Formative Design in the Development of Primary Mathematics Materials in Liberia and Kenya

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Outline

• Liberia
  – Background
  – Methods
  – Results & recommendations

• Kenya
  – Background
  – Lesson design
  – Results and Revisions
Background

- Intervention Program
- Development of New Materials for Classroom Use
- Teacher Professional Development
- Materials Revision
Background

Teachers don’t follow materials because they don’t understand them

Teachers are trying to teach the best lesson possible
High-level Conclusions

• Teachers modified existing lessons, in ways that either helped or hurt overall effectiveness of the lessons

• Close examination of teacher practices is a rich source of evidence for materials development
Liberia Teacher Training Project (LTTP)

- structured lesson plans and student books in reading and math for teachers in grades 1-3
- intensive training of Reading & Math Specialists, coaches and teachers
Methods

- 15 teachers in 3 counties
- Observations focused on pacing, use of materials, and modifications to the lessons
Results

Modifications (n=35)

1. Categories
   • Student participation
   • Elaboration of content
   • Sequence of the Lesson

2. Hurt or help effectiveness, Based on ”best practices”
   • Active learning
   • Clear explanation of content
   • Instructional model

Difficulty with Mathematical Representations
Modifications

% of modifications

- Sequence and Timing
- Elaboration of Content
- Student Participation

- Hurt effectiveness
- Helped effectiveness
Student Participation

Helped Effectiveness

What the lesson said:

Class, how many sides and angles do the triangles have? How do you know?

What the Teacher did:

3 sides

3 angles
Student Participation

Hurt Effectiveness

What the lesson said:

Class, can you tell me different ways to make 20 by adding 2 or 3 numbers?

What the Teacher did:

10 + 10 = 20
15 + 5 = 20
12 + 8 = 20
14 + 6 = 20

Here are ways to make 20 by adding 2 or 3 numbers.
Recommendation

• Increase opportunities for teachers to check for understanding immediately after demonstrating content
• Integrate more “why?” questions
Elaboration of Content

Before you start, let’s review our number family for 10. What numbers make 10?

Class, today you will find numbers in the number family for 10 using numerals and arrays in your copybook.

What the lesson said:

What the Teacher did:

4 + 6 = 10
3 + 7 = 10
8 + 2 = 10

Before you start, let’s review our number family for 10. What numbers make 10?
Elaboration of Content

Hurt Effectiveness

What the lesson said:

Class, how many circles and rectangles on the board?

Class, how many circles and rectangles? Can you count the circles and rectangles?

What the Teacher did:

Class, can someone count the rectangles?

Class, how many rectangles? Can you count the circles and rectangles?

Class, how many circles?
Recommendations

• Provide resources in the teachers guide for teachers to review content they feel their students need

• Provide pacing guidelines

• Provide clear indications of the purpose of each step
Summary

• by using help/hurt framework, recommendations take advantage of what teachers were doing
  – try to reduce likelihood of modifications that hurt effectiveness
  – Try to increase likelihood of modifications that help effectiveness
Today I will teach you about place values and how to show them with number sentences.

**Step 1**
Draw a tens frame (2 rows of 5 boxes) on the board. Write the numeral 12 nearby.

*This is a tens frame. We have used this kind of chart before to show the numbers from 0 to 10. Now I want to show the number 12. Count with me while I fill the frame with dots: 1-2-3-4-5-6-7-8-9-10. I have filled the tens frame, but I need to count 2 more to reach 12.*

Draw another tens frame on the board to the right of the first one.

*I add 2 more dots to this new tens frame and finish counting: 11-12. These frames together now show the number 12. I can say that the full frame is 1 “ten” and the dots in the unfilled frame are “ones.”*

Point to the tens place and ones place in the number 12 as you discuss each place value.

*Looking at the number 12, the 1 means there is 1 ten. The 2 means there are 2 ones. The parts of this numeral are its place values. Now I can write 12 as a number sentence: 12 equals 1 ten plus 2 ones.*

Write $12 = 10 + 2$. Point to the 1 and write “tens” over it. Then point to the 2 and write “ones” over it.
Draw this tens frame on the board:

This is a tens frame. I want to show the number 12. Count with me as I fill it in.

I need to count 2 more to reach 12. Draw another tens frame to the right. Draw 2 more dots and finish counting.

These tens frames now show the number 12. The first frame is the 1 “ten” and the dots in the unfilled frame are “ones”.

Look at the number 12. The “1” means there is 1 ten. The “2” means there are 2 ones. Now I can write 12 as a number sentence.
Conclusions

• Liberia
  – Example of qualitative observations to review materials to inform revisions

• Kenya
  – Materials revision process
  – Results and revisions
Improving Math in Kenya: The PRIMR Approach
Kenya Background

- Vision 2030 emphasizes Math
- Kenyan textbooks focus on computation
- Reorganize the sequence
- Practice varied strategies
- Need much more time on task
Kenya PRIMR

• Primary Math and Reading (PRIMR)
• Supports 1384 schools in 7 counties
• DFID and USAID funding
• Randomized Control Trial (RCT)
• 2-3 days of teacher training of 10 total
• Math integrated with literacy
• Focus on affordability
PRIMR Math Design

- Explaining thinking (even for computation)
- Number sense activities
- Multiple strategies to solve problems
  - Creates procedural fluency and flexibility
- Training quality depends on modeling/practice
- Daily instructional feedback is essential
- Builds on Liberia LTTP2 Math materials
- Pupil Activity Book
Grade 1 book

2013 design

Number what happens first (1), second (2), and third (3).
1. 
   ![Image 1](image1)
   2. 
   ![Image 2](image2)

Write the number of shapes.
3. 
   ![Image 3](image3)
   4. 
   ![Image 4](image4)
   5. 
   ![Image 5](image5)
   6. 
   ![Image 6](image6)

Write the numerals that come next.
7. 
   1, 2, 3, 4, 5
8. 
   1, 2, 3, 4
9. 
   1, 2, 3, 4, 5

Draw lines through the circles.

2014 design

Number what happens first (1), second (2), and third (3).
1. 
   ![Image 7](image7)
   2. 
   ![Image 8](image8)

Count and write the number of shapes.
3. 
   ![Image 9](image9)
   4. 
   ![Image 10](image10)
   5. 
   ![Image 11](image11)
   6. 
   ![Image 12](image12)

Write the numbers that comes next.
7. 
   1, 2, 3, __, __.
8. 
   1, __, __, __, __.

Draw lines through the circles.
2013 Scripted Lesson Plans

LESSON PLAN  WEEK 7, DAY 3

<table>
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<th>Subject</th>
<th>Class</th>
<th>Date</th>
<th>Time</th>
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Introduction (5 min.) Review

- Good morning, children. Today we will learn how to count by 2s starting with 1 and ending with 9. We will also count to 20 from a number between 10 and 19. And we will learn how to use objects to help us take 1 away from a number up to 10.
- Before we begin our new lesson, let’s practice counting by 2s starting with 0. Let’s also practice finding number families up to 10 using our fingers.

Development (20 min.)

Now, using the instructional model below, teach pupils to count by 2s to 9 starting at 1, to count to 20 from a number between 10 and 19, and to subtract 1 from a number orally, using objects to help them.

We just counted to 10 by 2s starting at 0. Now I will teach you how to count by 2s to 9 starting at 1.

Step 1

Write the numerals from 1 to 10 in a line on the board. Point to each numeral as you count it.

To count by 2s starting at 1, I count a number and then skip the next number: 1, 3, 5, 7, 9.

Count by 2s from 1 to 9 a few times, saying each number clearly and slowly. Point to each numeral on the board as you say the number.

Step 2

Next, let’s talk about counting to 20 from numbers between 10 and 19. I have counted to 20 starting at 10. To count to 20 from a number other than 10, I simply start at a different number and count the same way.

Count from 11 to 20 and then from 12 to 20, saying each number clearly and slowly.

Step 3

Now I will solve a problem. Let’s say someone asks me to take away 8 from 1. I can use objects to help me.

Show 8 beans or other similar objects. Then take 1 away to show how you can subtract using objects.

If I start with 8 objects and take 1 away, I have 7 objects left. Now I know that 8 take away 1 equals 7.

Evaluation

Note where pupils make errors or have difficulties. Suggest how future lessons can address these problems.

Notes:
2014 Scripted Lesson Plans (Week 1 to 3)

TEACHER’S GUIDE  WEEK 1, DAY 5

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Topics
Whole numbers

Activities
- Basic addition of different objects to make 2
- Creating groups of 5 and writing the number 5

Objectives
By the end of the lesson, pupils will be able to:
- add objects to make 2.
- create groups of 5 objects and write the number 5.

Learning Resources
1. Objects of different sizes: bottle tops, beans, and tin cans (5 bottle tops and 2 each of other groups of objects)
2. Pupil’s exercise books

Pupil Activity Book
Classwork page 5

Introduction (5 min.)

Review
- Good morning, children. Today we will learn to add 2 objects together to make groups of 2. We will also learn to create a group of 5 objects and write the number 5.
- Before we begin our new lesson, let’s practice sorting objects.
- Draw the following groups on the board: circles, squares, and triangles. Ask pupils to sort out the shapes that look a like.

Development (20 min.)

New
Using the instructional model below, teach pupils how to put 2 objects together. Gather objects before you begin.

Teacher Activities “I do.”

Now I want to teach you how to write the number 5 and how to combine groups. When we combine the groups, we put them together to make larger groups.

Activity 1: Whole numbers: Writing numbers
Demonstrate: Everyone, watch me. I am going to write the number 5 on the board. To write the number 5, you start at the upper left, draw a straight line halfway down, form a loop around to the right, and then come back to the top and draw another line moving to the right. Write a 5 on the board.
Show pupils 5 objects and point to the number 5. This is number 5. I also have 5 objects. Let me count the objects. Count the objects. 1, 2, 3, 4, 5.

Guide: Now let’s talk about the number 5. Call out the number 5 as I write it.
Write the number 5 on the board as pupils call out. Then show pupils how to write a 5 in the air, facing the same direction with them.
Let’s write a 5 in the air together.
Use your finger to show how to write a 5 in the air.
Now write number 5 in your books.

Activity 2: Operations: Addition as putting together
Demonstrate: I am going to combine 1 bottle top and 1 more bottle top to make a group of 2 bottle tops. I will say, “1 bottle top and 1 bottle top is 2 bottle tops.”
Show the bottle tops individually. Then pick up each bottle top to add it to a pile (1 at a time). Say the quoted sentence above as you do this.
Then add 2 bottle tops to another 2 bottle tops, using a similar sentence.

Teacher/Pupil Activities “We do.”

Now write number 5 in your books.

Teacher Activities “I do.”

Guide: Let’s practice combining objects.
Draw 2 bottle tops. Choose a pupil to combine these to make a group of 2.
If we combine 1 ball and 1 more ball, how many balls do we have? (2)
That’s correct, 1 ball and 1 ball makes 2 balls. Repeat by putting 2 pencils together as a group.
How many pencils are in the group after we combine 1 pencil and 1 other pencil? (2)
That’s right, 1 pencil and 1 pencil makes 2 pencils.
2014 Teachers’ Guides

Week 7, Day 3

Introduction
Draw a number line with numbers 1 to 10 and let the pupils count from 1 to 10.

Development
Activity 1: Operations: Number families
- **Demonstrate:** Have two pupils come in front of the class; the first to raise 5 fingers and the second to raise 3 fingers. Count all the raised fingers to get 8.
- Explain to the pupils that 5 and 3 make a family of 8.
- **Guide:** Using the 2 pupils, show how to make other families of 8 by asking one pupil to fold a finger to get 4 while the other raises one more finger to get 4.

Activity 2: Operations: Number patterns
- **Draw:** Draw a number line from 0 to 10 on the board.
  
  0 1 2 3 4 5 6 7 8 9 10
- **Demonstrate:** Tell the pupils that numbers on a number line increase from left to right.
- **Draw:** Draw a number line on the board as shown.
  
  0 1 2 3 4 5 6 7 8 9 10
- **Guide:** Work with the pupils to fill in the missing numbers as they count.

Activity 3: Whole numbers: Equivalence
- **Draw:** Draw 2 groups of 5 stones each.
- **Demonstrate:** Count each group and write the number they represent.
  
  5 5
- **Draw:** Write the equal sign to show that the 2 groups of 5 are equal. \(5 = 5\)

Weekly Homework
Write how many more objects you need to make a family of 8.
1. \(\triangle \triangle \triangle \triangle \) ______.
2. \(\odot \odot \odot \odot \odot \) ______.
3. \(\square \square \square \) ______.
Write the next numbers.
4. 15, 16, ____, ____, ____, ____, ____, ____, ____, ____, ____.  

Teacher Tip
From: Teacher Linda
For counting activities, you can make use of the hundreds chart which is at the back of all the pupil books. This will spare you from writing the numbers down.

Match the numbers of objects in the family of 8.

Week 7, Day 3

Fill in the missing numbers.

Count the shapes. Write the numbers or equal sign.

Count by ones. Write the next numbers.

Remarks:

Week 7, Day 3: ____________________________
Duration: ____________________________
Roll: ____________________________
Initial Feedback on 2014 changes

• Shorter lessons
• Increased teacher flexibility
• Increased teacher/pupil interaction
• Correlation between materials
• Training focuses on strategies
• Take-up is significantly higher
Impact of USAID PRIMR on Math (2013)
### DFID PRIMR Research Design

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<th>Lesson Plans</th>
<th>Pupil Books</th>
<th>Training</th>
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Impact of DFID PRIMR by Treatment

Bar chart showing the impact of PRIMR by treatment type for various math topics.

- **Number ID (cpm)**
- **Quantity (%)**
- **Missing # (%)**
- **Word Problems (%)**
- **Addition (cpm)**
- **Subtraction (cpm)**

Legend:
- Full PRIMR
- Books & Training
- Training Only

Math topics include:
- Word Problems (%)
2013 Effect Size Comparison by Subject

USAID - 1 year of Math

- English: 0.46
- Kiswahili: 0.35
- Math: 0.20

DFID - 4 months total

- English: 0.25
- Kiswahili: 0.35
- Math: 0.22

DFID - 4 months total
Reflections

- Comparison with the US?
- Improve automaticity and number sense
- Exam structures need overhaul
- Teachers need teacher’s guides
- Choose from teacher’s guide design options
- Use varied strategies
- Math is easier to improve alongside literacy
Thank You!
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