Early Grade Mathematics in Phnom Penh, Cambodia

Data for this report was collected in June 2012 in collaboration with the Ministry of Education, Youth and Sport in Phnom Penh, Cambodia and the Global Partnership for Education

PURPOSE/OBJECTIVE

In preparation for their next grant from the Global Partnership, the Cambodian Ministry of Education, Youth, and Sport (MoEYS), expressed interest in understanding the current levels of student mathematics performance in their country. Cambodia has achieved great success in early grade reading, and after achieving this success, they are interested in assessing and improving other subject areas, like mathematics. Accordingly, the MoEYS requested technical assistance from the Global Partnership to start assessing mathematics education at the early grades (1, 2, and 3), since testing at the early grades assesses students when they may be first encountering problems in mathematics.

METHODOLOGY

In order to meet the objectives outlined by the MoEYS, 2 primary schools in Phnom Penh, were selected to participate in a small-scale study. In each of these schools, 20 students, per grade, were randomly selected to participate in early grade mathematics testing. An equal number of male and female students were tested. The randomly selected students were given a battery of assessments assessing basic mathematics skills which included: number line estimation skills, skip counting, double-digit subtraction, division, pattern recognition, and word problem skills [See examples of the assessments attached].

The assessments test the three parts of our brain that are used for mathematics. Our brains are configured to interpret numbers in three different ways: 1) Arabic codes: reading and writing Arabic digits (or digits in the local language) which are important for multidigit calculations; 2) Verbal codes: reading or writing the number as a word, such as "three," which is important for rote memorization like multiplication tables; and 3) Quantity codes: where the number is seen as a non-symbolic quantity, such as three dots, which is important for proximity judgment and approximation skills.

All three of these codes are important to build on for advanced mathematics, however, the Arabic code and Verbal codes are often times the only two codes emphasized in early grade mathematics curriculum. The quantity code is not emphasized as much.

Assessments for this battery came from RTI's Early Grade Mathematics Assessment (EGMA) and the Assessment Survey Evaluation Research test used in India. The objective of administering these tests was three-fold: 1) Try out early grade mathematics assessments in the Cambodian context and check their feasibilities; 2) Collect sample base line scores at the early grades based on these basic mathematics skills; and 3) Identify challenges students may be facing with these basic mathematics skills. Below are details regarding the tests:

- **Number line estimation**, from the EGMA test, measures children's estimation abilities (Siegler & Opfer, 2003). Estimation skills are essential in mathematics learning.

  In number line estimation activities participants are presented with a line with zero at one end and an upper limit number, such as 10, 100, or 1000, at the other end. Students are asked to estimate where on the line a certain number falls or estimate what number is represented by a mark on the line. Halberda, Mazzocco, and Feigenson (2008) note that people who approximate numbers quickly, and accurately, are more successful in advanced mathematics.

- **Skip Counting**, from the EGMA test, is a precursor to developing multiplication skills. Students are presented with a series of number sequences such as 3, 6, 9, 12 in which one of the numbers is left blank, and students need to fill in the sequence.

- **Double-digit subtraction**, from ASER. Students in grade 1 were not expected to do double-digit subtraction problems. This assessment targeted grades 2 and 3 students to understand how much of the curriculum they have mastered.

- **Division**, from ASER. Likewise, the division assessment targeted grade 3 students, however, can also be used to identify students in grade 1 and 2 who recognize the division symbol.

- **Pattern recognition**, from EGMA, like skip counting, tests students on their sequencing skills using non-symbolic values. Testing using non-symbolic values are important to ensure students have not simply memorized Arabic, or Khmer digits, and their values. In this test, students are presented with a series of shapes and asked to fill in the sequence.

- **Word problems**, from EGMA, are simple addition and subtraction problems that were read out the students (in case they had trouble reading) and also presented in paper in front of them. Students were offered manipulatives to help them solve these problems.

Number line, skip counting, and pattern recognition test students' problem solving skills and their ability to manipulate numbers beyond rote memorization.

Magnitude Processing Test. In addition to the battery of tests, students were given a 2-minute test which measures magnitude processing, or number discrimination skills. The 2-minute assessment is based on evidence that a simple number cancellation task can be related to individual differences in student's mathematics achievement (Durand, Hulme, Larkin, & Snowling, 2005) and tests a student's math skill based on their ability to compare and distinguish numbers (Holloway & Ansari, 2009; Bugden & Ansari, 2011). Therefore, students who are better at distinguishing numbers are proposed to have a higher mathematics achievement.

The magnitude processing test is divided into two sections. Each section has 56 problems and students are given 1 minute to complete as many problems as possible in that section. The average grade 1 student is expected to complete 28 problems. Grade 2 and 3 students should be able to finish 37 – 42 problems. Grade 5 students should come close to finishing the test, or all 56 problems (between 51 – 56 problems).

The first section asks students to select the larger of two numbers (in Arabic or Khmer script) and the second section asks students to select the larger of two non-symbolic quantities (presented as an array of dots). Since the non-symbolic quantities are an array of dots in a box, students are also tested on their approximation or estimation skills (as also tested in the number line activity).

A total of 120 students participated in these assessment activities (60 students from each school).

In addition to the administration of the assessment, 35 classroom observations (of grades 1, 2, and 3) were conducted across the two schools to measure time on task. 35 individual teacher interviews were also

conducted after classroom observations, and based on preliminary data analysis, short mathematics interventions were introduced to grade 1, 2, and 3 teachers to determine the feasibility of these interventions in the context of mathematics learning in Phnom Penh.

The magnitude processing test was also administered in 4 additional schools in grades 1, 2, 3, and 5. Grade 5 was chosen in this sample to see how far students have progressed in their mathematics curriculum. The purpose of administering this test in an additional four schools was to determine whether this short 2 minute test can act as a stand-alone assessment in determining students' mathematics achievement at the early grades. Logistically it was also possible to test a larger number of students (approximately 80 -100 per grade in each school, with an exception of a smaller student population in one school).

A total of 1,114 students were tested in the additional 4 schools. And, a total of 1,243 of the magnitude processing assessments were administered overall.

DISCUSSION OF RESULTS

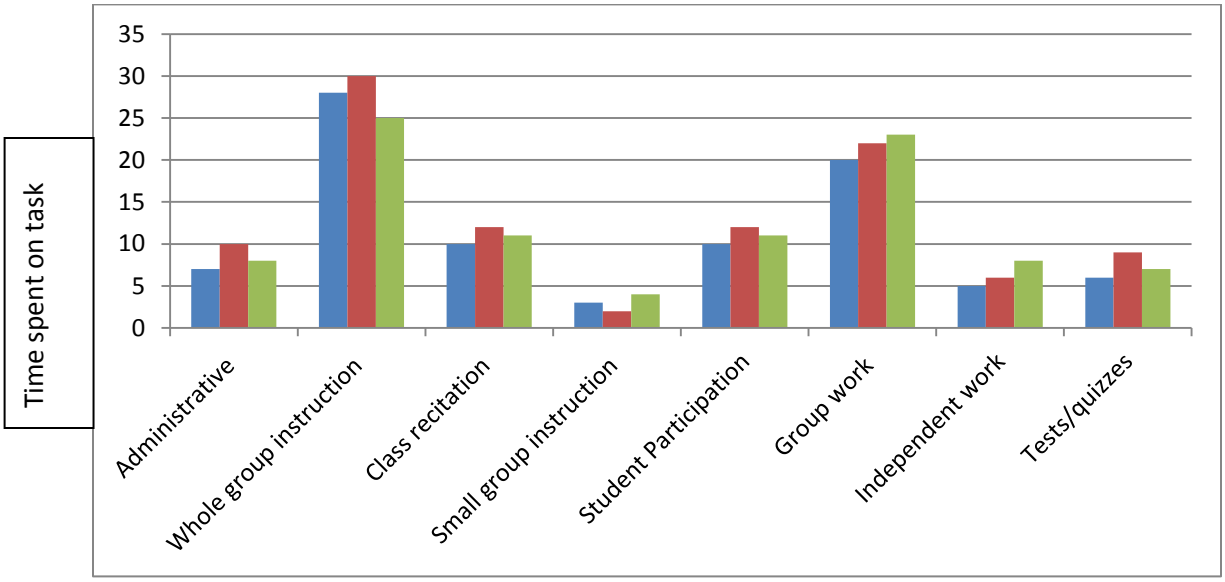
Summary of classroom observations/teachers interviews (Preah Norodom and Beung Salang)

35 classroom observations were conducted to measure time on task in the classroom. Teachers that were observed used structured lessons/scripts; therefore, time on task results were consistent across the 35 classrooms, and three grades. Whole group instruction, and group work activities dominated the tasks in a given 45 minute lesson.

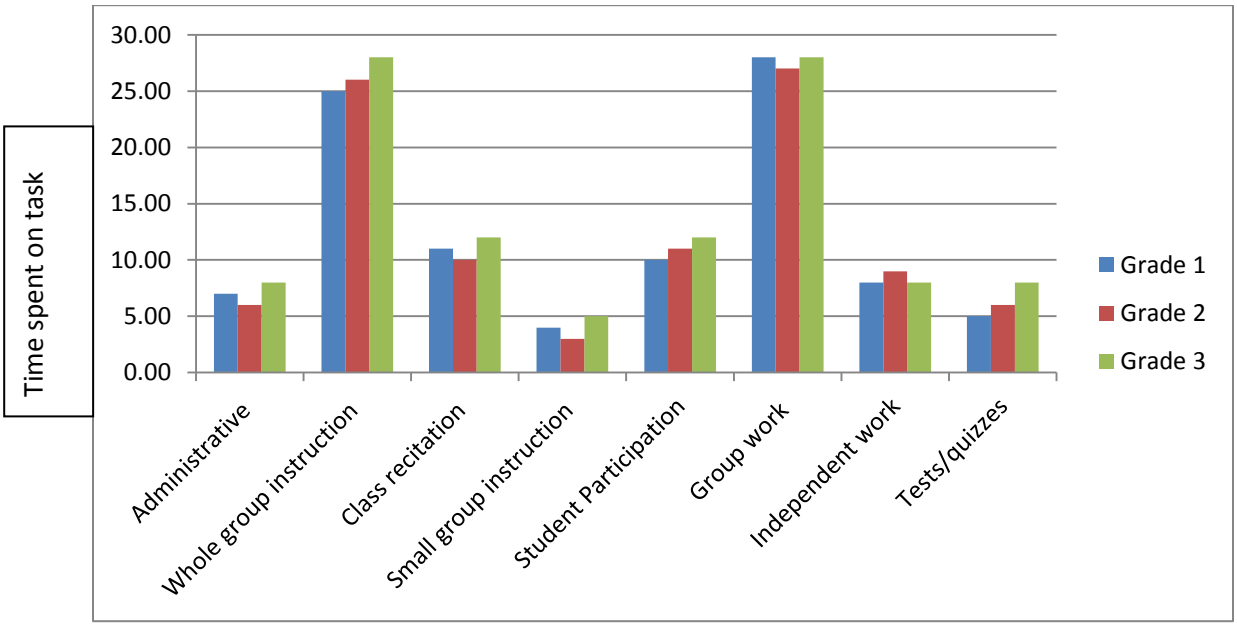
During the teacher interviews, 4 teachers, however, did mention that they do not regularly use the scripted lessons, which includes group and individual work. They felt that whole group instruction, or direct instruction, was more effective to ensure all material was covered in a timely fashion. These teachers mentioned that the scripted lessons were mainly used when they had more time, and when observers came to the class. However, given the consistency of the time on task across the classrooms, it shows that structured/scripted lessons can be used to ensure instruction is uniform across classes and schools.

All classrooms had chalkboards, desks for the students, textbooks, and students had little chalkboards or whiteboards which they used for group and individual activities. 80% of the classrooms, however, lacked number charts or other type of arithmetic charts (like multiplication charts).

Time on task in the Primary School Preah Norodom; average time spent in classes: 45 minutes; Total 18 classes observed



Time on task in the Primary School Beung Salang; average time spent in classes: 45 minutes; Total 11 classes observed



35 teachers from Preah Norodom and Beung Salang were interviewed after classroom observations. They were asked about the challenges they faced in teaching the mathematics curriculum. Close to 90% of the teachers interviewed mentioned that there is not enough time to cover all the material in the curriculum during the school year. To complete a full mathematics lesson, teachers said they need at least 1 to 1 ½ hours. However, given there are about 4 hours in the school day, and teachers also need to teach Language and Social Studies, teachers find it challenging to cover all the material in the mathematics curriculum. 5 teachers added that due to the large amount of curriculum to cover, they felt that students were not grasping material properly.

Teachers also discussed these content areas students faced difficulties with in mathematics:

- Grade 1 Difficulties: Learning numbers past 30 (difficult for students, because they cannot keep track of the numbers using their fingers); Volume and measurement
- Grade 2 Difficulties: Addition and Subtraction (specifically with carry overs); Multiplication Tables
- Grade 3 Difficulties: Multiplication tables; Word Problems; division

Summary of the battery of assessments (Preah Norodom and Beung Salang)

A total of 120 students participated in these battery of assessments between the two schools, which was divided into 40 students per grade, and 20 male students and 20 female students per grade.

Students from both Preah Norodom and Beung Salang scored close to their grade level on the assessments that tested their Arabic and Verbal codes, such as on subtraction and division (no statistically significant differences). However, they scored below average on the assessments that measured their Quantity code skills, which includes approximation, manipulations, and problem solving. For example, in both schools, scores for both the number line activity and pattern recognition tests were below average. 5-10% below average for the number line assessment and close to 20% below average for pattern recognition. In Beung Salang, grade 1 students averaged a score of 0 on the number line assessment. As discussed earlier, estimation skills are an important skill to learn in early grade mathematics, and helps with quantity manipulation as well as problem solving skills. Learning the Quantity code will also complement student learning of multiplication, division, and multi-digit calculations. More attention needs to be given towards addressing Quantity codes in mathematics instruction. These are important skills that need to be addressed in pre-school, and Kindergarten, and are building blocks in mathematics.

Overall observations on demographic data collected

Across the 6 schools, data collection included age of the child, gender, and whether or not the child attended pre-school.

- Data showed a large age variance within a single grade. In grade 1 classes, ages ranged from 6, 7, 8, 9 (age 7 being the mode). In grade 3 classes, ages ranged from 8 to 12 (age 9 being the mode). It is uncertain why this variance exists, and this will be important to identify why in future data collection samples. It could be that students are starting school late or repeating grades. If they are repeating grades, this will impact assessment scores, as students will see information multiple times (as opposed to being exposed to material for the first time).
- Data showed that overall pre-school attendance was 50%. More boys attended pre-school than girls. Without pre-school education, in many cases, children are exposed to numbers and concepts of numbers for the first time in 1st grade, and therefore, this delays their progress in mathematics.

Overall student performance on magnitude processing (all 6 schools)

A total of 1,243 students participated in the assessment. Here is a breakdown per grade level. Grade 1 students: 395; Grade 2 students: 312; Grade 3 students: 350; and Grade 5 students: 186

Overall, students performed slightly below the average (10% – 20% below) on the magnitude processing assessment. Their performance was on par to urban areas tested in India. Although students were below the average on both sections, it is important to note, that as grade levels progressed (from grades 1 to 5), students' performance was stronger on the symbolic section of the assessment.

Grade 1 students averaged 21% below the average score for the symbolic section and averaged 11.20% below the average score for the non-symbolic section of the test. Although results varied slightly by schools, in general, since students in grade 1 performed better on the non-symbolic sections, this indicates that their Khmer script number sense is still developing. This is normal, and also indicates that children come to school with stronger Quantity codes. Students in grades 2 and 3 performed better on the symbolic magnitude processing test, indicating that the Arabic and Verbal codes are more likely emphasized in the early grade instruction and curriculum (this is also seen in the mathematics textbooks). Therefore, although students come to school, in grade 1, with stronger Quantity codes, as they progress in the curriculum, their Arabic and Verbal codes dominate. This also shows why students in Preah Norodom and Beung Salang performed close to the average on the Arabic and Verbal code assessments. However, as mentioned earlier, in order to be successful in mathematics, particularly in the higher grades, students need to develop all three codes: Verbal, Arabic, and Quantity.

In an ideal situation, students are expected to perform equally on both sections of the assessment as this indicates that they are using the three areas of the brain needed to succeed in mathematics. However, what is noticed in mathematics curriculum and instruction is that tasks related to developing the Arabic and Verbal codes is emphasized more than tasks related to developing Quantity codes. For example, through rote memorization, students will learn the number "three" as a value 3 and immediately recognize these values. However, when they are presented with three dots, it will take them longer to decode that three dots is the value 3 or "three." All three interpretations, however, are important for students to understand and advance in mathematics.

In the 4 schools where grade 5 children were tested, students also performed below average, and performed better on the symbolic (average of 9.88% difference) compared to the non-symbolic (average of 12.41% difference). Again, students performed worse on the non-symbolic section.

Below is a summary of the percent differences. More details are available in the appendix.

Percentage below the average scores on magnitude processing test -- grades 1 to 3 (all six schools)

	Grade 1	Grade 2	Grade 3
Symbolic	21.00%	11.00%	2.1%
Non-symbolic	11.20%	19.46%	18.82%

The primary school Wat Toul Tumpong was an exception, where grade 2 and 3 students scored, on average, 10 points higher on the symbolic section than the expected score for their grades.

Based on this preliminary data collected in Phnom Penh, more attention needs to be given to teaching Quantity codes, including problem solving, manipulating numbers, and estimation skills. Interventions based on these concepts can be introduced into teacher training and activities can be included in the mathematics curriculum.

In addition, to get a better perspective on mathematics education in Cambodia, in preparation for the next GPE grant, it is recommended that a similar study be carried out in rural areas get a better understanding on the technical assistance Cambodia may need on mathematics.

SAMPLE INTERVENTIONS

Below are some interventions that were introduced to teachers, and worked well in the classroom context:

1. **Present information in multiple ways.** Students have 12-15 seconds to retain information, so the more often they see information, and in multiple ways, the more likely they are going to remember the information when applying it. Material can be presented using:
    a. Visual aides
    b. Manipulatives
    c. Analogies
    d. Show and tell
2. **Sample activities:**
    a. Estimation: Treasure hunt activity
        i. In this activity, students are asked to measure themselves against a meter stick, so they have an "estimated" idea of how tall they are. Then students are asked to identify objects in the classroom that are shorter than them, or taller than them, and "estimate" the length of these objects. A doorway is one example.

    b. *Manipulating numbers:* Fill in the blank. As the number of dogs increases, what happens to the ears?

DOGS	**1**	**2**	**3**	**5**	**7**	**8**
EARS	2	4			14	

    c. Manipulating numbers using word problems
        i. Example word problem: There are 6 cans in a row and Kumari must knock over can 3 and can 1 to score 4 points. Which cans must Kumari knock over to score 5 points? Find another way to score 5 points? Find 3 different ways to score 6 points. Find 3 different ways to score 7 points. Find 4 different ways to score 8 points? If Kumari knocked all the pins down, what would her score be?

    d. Group/whole classroom manipulation exercises:
        i. Single digit arithmetic

        1. I have 2, what do I get if I add 5?
        2. What must I add to 3 to get 8?
    ii. Arithmetic with multiples of 10
        1. I have 30, what will I get if I add 50?
        2. I have 70, what will I get if I take away 30?
        3. What must I add to 10 to get 70?
        4. What must I take away from 90 to be left with 30?

e. Group/whole classroom manipulation exercises:
    i. Adding to multiples of ten
        1. I have 17, what will I get if I add 33?
        2. What must I add to 27 to get 60?
        3. Subtracting to multiples of ten
        4. I have 27, what do I get if I take away 7?
        5. What must I take from 45 to get 40?
    ii. Subtracting from multiples of ten
        1. I have 70 what do I get when I take away 8?
        2. What must I take away from 40 to get 36?

APPENDIX –ADDITIONAL DATA

I. Primary School 1: Preah Norodom Primary School

a. Distribution of sample by grade and gender & gender and age

Grade	Gender		
	Boys	Girls	Total
1	10	10	20
2	10	10	20
3	10	10	20

Equal numbers of boys and girls were selected from each grade; a total of 60 students were tested.

Distribution of sample by gender and age							
Age	6	7	8	9	10	11	12
Boys	2	6	16	4	1	0	1
Girls	4	3	11	5	6	0	1

Distribution of sample by grade and age							
Age	6	7	8	9	10	11	12
Grade							
1	6	9	4	2			
2		1	18	2			1
3			4	9	7		1
Total	6	10	26	13	7		2

Majority of students are 8 years old

Distribution of the sample by gender and pre-school attendance			
Gender	Yes	No	Total
Boy	15	15	30
%	50.00	50.00	100
Girl	14	16	30
%	46.66	53.33	100
Total	29	31	60
%	48.33	51.66	100

Approximately half of the students tested attended pre-school.

Percentage differences on magnitude processing test

	Grade 1	Grade 2	Grade 3
Symbolic	27.70%	10.90%	2.67%
Non-symbolic	19.60%	11.80%	25.70%

II. Primary School 2: Beung Salang

Grade	Gender		
	Boys	Girls	Total
1	10	10	20
2	10	10	20
3	10	10	20

Distribution of sample by gender and age							
Age	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Boys	2	4	14	2	7		1
Girls	1	3	12	2	10		2

Distribution of the sample by gender and pre-school attendance			
Gender	**Yes**	**No**	**Total**
Boy	15	15	30
%	50	50	100
Girl	5	25	30
%	16.67	83.33	100
Total	20	40	60
%	33.33	66.67	100

Distribution of sample by gender and age							
Age	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Grade							
1	4	7	6	3	1		
2		1	10	3	7		1
3			2	5	10	1	1
Total	4	8	18	11	18	1	2

Percentage differences on magnitude processing test

	Grade 1	Grade 2	Grade 3
Symbolic	22.50%	12.50%	1.78%
Non-symbolic	7.50%	29.30%	2.32%

III. WAT TOUL TUMPOUNG

Percentage of children who attended pre-school	
Grade 1	68.40%
Grade 2	43.00%
Grade 3	46.20%
Grade 5	87.10%

Percentage differences on magnitude processing test

	Grade 1	Grade 2	Grade 3	Grade 5
Symbolic	18.20%	5.36%	33.20%	0.71%
Non-symbolic	15.10%	33.90%	0.71%	0.72%

Scores in red indicate that students performed above the expected scores.

IV. PREAH ANG ENG

Percentage of children who attended pre-school	
Grade 1	40.00%
Grade 2	28.60%
Grade 3	44.60%
Grade 4	85.00%

Percentage differences on magnitude processing test

	Grade 1	Grade 2	Grade 3	Grade 5
Symbolic	11.64%	9.57%	9.14%	5.00%
Non-symbolic	14.00%	5.85%	17.71%	9.28%

V. KOLAB MOIE

Percentage of children who attended pre-school	
Grade 1	53.20%
Grade 2	60.42%
Grade 3	71.43%
Grade 5	90.00%

Percentage differences on magnitude processing test

	Grade 1	Grade 2	Grade 3	Grade 5
Symbolic	19.20%	12.60%	20.53%	17.61%
Non-symbolic	9.75%	14.14%	30.46%	20.53%

VI. TOULE SANKE

Percentage of children who attended pre-school	
Grade 1	49.30%
Grade 2	59.40%
Grade 3	35.50%
Grade 5	66.70%

Percentage differences on magnitude processing test

	Grade 1	Grade 2	Grade 3	Grade 5
Symbolic	26.60%	13.82%	11.68%	17.61%
Non-symbolic	1.14%	21.80%	37.43%	20.54%