time restraints mean that they tend to use lecture methods. They also felt that there is a lack of specialised training in mathematics when compared to, say, language. Finally, they felt that TTC lecturers need training on teaching large classes, so that they can in turn train the students. As part of the classroom observation activity, one of the researchers was able to observe lectures by two lecturers at one of the TTCs. What was striking about these lectures was how the lecturers were both skilful in their management of the classes, effectively using a wide range of classroom and, in particular, in group management strategies. The contents of the lectures was, however, informed by the existing teacher’s guide and focused on how to teach the content in the way described in the teacher’s guide, without much reflection on whether that was effective or not, and without any discussion of the effective classroom management strategies that the lecturers themselves had modelled.

In-service teacher training

Head teachers are seen to be at the core of teacher development, especially to identify gaps and supervise teachers, and are encouraged to use some of their School Improvement Grant to conduct CPD in their schools. In reality, however, it was felt that the majority of head teachers lack the skills to do this effectively. School-based CPD activities are not carried out regularly, nor are they numeracy-focused as there are many other issues to be addressed. Time and resource constraints often mean training by PEA or TTCs is not held as frequently as intended, and respondents felt it is not necessarily effective.

NRP

MoEST has been implementing the NRP since 2015, with technical assistance and funding support from USAID and DFID. This reading programme aims to improve early grade learners' literacy skills. Central to achieving this goal is building teachers' capacity to teach foundational reading skills that are key for successful reading, and comprehension skills that are needed for learning content across the curriculum. The NRP introduces teachers to effective reading instruction through the five essential components of Phonological Awareness, alphabetic principle, vocabulary, fluency, and comprehension (MoEST, 2014 *Malawi National Reading Strategy 2014–2019*[9]). The NRP aims to provide teachers and head teachers with training in how to better teach children in the early primary grades to read and write in Chichewa and English.

In light of the role that this research activity will play in determining the terms of reference for a national programme designed to improve early grade numeracy, the researchers were eager to establish how the respondents were experiencing the NRP. Without exception, the respondents were enthusiastic with regard to the NRP. They were impressed by the effective provision of textbooks to every student, as well as the opportunity for students to take the textbooks home. The respondents also found the teacher’s guides to be clear and easy to follow. They identified the capacity building activities (coaching and frequent CPD) to be positive, but expressed concern that this was only being provided to teachers in Standards 1 to 4. There was a strong feeling that all primary teachers should be trained in the same way as problems have arisen because teachers are not restricted to teach in a single standard: they move around to different schools and teach in different standards. This means teachers who are teaching in Standards 1–4 can potentially not have been sufficiently trained for those standards. Scripted lessons were reported to be a good idea; however, respondents felt teachers should be encouraged to use them as intended. Some respondents expressed concern that ‘lazy teachers’ rely on them and do not adapt them for their classes, while other respondents felt they could support change in teaching methodology, freeing teachers’ time to enable them to prepare and gather resources. Respondents also commented that the lessons were hard to complete in 30 minutes, and not well suited to large classes. That every

[9] https://shared.rti.org/content/malawi-nrp-std-1-chichewa-teachers-guide

lesson follows the same ‘I do, we do, you do’ pattern was of concern to some respondents, who felt that there needs to be more variety. Some respondents also found the content of the lessons to be too difficult for students and suggested that the methods rely too much on memorisation.

Without exception, the respondents were all positive about the impact of the NRP and **expressed surprise at the observation that Standard 1 students could learn to read so quickly**.

2.4.2 Discussion

That mathematics performance is not what it could/should be is well accepted among the key informants who participated in this component of the scoping study. In the main, language issues and large classes were suggested to be the most significant explanatory factors for this poor performance.

However, what was striking about the interviews was how respondents struggled to answer the question(s): ‘*What, in your words, does it mean to do mathematics? And, what mathematical skills and/or knowledge do you think Standard 1 to Standard 4 students should develop?’* In describing an effective mathematics lesson, much was made of the need for teachers to demonstrate the process of calculating practically using locally available resources. It is clear that for most respondents the learning of mathematics is understood to be procedural (see instrumental vs relational understanding (Skemp, 1986)) and that teaching mathematics is about teaching procedures to complete tasks. Notwithstanding the efforts of the TTC to focus on what it means to teach mathematics, the student teachers revert to ‘telling’ as soon as they get to the classroom.

Nether differentiated instruction nor continuous assessment, although acknowledged as important, are implemented and this too is explained in terms of large classes. It is clear that any national programme designed to improve early grade numeracy will need to address the reality of very large classes and the effective implementation of the proposed methodologies in this context.

As indicated above, possibly the most striking observation that emerges from this component of the study is that the respondents expressed surprise at how well the Standard 1 students are able to read on account of the NRP activities. This is striking in as much as it reinforces an emerging theme in the scoping study – low expectations. That respondents can be so impressed (and surprised) by Standard 1 students’ success with reading reinforces the notion that ‘the system’ has limited, and hence limiting, expectations of what students are capable of.

2.5 Summary of findings

Analysis of the various assessment reports and the detailed assessment data, where they are available, clearly indicates the following:

- Student performance is poor: on the MLSS assessment, administered to Standard 4 students, the Standard 4 student average was 50% for the Standard 1 items, 33% for the Standard 4, and 43% overall.
- The assessments measure current expectations of what learners can do rather than what they should be able to do: there are no beginning numeracy/reasoning items in either the MLSS or MLA assessments, and so these assessments will struggle to measure improvements in numeracy learning if it moves beyond the current limited set of mathematical knowledge learners possess.
- Students are only able to answer items with confidence when they are presented in a familiar manner requiring the reproduction of standardised procedures taught by rote in class.

Analysis of the various curriculum documents (syllabuses, teacher guides and textbooks), show quite clearly that:

- For the core curriculum element *Numbers, operations and relationships*, the 145 lessons of the Standard 1 year are devoted to counting, reading, writing, and doing addition and subtraction in the number range 0 to 9.
- In Standard 1, students are not exposed to the number 10 – the basis of the decimal system.
- Bridging (regrouping, or more colloquially carrying and borrowing) is not introduced into calculations until the second half of Standard 3.
- The teacher's guide approach to addition and subtraction is identical from Standard 1 through to Standard 4, relying only on a setting out in columns method and on a 'counting all' strategy using locally available resources (stones, leaves, and twigs etc.) to determine the sum (or difference) of the digits in each column.

Observation of lessons shows that across the standards, school types (urban, rural, and remote) and performance levels (good, average, and poor):

- the dominant pedagogy is one of teachers demonstrating a standardised procedure for doing what must be done;
- the role of the student is to reproduce the procedure demonstrated by the teacher; and
- little or no attention is given to developing **understanding**, supporting students to **apply** what they know in an unfamiliar setting, and/or to **reason** about what they are doing. This is reflected in continuing use of 'counting all' strategies even when students are working beyond this level.

Interviews with key informants at the District Education Offices and TTCs, demonstrates that:

- the shared understanding of a good mathematics lesson has the teacher teaching procedures, in a practical way using locally available resources;
- there is a commonly held belief that performance in mathematics is poor on account of class sizes, language issues, and the availability (or not) of appropriate teaching resources; and
- the NRP has surprised observers as they did not think that Standard 1 students would be able to make so much progress and to read as well as they are doing on the programme.

Taken together there are two overriding themes that emerge from all the study elements:

- the Malawian mathematics/numeracy environment is characterised by limited and limiting expectations of students; and
- the focus of teaching is on form over substance.

This has profound implications for the success elements of a programme designed to improve early grade numeracy. In particular, the programme will need to shape a modernised vision of what it means to do and teach mathematics. To do so the programme will need to:

- address expectations of what students are capable of at all levels of the education system;
- modernise the curriculum, assessment, and teaching practices; and
- involve stakeholders from all sectors of the education system (curriculum, assessment, pre- and in-service teacher training and supervision, teachers, and school leaders). This involvement from the start will be key to the institutionalisation of the programme methodologies.

In accepting the above, it should be noted that there are also many positives that the study has revealed:

- Classrooms are safe and happy spaces in which students are enthusiastic to participate.
- Teachers work hard to make lessons interesting (varying resources, praising students who respond correctly, etc.).
- Teachers uniformly follow the teacher's guides, with the dominant pedagogy being very similar from one class to the next. This is positive in as much as it suggests that if teachers are introduced to a different methodology and provided with sufficient support, they may well be able to adapt their practice and implement the approach with enthusiasm.
- The education system is highly functional, with each directorate committed to the success of the students.

The study has also revealed that there are a number of significant structural issues that hamper progress and success. While these need to be addressed at a system level, the implication of these issues needs to be considered in the development and implementation of any programme designed to improve early grade numeracy. These include, but are not limited to the following:

- Class size and resourcing. Even the reported national average of 1 teacher to 70 students is not optimal, but with a 1:70 ratio as the national average, classes of more than 100 and even 200 students are not unusual. Add to this the fact that as classes get larger, so the basic infrastructure struggles to keep up with many classes having no or insufficient seating and it is clear that a less than optimal learning environment for individualised and differentiated teaching exists. The programme should include innovative practicable teacher management strategies to support learning in oversize mixed-ability classes.
- Language. It is clear that language is a significant issue. Although the researchers may disagree with some respondents over the significance or not of Chichewa not having a well-developed mathematics lexicon etc., it is clear that having early grade students learning in Chichewa, where Chichewa is not their home language and their teacher does not speak their home language, creates challenges.
- Textbook and exercise book provisioning. As the programme develops teaching and learning materials, care needs to be taken to provide each student in every class with the necessary learning materials for them to be able to participate effectively in learning.
- Absenteeism. Although not raised as an issue by interview respondents, absenteeism is known to be an issue. As the programme develops and implements a more ambitious curriculum, measures to address persistent absenteeism will be required.

Finally, it is recommended that effort is devoted to the setting of increased expectations, possibly in the form of clearly articulated standards/benchmarks that are grade aligned for each of the key concepts and skills in the mathematics curriculum. The setting of these standards/benchmarks should provide a clear developmental learning trajectory for students from Standard 1 through to the end of primary school and possibly beyond.

3 Recommendations

This scoping study has revealed that current performance in early grade numeracy in Malawi has as much to do with perceptions of what it means to do mathematics as it does with doing the mathematics.

The TIMSS Assessment Framework (described earlier) demarcates both content domains and cognitive domains for the TIMSS mathematics study. The content domains describe the mathematical topics with which students are expected to be familiar at Standard 4 and Standard 8 levels. The content domains for TIMSS are: Number, Geometric Shapes and Measures, and Data Display in Standard 4. And: Number, Algebra, Geometry, and Data and Chance in Standard 8. These content domains align well with the core elements of the Malawian mathematics curriculum, namely: Numbers, operations, and relationships; Accounting and business studies; Space and shape; Measurement; Patterns, functions, and algebra; and Data handling. The TIMSS cognitive domains for mathematics describe the mathematical 'behaviours' (or heuristics) that students are expected to display with the mathematics that they know. According to the TIMSS Mathematics framework, students should know, apply and be able to reason with their mathematical knowledge.

Another framework that is worth exploring is *Mathematical Proficiency*, developed by Kilpatrick, Swafford, and Findell (2001). The authors recognise that the meaning of successful mathematics learning has changed over time in response to changes in the world and in schooling. For roughly the first half of the twentieth century, success in learning mathematics usually meant confidence in using the computational procedures of arithmetic, with mathematics instruction emphasising the need for skilled performance. The view of success in mathematics learning has evolved and today the authors use the term mathematical proficiency to describe a more nuanced understanding of what it means to be successful in mathematics. The authors argue that to describe the mathematical knowledge, understanding, and skill people need today they have adopted a composite view of successful mathematics learning and have referred to that as mathematical proficiency, which they argue has five components, or strands:

- procedural fluency (computing)—skill in carrying out procedures flexibly, accurately, efficiently, and appropriately;
- conceptual understanding (understanding)—comprehension of mathematical concepts, operations, and relations;
- strategic competence (applying)—ability to formulate, represent, and solve mathematical problems;
- adaptive reasoning (reasoning)—capacity for logical thought, reflection, explanation, and justification; and
- productive disposition (engaging)—habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy.

Using these frameworks as a lens through which to examine the Malawian mathematics curriculum, it becomes quite clear that the enacted Malawian curriculum focuses on knowing (TIMSS) and/or computing (Mathematical Proficiency): there is little or no evidence in the assessments, curriculum, and/or classroom pedagogy of Malawian mathematics education of application, reasoning or understanding. It follows that, according to the Kilpatrick *et al*. description, mathematics education in Malawi is still using the approach favoured in the first half of the twentieth century, namely: developing confidence in using the computational procedures of arithmetic. The observations of the scoping research indicate that even this focus on computational procedures in Malawi is limited by its lack of success in producing appropriate computational skills.

As MoEST (with support from DFID) contemplates a programme designed to improve early grade numeracy, a key question from the outset needs to be whether this programme will focus on doing better what is currently being done – i.e. developing confidence in using the computational procedures of arithmetic more effectively. Or whether such a programme provides the opportunity of developing a modernised vision of what it means to do mathematics for Malawi:

- a vision of mathematics in which students experience mathematics as a meaningful, sense-making, problem-solving activity; and
- a vision of mathematics teaching and learning that expects students not only to know mathematics, but also to understand the mathematics they know, be able to apply the mathematics they know to solve unfamiliar problems, and be able to reason (argue) with the mathematics that they know.

It is the view of the authors of this report that it would make sense to use the opportunity of an intervention programme to set a 21st Century vision for mathematics in Malawi and then to use the programme to achieve this.

3.1.1 Suggested implementation of a programme designed to improve early grade numeracy

In this section we describe, in outline form, the suggested implementation of a programme designed to improve early grade numeracy. We see this programme going through the following stages, each of which is described below:

- identification of the core group to lead the programme;
- setting the vision;
- developing pilot materials;
- rigorous piloting;
- programme refinement; and
- taking the programme to scale and institutionalisation.

Identification of a core group to lead the programme

From the outset it will be important that this is a Malawian project and to that end MoEST will need to identify a core group (hereafter referred to as **the core group**) of people to lead the process. It is imagined that the group will consist of representatives of key constituents:

- Curriculum
  - At least four to six people from curriculum (MIE) who are currently responsible for writing syllabi, teacher's guides, and textbooks.
- Assessment
  - At least two to four people from assessment (DIAS and MANEB) who are involved in and responsible for assessments such as the MLA and PSLCE. The involvement of these people is critical to ensure that the revised vision is reflected in future examinations.
- DEMs, PEAs, and inspectors
  - Representative DEMs, PEAs, and inspectors with mathematics subject specialisation. It is recommended that these members of the core team represent a wide range of districts (e.g. urban, rural, and hard-to-reach) as well as high, average and poor performing.
- TTC lecturers
  - Mathematics lecturers from a range of TTCs.
- Head teachers and teachers

- o A good number of head teachers (who will know how best to support teacher implementing a new programme) and teachers (who will have to implement the programme).

Altogether, it is imagined that the core group will consist of approximately 40 to 50 people. Although this size is large, it is believed that having a large core group will ensure greater buy-in, increased capacity to support implementation, and an improved likelihood of institutionalisation.

Setting the vision

Identify a technical expert(s) to conduct an intensive and extensive training/vision setting workshop(s) for the core group.

The key purpose of the training/vision setting workshop for the core group would be to provide them with the practical experience of a 21^{st} Century vision of doing mathematics and the pedagogy to support it. It is important that this vision setting exercise involves practical experience and demonstrations with school students and the exposition (by the technical expert[s]) of practical classroom routines and activities that have been demonstrated to be successful in other similar country contexts.

Developing pilot materials

Guided by the technical expert(s), the core group develops pilot teaching, learning, and training materials that translate the vision into classroom reality. It is imagined that these materials will include: teacher's notes (teacher's guides) that provide descriptions of classroom routines, daily lesson notes, and student workbooks.

It is expected that the materials developed during this exercise will target at least Standards 1 and 2, with materials for Standards 3 and 4 being developed after the Standards 1 and 2 materials have been piloted.

Throughout this process, which is expected to last several months, the teacher members of the core group will engage in ongoing informal piloting of materials in their classes.

Rigorous piloting

MoEST, with appropriate technical support, will need to determine the most appropriate research methodology (e.g. randomised control study or pre-/post-test impact assessment etc.) for assessing the impact/success of the pilot programme. It is anticipated that piloting will involve piloting: the successful implementation of the methodology; the efficacy of the newly developed materials; and the in-service teacher training approach adopted by the programme.

Based on the research model identified, MoEST will identify schools and/or districts in which to pilot the programme.

The core team, with appropriate technical support, will:

- develop and conduct a baseline assessment (including, as appropriate, control schools);
- train the participating teachers to implement the programme;
- coach the teachers as they implement the programme;
- conduct an end-line assessment; and

- develop a report on the pilot study which is appropriately disseminated and informs the next steps of the programme.

Programme refinement

Based on the assessment of the pilot research activity, as well as the general lessons learned from the pilot, the core team will, with appropriate technical support:

- refine the programme materials; and
- conduct training of trainers training for the national scale up/roll-out.

Taking the programme to scale and institutionalisation

Finally the programme is expanded to all 34 education districts.

On account of the roles that the members of the core team have played throughout the implementation of the programme, the methodology of the programme impacts on:

- curriculum: syllabus, textbooks and teacher guides;
- assessment practices;
- teacher training at TTCs;
- in-service teacher training;
- supervision and inspection practices; and
- most importantly – student learning!

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Annex A Classroom observation instrument

Education District	
School Name	
Standard and Lesson content	Standard ______ ☐ Numbers, operations and relationships ☐ Accounting and business studies ☐ Space and shape ☐ Measurement ☐ Patterns, functions and algebra
Date and time of visit	______ November 2018 ________________ start time ________________ end time
Observer Name	

Number of students/desks	______ Boys ______ Girls ______ Desks/chairs
Classroom map with approximate dimensions. Showing: • Walls • Door & windows • Chalkboard • Teacher desk • Student desks/chairs • Students	
Student resources	Textbook: ☐ All/nearly all ☐ >50% ☐ <50% ☐ None Exercise book: ☐ All/nearly all ☐ >50% ☐ <50% ☐ None Pen/pencil: ☐ All/nearly all ☐ >50% ☐ <50% ☐ None

Mathematics Classroom Observation (select only one response per section per time interval)		3	6	9	12	15	18	21	24	27	30
Teacher activity	Classroom management										
	Teaching – explaining										
	Teaching – demonstrating										
	Teaching – facilitating discussion										
	Teaching – monitoring students working										
	Teaching – assessing										
	Other										
Student activity	Sitting										
	Listening										
	Copying from the board										
	Participating in class discussion										
	Working independently in pairs or groups										
	Working independently alone										
	Other										
Teacher questioning	Whole class: no content questioning/discussion										
	Whole class teacher-student chanting										
	Whole class – asks individual students questions										
	Individual student – questions/discussions										
	Other										
Student questioning	None										
	Students ask questions about what to do										
	Students ask questions about the lesson content										
	Other										
Cognitive demand	Knowing (procedural)										
	Applying										
	Reasoning										
Language	Chichewa (or other) only										
	English only										
	Chichewa (or other) with mathematical vocab in English										
	Code switching										

Teacher resources	Teacher Guide: ☐ Evident ☐ Evident and used ☐ Not evident Textbook: ☐ Evident ☐ Evident and used ☐ Not evident Lesson plan: ☐ Evident ☐ Evident and used ☐ Not evident
Teacher subject knowledge and knowledge of student as it relates to the lesson observed	With regard to the content, the teacher seems able to (check all that apply): ☐ Compute ☐ Understand ☐ Apply ☐ Reason With regards to the students, the teacher seems to (check all that apply): ☐ Treat them all the same ☐ Provide differentiated support according to student needs ☐ Provide different explanations for different groups of students With regard to resources, the teacher uses (check all that apply): ☐ No resources ☐ Uses resources effectively to support concept development ☐ Uses resources but the link to concept development is unclear With regard to classroom atmosphere (check all that apply): ☐ The teacher creates a calm and safe space for learning ☐ A lot of time is spent on disciplining students ☐ When a student makes a mistake, the teacher reprimands or punishes the student ☐ When a student makes a mistake, the teacher encourages the student to try again and/or moves on to another student. ☐ When a student makes a mistake, the teacher asks a clarifying question or breaks down the task as appropriate.
General notes	

Annex B Key informant (semi-structured) interview protocol

Key informants include: District Education Managers (DEM); Primary School Inspectors; and Primary Education Advisors (PEAs) at the District Education Offices as well as the lecturers at the Teacher Training Colleges (TTCs).

The semi-structured interviews will be guided by these questions:

- Can you tell us about your role and how you came to this position?

- Do you agree that mathematics performance among students in the early grades is poor in Malawi?
  - Why do you think this is the case?
  - How do the current curriculum and textbooks contribute to pupil performance?

- To what extent are head teachers involved in teacher professional development and influencing learner outcomes?

- What, in your words, does it mean to do mathematics?
  - What mathematics skills and/or knowledge do you think Standards 1-4 pupils should therefore learn?
  - Are teachers sufficiently prepared to teach these skills? (TTCs)
  - What do you expect to see in an effective/good mathematics lesson? / What do you think makes an effective/a good) mathematics teacher? (TTCs)

- Do you use the national teaching standards to review/observe teaching performance?
  - How do you decide the quality of teacher/ trainee (TTCs) performance?

- How do teachers monitor pupil progress? / How are teachers trained to monitor pupil progress? (TTCs)
  - How do teachers adjust for different ability and developmental levels? / How are teachers trained to adjust for the different ability and developmental levels amongst the students in her class (TTCs)
  - How are pupils with special educational needs identified?
  - How do teachers support pupils with special educational needs in mathematics lessons?
    - Is there any other support available for them?

- What do you think are the key strengths and challenges of the National Reading Programme? (Probe on replace/fix approach to an intervention, TLCs, scripted lessons, capacity of district staff e.g. PEAs if not mentioned)

- What are the strengths and challenges of the new 2-2-2 syllabus and lesson study models? (TTCs)