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Towards the Design and Implementation of Comprehensive Primary Grade Literacy and Numeracy Programs

A Working Paper by the Global Reading Network

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Acknowledgments

This document, *Towards the Design and Implementation of Comprehensive Primary Grade Literacy and Numeracy Programs: A working paper from the Global Reading Network*, was developed for the United States Agency for International Development (USAID). It is intended to support all stakeholders involved in designing, implementing or overseeing early grades literacy and numeracy program development and implementation. It provides a wealth of information about the synergies and unique characteristics of early grades literacy and early grades numeracy programs. It is our hope that implementers will find it useful in their work, as they strive to provide quality education for all young learners, and set them on a strong foundational pathway toward future learning.

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LIST OF ACRONYMS

BMLK	Big Math for Little Kids program
CK	Content knowledge
CPA	Content, Pictorial, Abstract or Symbolic
EDC	Education Development Center
EGMA	Early Grade Mathematics Assessment
EGRA	Early Grade Reading Assessment
ESSP	Education Sector Strategic Plans
GRN	Global Reading Network
IDB	Inter-American Development Bank
LMIC	Low- and Middle-Income Countries
LMT	Learning Mathematics for Teaching project
MERL	Monitoring, evaluation, research and learning
MKT	Mathematics knowledge for teaching
OECD	Organization for Economic Co-operation and Development
OEI	Organization of Ibero-American States
ORF	Oral reading fluency
PCK	Pedagogical content knowledge
PIRLS	Progress in International Reading Literacy Study
TIMSS	Trends in International Mathematics and Science Study
TK	Technological knowledge
TPTK	Teacher pedagogical technological knowledge
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WASH	Water, sanitation and hygiene

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MOSAIC

Towards the Design and Implementation of Comprehensive Primary Grade Literacy and Numeracy Programs

Comprehensive (adj.): Complete; including all or nearly all elements or aspects of something

Executive Summary

Over the last decade, the international donor community has focused considerable resources on increasing literacy levels in the early grades as a means of improving learners' overall academic success. Learners' early grade reading skills predict their reading abilities in later grades (Butler et al., 1985; Stainthorp & Hughes, 2004; Wagner et al., 1997) as well as their overall future academic performance (Francis et al., 1996; Juel, 1988; Lipson & Wixson, 1997; Snider & Tarver, 1987; Wharton-McDonald et al., 1998). However, learners' overall academic success is also predicated on their early numeracy skills. These skills predict the likelihood learners will repeat a grade (Duncan-Magnuson, 2011), their later achievement in numeracy, and their reading abilities (Duncan et al., 2007, Watts et al., 2014; Claessens & Engel, 2013).

The MOSAIC Framework

Given the strong predictive relationship between early numeracy and literacy skills and overall academic success, it is clear that learners need to develop strong skills in ***both*** these disciplines. The most promising means of achieving this goal in low- and middle-income countries is via interventions that are "pedagogy and learning focused" (Crouch & DeStefano, 2017), i.e., that direct resources to aspects of educational systems that have a direct bearing on the quality of teaching and learning. The MOSAIC framework described in this paper is a tool to assist interventions in meeting the standards for "pedagogy and learning focused" large-scale and comprehensive literacy and numeracy programs.

The six components of the MOSAIC framework are:

1. **Enabling Policies and Standards:** Ensuring that the content and pacing of learning in literacy and numeracy curricula respect research-based learning progressions in each discipline, that there are clear standards and benchmarks in place for assessing learners' progress and that the policies needed to enable improved learning in both disciplines (minimal instructional time, delivering instruction in a language learners understand and are able to use, monitoring learners' progress with respect to standards and assessment, etc.) are in place.

2. **High-Quality Texts and Materials:** Teachers and learners need access to high-quality print and non-print literacy and numeracy instructional materials that align with evidence-based instructional models and practices for each discipline, both print and non-print (reading primers, math work/text books, etc.). In the case of numeracy, a critical component of high-quality materials is the use of

appropriate and accurate mathematical models (manipulatives, objects, diagrams, etc.) to represent and explain abstract ideas.

3. **Effective Teachers and School Leaders:** Merely providing learners with learning resources is not sufficient to improve learning outcomes (McEwan, 2015; Tilson et.al., 2013b, cited in Kim et al., 2016). Learning outcomes improve when learners have access to learning resources AND teachers receive training on the use of those resources (RTI, 2015, cited in Kim et al., 2016). Investing in good teacher education at both the preservice and in-service level is in fact the most research-based strategy available to programs focused on improving learning outcomes (Allington 2002). Learning-focused literacy and numeracy interventions need to equip teachers with discipline-specific, cross-disciplinary, pedagogical and content-related knowledge and skills required to deliver effective instruction, as well as the technological knowledge required to use evidence-based literacy and numeracy instructional materials appropriately. Finally, school leadership accounts for about a quarter of the total of all school effects on children's learning outcomes (Leithwood et al., 2004). Learners in schools where head teachers adopt effective leadership practices have higher learning outcomes than those in schools where head teachers do not (Seashore Louis et al., 2010; Leithwood et al., 2004). Learning-focused interventions need to ensure that school leaders understand school and classroom-based decisions and actions that result in improved literacy and numeracy learning outcomes and have the skills and tools necessary to implement them.

4. **Effective Teacher Coaching and Mentoring:** Training, when accompanied by ongoing coaching or mentoring, offers the maximum possibility of teachers implementing new practices, and subsequently of children improving their learning outcomes (Joyce & Showers, 1982, Cilliers & Taylor, 2017). For that reason, learning-focused interventions need to ensure that coaches or mentors knowledgeable in effective literacy and numeracy instructional practices provide ongoing support to teachers and head teachers. This includes modeling for teachers how to implement discipline-specific and cross-disciplinary instructional models, as well as how to use new instructional materials effectively, and providing teachers with focused feedback on their classroom practices. Coaches or mentors also need to provide school leaders with focused feedback on the quality of their school and classroom-based initiatives to improve learning outcomes.

5. **Continuous Assessments that Inform Instruction:** Learners whose teachers assess their performance on a regular basis, and with respect to performance standards and benchmarks, have better learning outcomes (Piper & Korda, 2011, cited in Popova et al., 2018). When that information is used to guide future instruction and identify remediation efforts at the class or individual learner level, learning outcomes improve (Black & William, 1998). For that reason, comprehensive, learning-focused literacy and numeracy interventions need to ensure that all levels of the education system, from the classroom to the national level, have the tools and skills necessary to gather informal and formal data on learners' literacy and numeracy progress and performance with respect to established standards and benchmarks, and to implement appropriate remediation efforts for those in need.

6. **Regular Practice Outside of School:** There is a direct correlation between the total amount of time learners spend practicing skills in context and children's learning achievement (Allington,

2014; Cunningham & Stanovich, 1998; Krashen, 2004). One way to increase the amount of literacy and numeracy learning time is to ensure that children have opportunities to engage in authentic and context-embedded numeracy and literacy learning activities outside the boundaries of the classroom and school.

Each of the six components addresses elements critical to improving classroom teaching and learning in low- and middle-resource countries (see Kim et al., 2016). All six, when implemented in a cohesive, integrated and synergistic manner, result in a comprehensive, learning-focused intervention identified by Crouch & DeStefano (2017) as holding the greatest potential to produce large-scale improvements in learning outcomes.

The six components are necessary to produce optimal gains. However, the level of attention or resources that need to be directed to different components of the MOSAIC framework, or to literacy versus numeracy, to produce desired results is context dependent. In certain contexts, some of the MOSAIC components may already be in place – or will soon be in place thanks to support from other donors. In such contexts, resources can be directed to those components requiring additional support. In other contexts, it may be necessary to distribute resources across all six components, and for both literacy and numeracy. Undertaking a data-driven process to map the existing environment with respect to the six MOSAIC components is a first step to identifying existing gaps, and by extension how best to distribute available resources.

Finally, although the evidence base for the design, delivery and monitoring of literacy programs is considerable and growing, the same cannot be said of numeracy. There is a need for a more extensive and systematic evidence base for the design and delivery of effective primary numeracy programs in low- and middle-income contexts, as well as programs that have a dual focus on literacy and numeracy. Among the research gaps is a need to better understand teachers' application of key evidence-based numeracy instructional strategies, including their use of problem-solving-based instructional models and of manipulatives to represent abstract concepts. There is also a need to better understand effective ways of increasing teachers' numeracy pedagogical content knowledge.

Purpose and Structure of this Paper

This paper seeks to advance the international education community's reflections on how to design primary grade literacy and numeracy programs that bring an efficient and effective dual approach to the teaching of both essential skills. It proposes an overall planning framework that is "pedagogy and learning focused," and that lends itself to the implementation of comprehensive and system-wide reform. The framework, known as the MOSAIC, identifies the essential components of sustainable, scalable programs (cf. Crouch & DeStefano, 2017; Fullan, 2000; Moore et al., 2017) and describes how they can be actualized in literacy and numeracy initiatives for the primary grades. Using the MOSAIC framework can assist program developers in designing context-appropriate interventions that honor the integrity of both disciplines, while leveraging the natural connections between them.

This paper contains four chapters, plus a glossary and appendix:

- Chapter A summarizes foundational literacy and numeracy skills that children begin to acquire before, and just after, enrolling in formal schooling.
- Chapter B examines the key components of a comprehensive, learner-focused program design within the context of the MOSAIC framework and how each is actualized in primary grade literacy and numeracy programs.
- Chapter C addresses comprehensive literacy-numeracy program design from a broader programmatic level. It presents considerations to guide deliberations on optimal weighting of resources for each MOSAIC component within country-specific contexts. It also presents issues to consider when determine how to distribute resources across literacy and numeracy initiatives, including in cases when resources for one or both disciplines are limited.
- Chapter D outlines an initial research agenda to inform the future design and implementation of evidence-based primary numeracy programs.

The ideas and potential decision pathways presented are intended to assist a wide range of education stakeholders—including ministries of education, their diverse partners, education officers of the United States Agency for International Development (USAID) and members of civil society—to make informed choices about how to design and implement comprehensive literacy and numeracy programs. They are also intended to guide decision-making around how to use resources in a cost-efficient manner and in a way that has the potential to result in optimal learning gains.

The information and discussions included in this paper are supported by illustrative case studies and examples from different numeracy-related inventions in low- and middle-income contexts, to help the reader place new ideas in context. The decision to focus the illustrative examples exclusively on numeracy interventions recognizes that numeracy is a relatively new area of focus for many readers.

Literacy and Numeracy Reform in International Basic Education

"Well-begun is half done."

~Louise Fox, Chief Economist at USAID, speaking about the Agency's work to improve learning outcomes in reading

MAIN IDEAS

Early success in reading is predictive of children's later reading skills.

Early success in numeracy is predictive of future academic successes in all disciplines, including in reading & literacy.

The strong, predictive ability of early grade literacy and numeracy means that learners need powerful learning experiences in BOTH these disciplines.

The many early grade literacy interventions launched in low- and middle-income contexts over the past decade has produced a considerable research base to inform future programming.

There have been fewer numeracy-focused interventions in such contexts, or interventions with a dual focus on literacy and numeracy, and as a result a significantly smaller research-base to guide future decision making.

Over the last decade, the international donor community has focused considerable resources on increasing literacy levels in early grades as a means of improving learners' overall academic success. The decision to concentrate efforts on improving primary literacy levels acknowledged the fact that learners in low- and middle-resource countries were completing primary school without the most basic literacy levels required to take advantage of the considerable benefits of higher education, including

increased professional and financial opportunities (Graham & Kelly, 2018; Gove & Cvelich, 2011; Platas et al., 2016).

Armed with the substantial global research base indicating that children's reading skills in early primary predict their reading abilities in later grades (Butler et al., 1985; Stainthorp & Hughes, 2004; Wagner et al., 1997), and that children who develop at least minimal reading proficiency levels by the end of early primary have the foundational skills required to support their learning through the end of primary and beyond, the global community committed to ensuring that children in low- and middle-income countries acquire strong literacy skills by the end of early primary.

This consensus was reinforced by research suggesting that how well children read in the early grades predicts their overall future academic performance (Francis et al., 1996; Juel, 1988; Lipson & Wixson, 1991; Snider & Tarver, 1987; Wharton-McDonald et al., 1998). Simply put, children who are better readers in the early grades go on to become more successful learners.

The above findings confirmed the urgency of directing resources toward the improvement of early grade reading skills. Donor agencies responded accordingly. Over the past decade, the United States Agency for International Development (USAID) has been a leader in the global effort to improve literacy levels, funding early-grade reading programs in over 40 low- and middle-resource countries around the globe.

As a result of global efforts to improve primary reading skills, there has been a significant increase in the evidence-base for literacy acquisition and instruction in low- and middle-income countries. The recent Landscape Report on Early Grade Literacy[1] (Kim et al., 2016) summarized evidence collected over the past decade on the design and implementation of early grade literacy programs in such contexts, identifying what has worked, which practices show promise, and the gaps in the evidence base. Among the research consensus is that if children are to develop strong literacy/reading skills, they need to learn to read in a language they use and understand and that learning needs to take place in an instructional and materials-rich environment, using a systematic, phonics-based approach (Moore et al., 2017). Although the evidence base for effective primary literacy/reading programming is considerable and continues to grow each year, USAID recognizes that much remains to be done to raise literacy/reading levels to desirable standards.

[1] Literacy, as used in this paper, is defined as the ability to read, write and communicate effectively using the language of a particular community. Reading, writing, listening, speaking and representing are used when referring to the component skills required to be literate.

Considerably less is known about the design and delivery of effective numeracy[2] programs in low- and middle-resource contexts, despite the poor performance of children from these contexts on international assessments (see Textbox 1) and the substantive global research base demonstrating that early numeracy skills predict:

1. children's overall academic success in higher grades (Watts et al., 2014; Claessens & Engel, 2013, Duncan et al., 2007; Bodovski & Youn, 2012; Duncan & Magnuson, 2011);

2. the likelihood they will repeat a grade (Duncan & Magnuson, 2011);

3. their later achievement in numeracy (Watts et al., 2014; Claessens & Engel, 2013; Broberg et al., 1997; Campbell et al., 2001; Peisner-Feinberg et al., 2001; Duncan et al., 2007); and

4. their ability to read (Duncan et al., 2007; Purpura et al., 2011; Duncan & Magnuson, 2011).[3]

TEXTBOX 1: Differential Performance of Low and Middle/high Resource Countries on International Assessments

Low-resource countries consistently score at the bottom of international assessments. The average performing student in low-resource countries scores lower on international assessments (Progress in International Reading Literacy Study [PIRLS] or Trends in International Mathematics and Science Study [TIMSS]) than 95% of ALL of the learners in Organization for Economic Co-operation and Development (OECD) high-resource countries (Crouch & Gove, in press).

Given the strong predictive value of early numeracy skills, and of early numeracy and literacy skills on children's overall academic success, it is obvious that children need powerful early learning experiences in ***both*** these disciplines.

This paper outlines evidence-based considerations for the design of interventions to improve learning outcomes in both disciplines. It is hoped that the information garnered from the implementation of such programs will provide the evidence base needed to further refine best-practice in both primary literacy and numeracy, as well as in the design and delivery of dual focus programs.

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[2] Numeracy, as used in this paper, is defined as being able to reason with numbers and other mathematical concepts, and to apply these concepts in a range of contexts to solve problems. Number and number operations, geometry, measurement, data analysis/probability and algebra are the domains associated with numeracy.

[3] Early reading skills are strong predictors of children's later reading achievement, but they do not predict children's later numeracy abilities (Lerkkanen et al., 2005). Children who develop strong reading skills in the early grades go on to be more accomplished readers in the higher grades. However, they do not necessarily go on to develop strong numeracy skills (ibid.). Early numeracy skills predict later reading skills but early reading skills do not predict later numeracy skills.

MAIN IDEAS

Foundational learning in early literacy and numeracy takes place before children enroll in school.

In formal schooling, literacy learning and numeracy learning both proceed through learning phases or stages, each progressively more difficult or challenging then the last.

In both disciplines, children need to master a broad range of increasingly more difficult skills, each associated with a particular literacy or numeracy content area or domain.

In numeracy instruction, children must develop process-related skills, in addition to content-specific skills.

Scaffolded, gradual-release instructional models have been proven to be effective in both literacy and numeracy.

The type of scaffolded, gradual-release model best suited for instruction depends upon the discipline (literacy versus numeracy), as well as the skill being addressed.

CHAPTER A:
Literacy and Numeracy in a Child's Early Years

A1. Before School Begins…

Under the right circumstances, children begin to develop foundational literacy and numeracy skills at home and in the community long before they start school. In the case of literacy, young children who engage in meaningful, rich language experiences—like shared book reading, listening to and telling stories, playing word games, singing songs, and making up rhymes—begin to develop *phonological awareness*, meaning the ability to isolate and manipulate sounds in oral language, and *print awareness* (Hart & Risley, 1995).

Similarly, in math, infants are born with an inherent number sense that is increasingly developed through interactions with the environment and other people. Young children begin understanding the concept of quantity from an early age (Dehaene, 1997; Devlin 2010; Sousa, 2008). Studies with infants, for example, show that they can discriminate between set sizes, for example between sets of two objects and sets that have more or fewer than two objects (Lipton & Spelke, 2003; Xu, 2003; Xu & Spelke, 2000; Xu, Spelke & Goddard, 2005). Children also start to formalize concepts of number by watching or hearing adults or older siblings perform household or other community-related activities involving basic mathematics concepts, such as buying items in the market. All these experiences are important to children developing their conceptual understanding of numbers. As a result of their innate skills, and the mathematics they learn from playing games with friends or chores at home (Saxe, 1991; Davis & Ginsburg, 1993; Guberman, 1999; Khan, 1999; Clarke et al., 2006; Bodovski & Farkas, 2007; Sitabkhan, 2009, 2015; and Taylor, 2012), children come to school already knowing how to "do mathematics".

Starting out behind: In low and middle-income contexts, children may not have had early exposure to letter sounds or formal number concepts. This can negatively affect their progress when they transition to the formal school system (Brantlinger, 1993; DiMaggio & Mohr, 1985; Lareau, 1989; McDonough, 1997; Srikantaiah, 2008; Useem, 1992). The gap is further compounded when children in low- and middle-income contexts do not have access to pre-school or kindergarten, and hence have little or no preparation for the transition to formal literacy and numeracy skills (Srikantaiah & Ralaingita, 2014). Programs focused in early grade literacy and numeracy need to acknowledge the degree to which young children have had opportunities to develop essential pre-literacy and pre-numeracy skills prior to entering the formal school system and, if necessary, devote sufficient time to these skills before introducing formal literacy and numeracy skills.

A2. The Transition to Formal Literacy and Numeracy Learning

When children transition to primary school, they begin to develop, more explicitly and consistently, the broad range of skills that will enable them to become literate and numerate. The skills children need to

develop are generally grouped by content domains in both literacy and numeracy. Table 1 below lists and defines the principal content domains for literacy and numeracy. Although these domains have been identified and defined in Western academies, they are context-agnostic; there is no educational program in the world, including in circumstances of conflict and crisis, where their instruction in the early years of school is irrelevant.

Table 1: Literacy and Numeracy Domains

Literacy Domains[4]	Numeracy Domains
Oral Language – *Understanding oral language and communicating orally* **Phonological Awareness** – *Isolating and manipulating sounds in oral language. (Stanovich, 1992); for example, being able to identify that the word "rain" starts with the sound /r/, that the word "elephant" has three syllables or that the word "hat" rhymes with "cat." Phonemic awareness is part of phonological awareness and refers to the skill of being able to isolate individual letter sounds in spoken words.* **Alphabetic Awareness** – *Recognizing letters and the sounds they make; using this to read syllables and words accurately. For example, reading the word "bat" by sounding out each letter - /b/. /a/. /t/ and then blending the sounds together to produce the word /bat/. Learning to read words by associating sounds to letters is referred to as the study of Phonics.* **Vocabulary** – *Understanding the meaning of words* **Fluency** – *Reading at an appropriate pace, accurately and with appropriate expression* **Comprehension** – *Understanding the ideas presented in written texts* **Writing** – *Being able to express ideas in various written forms, with acceptable technical conventions*	**Number Concepts** – *Representing, estimating and describing number quantities; place value; the relative size of number quantities or the relationships among numbers/quantities, and number systems.* **Number Operations and Algebraic Thinking** – *Describing the meaning of operations and how they relate to one another; estimating the results of operations; carrying operations out accurately using a variety of strategies (including mentally); understanding and describing patterns, relations, and functions* **Geometry and Spatial Awareness**– *Analyzing the properties of two- and three-dimensional geometric shapes and developing mathematical arguments about geometric relationships* **Measurement -** *Understanding measurable attributes of objects and the units, systems, and processes of measurement* **Data and probability** – *Formulating and answering questions by collecting, organizing, and displaying relevant data*

Carefully sequenced instruction that respects the phases or stages of learning: In both disciplines, the learning process needs to be carefully sequenced so that children progress from simpler to increasingly

[4] It is important to note that, while print awareness and listening comprehension are not generally included when discussing the core elements of literacy, they are critical to early grades literacy skills development. Print awareness is an early text access skill, where learners gain basic understanding of the purpose and manipulation of print, including concepts of parts of a book, text direction, and basic physical use of text. Listening comprehension, also an early access skill, helps learners understand that they can listen and comprehend what they hear. By developing listening comprehension, learners are better able to access and understand content, communicate in response to new oral ideas, and can transfer this skill into the more challenging domain of reading comprehension over time.

more complex skills. Teachers, and the materials and assessments they use, must carefully structure the learning process so that children master skills as efficiently as possible.

In both literacy and numeracy, learning progresses through phases or stages. In literacy, children first learn that there are predictable relationships between sounds and letters (alphabetic awareness), and that they can use these relationships to read both familiar and unfamiliar words. Once they can read words, they can begin to read with fluency. And fluency is a bridge to comprehension. Once children can read the words in a text with a minimal level of fluency, they can begin unlocking the ideas presented. These stages of reading acquisition have often been codified, using typologies such as: pre-reader, emergent reader, transitional reader, and fluent reader (Fountas & Pinnell, 1996; Mooney, 1998; Taberski, 2000).

In numeracy, children in early primary begin by learning numbers and number operations and important geometric relationships, such as spatial sense. Instruction is carefully sequenced to explicitly guide young children through the three phases or stages of numeracy concept development: concrete-pictorial-abstract (C-P-A). These phases, which have long been a central tenet of children's conceptual development in numeracy (Bruner, 1964, and Dienes, 1971) and a conceptual framework for organizing instruction in numeracy classes, are defined as follows:

- **Concrete:** Where children represent a numeracy concept with objects; for example, representing the quantity "3" by grouping tangible objects they can hold or place on their desks or on the floor (i.e. blocks, stones, or counting sticks).
- **Pictorial:** Where children begin representing numeracy concepts with a picture. For example, they draw three lines to represent the number "3."
- **Abstract:** Where children begin to represent numeracy concepts with symbols that represent the concepts. For example, they write a "3" or spell t-h-r-e-e to represent the quantity "3."

The diagram that follows provides a visual representation of these phases.

Diagram 1: The Three Phases (or Stages) of Numeracy Concept Acquisition

Concrete C	Pictorial (P)	Abstract/ Symbolic (A)
Counters or Objects	Drawings/Diagrams	Symbols
∴	|||	3

Primary-level numeracy instruction is unique in that in addition to skills related to the different content domains, teachers must also nurture in their learners a number of mathematical process skills. These are the higher-level thinking skills required to do mathematics and include problem solving, reasoning, constructing viable arguments and critiquing the reasoning of others, connecting ideas, and representing mathematical ideas or concepts with models (NCTM, 2000). Children acquire mathematical process skills when teachers give them rich problems or tasks to solve, and then incorporate opportunities for them to explain their thinking or solutions or respond to the thinking or solutions of other learners (see Chapter B3 for further discussion of mathematical process skills and how to develop them). **This parallel and equal focus on content and process-related skills that starts in early primary and continues throughout children's formal study of mathematics means that how children learn mathematics is as important as what they learn**.

TEXTBOX 2: Link Between Mathematical Process Skills and Literacy Skills

Learners with strong oral comprehension and verbal skills, or who are able to understand and communicate in the language used to teach mathematics, are more likely to be able to engage in the type of numeracy-related discussions, debates and dialogues needed to develop strong process skills.

Scaffolded instruction: One of the most important advances in educational theory and practice in the last decades has been the development of an extensive body of research, much of it grounded in neurological science, about the instructional models that are most effective in helping learners build skills in the multiple literacy and numeracy competency domains. The use of scaffolded, gradual-release instructional models in early primary facilitates the acquisition of the essential skills in both literacy and numeracy (Pearson & Gallagher, 1983). When teachers used such instructional models, they structure the learning activity so that the responsibility for completing a task or demonstrating a skill is gradually transferred from the teacher to the learner. This includes the responsibility for determining whether or not the learner is applying the skill or completing the tasks correctly or appropriately, i.e., self-monitoring (ibid).

In literacy, one evidence-based, scaffolded, gradual-release model that has proven highly effective is the "*I do, We do, You do,*" model. With this model, the teacher begins by modeling a literacy skill (I do), the teacher and learners then do the skill together (We do), and then the learner is asked to do the skill independently (You do). The "*I do, We do, You do,*" model allows teachers to do direct, explicit instruction of foundational reading skills, like associating sounds with letters. It also allows them to ensure that learners can do those skills independently before progressing to the next, slightly more difficult skill. However, the "I do, we do, you do" model needs to be adapted when addressing more complex skills, like reading comprehension.

In numeracy instruction, scaffolded or gradual-release instructional models need to be problem solving-based to allow children to develop the process-related skills described above.

Similarities and differences in recommended, scaffolded, gradual-release instructional models for literacy and numeracy are discussed in Chapter B3 – Teacher Knowledge.

From this brief description of the stages and phases of literacy and numeracy acquisition, and of the instructional models that facilitate learners' progress through them, it is possible to infer:

- That teachers need to be able to:
  - recognize, child-by-child and class-by-class, at what stage or phase their learners are;
  - explicitly facilitate their transition, as individuals and groups, to the next stage or stages, and;
  - adjust their application of scaffolded, gradual-release models according to the discipline area (literacy or numeracy) and domain-related skills they are seeking to build. A scaffolded, gradual-release instructional model for literacy may not be appropriate for numeracy. As well, a gradual-release instructional model that works well for certain literacy domains (alphabetic awareness, for example), may not be appropriate for other domains (comprehension, for example).
- That, because of the above, the task of teaching literacy and numeracy skills is complex and ever-changing. Therefore, teachers who do not have a deep or rich understanding of literacy or numeracy concepts, or how to best present them to learners, will struggle to structure, deliver, and adjust instruction for their diverse learners. This point will be further explored in Chapter B3, in the section focusing on teacher pedagogical content knowledge.
- That systems and education stakeholders from the local to the national levels have a critical role to play in providing the policy support, materials, training, coaching, assessment, and home-based/community inputs that promote the implementation of evidence-based, scaffolded, and direct instruction targeting these skill areas and domains. All of these points are critical components of the MOSAIC framework introduced in the next chapter.
- That the pace at which factors affecting literacy and numeracy instruction are introduced in a given context or political economy will vary greatly, and that these variations in pacing must be considered when using the MOSAIC framework to design interventions. We will take a closer look at these issues in Chapter C.

CASE STUDY 1:

USING LOCAL LANGUAGE AND THE THREE PHASES OF CONCEPT DEVELOPMENT (CONCRETE, PICTORIAL, ABSTRACT OR CPA) TO SUPPORT IMPROVED NUMERACY SKILLS

AKSHARA GANITHA PROGRAM, BANGALORE, INDIA

The Akshara Foundation, a non-profit organization located in Bangalore, India, has worked extensively in the state of Karnataka to support early grade numeracy programs delivered in in local languages and using innovative, locally available materials to support children's progression through the three phases of numeracy concept development: concrete, pictorial, and abstract.

The Akshara Foundation recognized that despite a significant increase in the resources spent on primary schooling in India, improvements in numeracy learning have been difficult to achieve.

To address this issue, they developed the Akshara Ganitha primary numeracy program.

The grades 1 to 5 program provides hands-on experiences in numeracy teaching and learning with the aid of tactile and concrete teaching-learning materials. The program carefully structures learning to move children through the three phases of numeracy concept development:

- concrete (using objects or manipulatives),
- pictorial (using pictures, diagrams or symbols), and
- abstract (using symbols).

Concepts are introduced first by using having children use concrete tools or objects like counting boards, number grids, counters, dice, number lines, place value mats, and money. This is a departure from conventional direct instruction using the blackboard method. Once children can represent their understanding using concrete objects, they are gradually introduced to how to represent their understanding using pictures, and finally abstract symbols. All instruction is delivered in the local language and done in coordination with public/government schools. One of Akshara Ganitha's biggest successes is that it makes numeracy accessible and exciting for children.

CASE STUDY 1 (CONT.)

IMPACT: The impact evaluation used a combination of both qualitative and quantitative methods and a controlled before-and-after design, in which beneficiaries of Akshara Ganitha (10 treatment schools) were compared with non-beneficiaries (11 control schools). Treatment schools scored better than control schools across all grades in all the three years of the study. Effect sizes ranged from 0.27 to 0.43, depending upon the cohort and grade level. A cohort analysis showed that the greater the exposure to the program, the larger the benefit in terms of scores on the learning outcomes. The study also found a transition from low to effective usage of teaching and learning materials by the teachers and children, due to repeated trainings and in-class follow-up sessions. The findings suggest that classroom-based pedagogical support can be a viable tool in enhancing teachers' instructional practices.

For more information:

https://akshara.org.in/wp-content/uploads/Final-Math-Program-Research-Evaluation-Report-2016-05-12-16.pdf

CHAPTER B:
The Mosaic Framework and the Design of Comprehensive, Learning-Focused Literacy and Numeracy Programs

Mosaic (n.) A picture or pattern produced by arranging together small colored pieces of hard material, such as stone, tile, or glass.

MAIN IDEAS

Educational interventions that focus on improving classroom instruction have greater impact on student learning than those that focus on structural or accountability/management aspects.

The best way to improve learning outcomes is to focus on inputs that have a direct impact on the quality of teaching and learning in the classroom (policies, teacher training, instructional materials, assessment, etc.) and ensure they are introduced in a coordinated, synergistic manner.

The MOSAIC framework is an evidence-based tool (Kim et al., 2016) that supports the planning, implementation, and evaluation of comprehensive programs to improve literacy and numeracy outcomes in the primary grades.

In this chapter, we introduce the MOSAIC framework and describe how it can be used to support the design of comprehensive programs to improve children's literacy and numeracy learning outcomes. We begin by briefly reviewing the evidence supporting the framework. We then examine how each of the six "components" of the framework contributes to the design and implementation of a comprehensive and synergistic literacy and numeracy program, one where systems-level actors, institutions and parents work in concert so that all learners develop the literacy and numeracy skills necessary for their long-term academic success.

The framework is flexible enough to be used for interventions that focus on a single discipline. However, because literacy and numeracy skills are inter-related and both are important predictors of later academic success, programs should consider building comprehensive programs of support for both disciplines.

The Importance of Maintaining a Focus on Learning and Pedagogy in Educational Interventions

If the percentage of learners meeting minimal reading and mathematics proficiency levels is to increase over time, countries and their technical partners will have to implement programs to improve learning outcomes in these two key disciplines. But what types of programs are most likely to produce learning gains, particularly in low- and middle-income countries?

Crouch & DeStefano (2017) maintain that interventions that focus extensively on pedagogy, i.e., on improving the teaching-learning process at the classroom level, produce the greatest learning gains. Their comparative analysis of the impact of different types of interventions revealed that the median effect size of interventions focused on improving classroom instruction (i.e., pedagogy-focused interventions) was double that of non-pedagogy focused interventions, (i.e., interventions that focused on structural or accountability/management aspects). Their findings reinforce those a previous 2006 World Bank study.[5] Simply put, both studies found that in many—although admittedly not all—contexts, learning-focused interventions hold the greatest possibility of yielding large-scale improvements in learning outcomes (World Bank, 2006; Crouch & DeStefano, 2015 & 2017). Not only that, but the more tightly an intervention focuses on pedagogy, and on those aspects of the education system that have direct bearing on the quality of teaching and learning, the greater the effect size of the intervention on children's learning (Crouch & DeStefano 2017).

But what, precisely, are the aspects of an educational program that have a direct bearing on the quality of children's literacy and numeracy learning in the classroom? Kim et al., 2016, in a review of the research literature on evidence-based literacy programs in low- and middle-income countries, identified the following:

- policies that facilitate literacy teaching; for example, policies that mandate sufficient instructional time for literacy/reading learning or that ensure that children learn in a language they understand and which they can use to communicate;
- curricula and instructional materials based on evidence-based learning progressions and sequences and that pace learning appropriately;
- high-quality instructional resources aligned with the above;
- teacher training on effective literacy practices and ongoing, in-school coaching and mentoring in how to implement these practices effectively;

[5] See World Bank. (2006). From Schooling Access to Learning Outcomes: An Unfinished Agenda. An Evaluation of World Bank Support to Primary Education. Washington, D.C.: World Bank.

- existence of processes and systems to monitor progress and hold schools accountable for children meeting minimal learning outcomes; and
- time outside of school to practice reading.

All of these inputs are needed if children's learning outcomes are to improve. This is true for both literacy and numeracy. Planning tools like the MOSAIC framework presented below can help program planners ensure that all of the learning and pedagogy-related inputs needed to improve learning outcomes are or will be put in place, so that a comprehensive, coordinated program of support is offered to teachers and learners.

MOSAIC: A Framework to Guide the Development of Comprehensive Literacy and Numeracy Programming

In keeping with the evidence base described above, the MOSAIC framework is ***pedagogy and learning-focused***. Each of the six components of the framework (see Diagram 2) addresses elements critical to improving classroom teaching and learning in low- and middle-resource countries. Although it was originally developed as a planning tool for reading interventions, the six components are not discipline specific. For that reason, the framework can be used when designing **both** literacy and numeracy interventions.

TEXTBOX 3: Why Comprehensive?

Comprehensive, learning-focused interventions, and particularly those that are designed and implemented in an integrated and cohesive manner, are most likely to produce large-scale improvements in children's learning outcomes (Crouch & DeStefano, 2017; Healy & Morris, 2018, Moore et al., 2017).

The framework is ***comprehensive***: It is made up of the six pedagogy and learning-focused components identified by Kim et al. (2016) as necessary for improving learning outcomes. It can therefore assist program designers in developing the type of comprehensive, learning-focused programs identified by Crouch & DeStefano (2017) as having the greatest potential to improve learning outcomes.[6]

[6] Although all six components are required for a comprehensive program, the amount of attention or resources that might need to be directed to specific components of MOSAIC framework depends upon the context. For example, some components may already be in place or other funders/partners may have plans to strengthen certain components. What is important is that all six components be in place and implemented strategically and synergistically, so as to complement one another. Chapter C looks at factors literacy and numeracy program developers should take into account when determining how to best distribute resources across the six components.

Diagram 2: The MOSAIC

Each of the components is defined briefly below. The sub-sections that follow this section discuss each of the components in greater detail.

- Enabling Policies and Standards: This component covers curricular content and pacing and policies related to: 1) language of instruction, 2) instructional time, 3) teacher certification, promotion, accountability and deployment, 4) student evaluation and grade-to-grade promotion, including the establishment of clear grade-specific performance standards and benchmarks, 5) teacher incentives and accountability, and 6) the sustainability of educational resources.
- High-Quality Texts and Materials: This component covers the print materials and other instructional aids required for high-quality literacy and numeracy instruction. This includes guiding information for teachers on how and what to teach, and when (teacher guides) and instructional material for learners (basic reading primers and mathematics books, as well as supplementary material, including numeracy manipulatives).
- Effective Teachers and School Leaders: This component addresses the inputs and resources needed to ensure that teachers know how to use evidence-based literacy and numeracy instructional materials, and that school leaders know how to structure and manage classrooms and schools to improve learning results.

- **Effective Teacher Coaching and Mentoring:** This component addresses the need for ongoing, in school and in-class support—after training—to help teachers implement the instructional practices and models presented during training and use instructional materials effectively.
- **Continuous Assessments that Inform Instruction:** This component addresses the need for teachers to have the ability to gather informal and formal data on student progress and performance, within the context of the classroom, on a regular basis. This type of assessment should be used primarily for immediate response to student learning needs, including whole group reteaching of concepts and skills, small group remediation, and individual intervention for learners with the greatest needs.
- **Regular Practice Outside of School:** This component addresses the need to extend learning beyond the confines of the school day. The more time children engage in rich and cognitively challenging literacy and numeracy activities, the greater their learning gains.

TEXTBOX 4: Inclusive Education and the MOSAIC Framework

The MOSAIC framework can be used to determine the degree to which the elements required for a learning-focused and comprehensive literacy and numeracy initiative are serving the needs of learners with disabilities. This paper, however, does not provide detail on structuring instruction for disabled learners. Readers are encouraged to use the USAID/Global Reading Network publication "Universal Design for Learning to Help All Children Read: Promoting Literacy for Learners with Disabilities" in conjunction with the MOSAIC framework in order to promote increasingly inclusive instruction in diverse country contexts.

Inter-related nature of the six components: Although ***teacher quality*** plays a critical role in improving instruction, even the highest-performing teachers will struggle to build learners skills if the ***policy*** environment in which they work does not support improved learning, if the ***instructional texts and materials*** they possess are not of high quality or available in sufficient quantity, and if they do not receive sufficient and effective ***coaching and mentoring.*** All six MOSAIC components are equally important. Each must be of high quality, and all six must be implemented in a coordinated, synergistic manner, at the systems, school, and classroom levels, if children's learning outcomes are to improve. It is this type of programming that holds the greatest potential for increasing learning outcomes.

Data-driven program design: The MOSAIC framework should be used as part of a data-driven program design process. Considerable contextually specific analysis of the school system, classrooms, communities, and home situations should be done to guide resource allocation for literacy and numeracy programs. Data collected through systems or landscape analyses (such as the Literacy Landscape Analysis) can help identify gaps with respect to each component of the framework, at every level of the education system, that can guide deliberations on optimal distribution of resources across the six components, including how to best direct resources when resources for one or both disciplines are limited. Chapter C looks at some considerations that should figure into a data-driven program design process and proposes factors program designers should weigh when determining how to best distribute resources.

In the sub-sections that follow, we describe, component-by-component, for both literacy and numeracy instruction, considerations that must be examined in order for instruction in both disciplines to be maximally effective. These descriptions do not capture every similarity, or difference, between literacy and numeracy instruction that educational stakeholders or authorities need to consider when designing comprehensive learning-focused programs for both disciplines. Nonetheless, they offer an opportunity to consider the complexities of improving instruction in each of the disciplines, as well as in both synergistically.

CASE STUDY 2:

INFUSING LANGUAGE, THOUGHT AND MEANING INTO LITERACY AND NUMERACY TEACHING IN RWANDA

EDUCATION DEVELOPMENT CENTER

In Rwanda, many early grade teachers teach both literacy and numeracy. For that reason, it was important to present them with a common lens through which to view effective literacy and numeracy instruction. In the L3 Program, one common lens was identifying how to infuse language, thought and meaning into both disciplines.

Teachers were introduced to instructional practices that encourage children to explore, hypothesize reason logically and solve problems in both disciplines. The practices also focused on helping children in both disciplines make connections between ideas presented in class and their background knowledge or everyday lives.

Teachers were trained to use generic, higher-level thinking questions like those in Textbox 11 in both disciplines to help children build a deeper understanding of the ideas presented. In addition, in numeracy, teachers were taught how to flip traditional textbook math problems around to create open-ended problems that promote mathematical reasoning. For example, instead of "Deepa has 6 bananas, Yasmin has 4. Who has more?" teachers created problems like "Deepa has 6 bananas, Yasmin has 4. What can you say about that?". The latter is richer, more meaningful problem for children to solve and more reflective of the types of mathematical situations they encounter in their everyday lives. The flipped problems also created meaningful contexts for children to use their oral language skills in math class.

IMPACT - Teachers who received training reported having a deeper understanding of numeracy and literacy concepts and how these concepts can be used in a range of every-day applications to enable children to explore, hypothesize and reason logically, make connections with everyday situations and strengthen their ability to use a variety of methods to solve problems. Learners in grades 1 to 3 showed statistically significant improvements in oral reading fluency and reading comprehension from baseline to end line. By the end of the intervention 36% of grade 2 children were reading with 80% or higher comprehension. In numeracy, grade 1 children substantial gains from baseline to end line with an average increase of 12.6% (± 2.8%) in the average percent of numeracy tasks solved correctly. There was no significant change in the performance of children in grades 2 to 4.

B1. Policies that Create an Enabling Environment for Learning

MAIN IDEAS

Providing children with sufficient instructional time for both literacy and numeracy is vital.

Setting measurable, grade-specific performance standards and benchmarks allows Ministries to communicate clear expectations for children's learning and provides them with objective references against which to measure progress.

Having evidence-based language of instruction policies and implementing programs that are aligned with those policies are critical for improving learning.

Hiring, evaluation, promotion, and incentive policies must be in place to both hold teachers accountable and reward them for effective instruction.

Implementing data-driven measures to monitor the extent to which children are reaching grade-specific benchmarks and using that information for remediation results in improved learning.

Primary literacy and numeracy programs have a greater possibility of being sustainable if they are supported by learning-focused government policies. Such policies include, but are not limited to:

Policies that ensure that sufficient instructional time is set aside each week for literacy and numeracy: Increased instructional time has been identified as one of five policy-related initiatives shown to correlate with improved learning outcomes (Dobbie & Fryer 2013).[7] An increase in the amount of time allocated to a discipline correlates with increased learner interest in the discipline. This in turn correlates with improved learning outcomes (Traphagen, 2011; Blank, 2013; Fitchett et al., 2014).

[7] The Dobbie and Fryer (2013) study found five policies (increased instructional time, frequent teacher feedback, the use of data to guide instruction, "high-dosage" tutoring and high expectations) worked together to explain approximately 45% of variation in student results and school effectiveness in charter schools in New York (cited in European Commission, 2018).

A recent European Union report (European Commission, 2018) suggested that a minimum of 26% of the primary instructional week be devoted to literacy (reading and writing) and 18% to numeracy. This means that slightly less than half of the time primary children are in school should be devoted to literacy and numeracy. Given that most countries allocate between 700 to 800 hours per year of instructional time in early primary (Benavot & Amadio, 2014), the EU guidelines would result in children receiving 180 to 200 hours a year of literacy instruction and 125 to 140 hours of numeracy instruction.

Although allocating sufficient instructional time to literacy and numeracy is important, it is the total amount of time children spend learning, coupled with the use that teachers make of that time, that determines how well children learn (Gettinger, 1985; Carroll 1989; Kidron & Lindsay, 2014). Increasing the amount of time for literacy and numeracy needs to be accompanied with initiatives to ensure the learning time is being spent efficiently (see section 3 on effective teachers and school leaders).

TEXTBOX 5:
Contact Hours and Quality Instruction

Children need sufficient number of contact hours, as well as quality instruction, if they are to achieve the learning outcomes defined in the curriculum.

TEXTBOX 6:
Supporting Governments to Develop Evidence-based language of Instruction Policies

Program designers should work with stakeholders to explore the existing language policy landscape as it relates to classroom instruction. This can include completing detailed language mapping of the teachers' and learners' linguistic abilities and the degree to which they can easily mutually understand one another during instruction. Data about teachers' and children's ability to communicate can then be used to inform national and regional policies on language of instruction, as well as on teacher hiring and deployment.

Policies that define the grade-specific performance standards or benchmarks children need to meet to be successful at higher grade levels: All education stakeholders need a shared understanding of the important skills children need to develop at each grade level (content standards), as well as the minimum, observable level of performance (benchmarks) children must be able to demonstrate with respect to important skills in order to be deemed to be "meeting minimum grade level expectations." Once established, minimum benchmarks need to be used by educators at all levels of the system (classroom, school, district, national) to monitor progress and implement appropriate remediations.

Evidence-based policies that outline the language of instruction: Learning is optimized when instruction is delivered in a language the children understand and use for communication, including sign language for those who are Deaf/Hard of Hearing (UNESCO, 2008).[8] International best practice,[9] and USAID

[8] UNESCO has encouraged mother tongue instruction in primary education since 1953.

[9] The benefits of learning in a language that children understand and use to communicate are well documented and include being more likely to enroll and succeed in school (Kosonen, 2005), having parents who are more likely to communicate with teachers and participate

policy, support the consistent use of languages that young children use and understand. Doing so allows children to focus their cognitive energy on learning literacy and numeracy-related skills, as opposed to focusing their efforts on understanding the language in which literacy and numeracy instruction is taking place.[10]

Policies related to teacher hiring, assignment, and incentives: Teacher certification requirements, rules about their eligibility to teach certain grades or disciplines, and provisions for rewarding them for strong performance can all either promote or hinder high-quality literacy and numeracy instruction. Assessing the degree to which existing policies do or don't support efficient skills acquisition for learners in both disciplines is a critical step in determining what actions may be needed to ensure a supportive policy environment for high-quality instruction.

Policies defining accountability measures to monitor the extent to which children are meeting minimum, grade-specific benchmarks: Educators at all levels of the system need simple but valid and reliable instruments to measure and report on children's performance with respect to the benchmarks. Accountability measures need to be put in place to ensure that the instruments are used on regular basis to monitor children's learning and that appropriate remediation activities are directed to those not meeting benchmarks (see sections on assessment that follow).

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in children's learning (Benson, 2002), staying in school longer and repeating grades less often (this is particularly true for girls and rural children) (Hovens, 2002), and developing better thinking skills than monolingual counterparts (Bialystok, 2001; Cummins, 2000).

[10] In some circumstances, literacy or numeracy may be taught in children's second (or third, or fourth) languages, or in a foreign (for the children) but widely internationalized language (like English). In cases where instruction is offered in a language that learners do not fully understand, teachers need to use evidence-based second language or foreign language instructional strategies to support learning. These strategies may vary depending on context and subject area. There is some evidence that using code-switching, (i.e., switching fluidly between two languages during the same conversation or class) in numeracy classes enriches learning (Setai & Adler, 2000, cited in Essien & Sitabkhan, 2016, and Essien, 2018).

CASE STUDY 3:

USING MOTHER TONGUE TO STRENGTHEN MATHEMATICAL THINKING WITH PRE-SCHOOL CHILDREN IN PARAGUAY

EDUCATION DEVELOPMENT CENTER

Inspired by the budding research on the importance of early numeracy skills in children's learning trajectories, in 2009 the Paraguayan government, in partnership between the Japanese and Paraguayan governments, the Organization of Ibero-American States (OEI), the Inter-American Development Bank (IDB) and the Education Development Center (EDC), developed the Tikichuela (Mathematics in My School) program to strengthen preschool numeracy programs. The Tikichuela program, based on the EDC Big Math for Little Kids (BMLK) program, was designed to develop young children's mathematical thinking through instruction delivered in mother-tongue (Spanish and Guaraní). The BMLK program is based on the following research-based principles, drawn from https://www2.ed.gov/policy/gen/leg/foia/grants/edcmath.pdf:

- Young children are already engaged in learning (informal) mathematics. They do not need to be made ready to learn.
- Young children already possess many basic informal mathematical ideas upon which instruction can be built.
- Sensitive adult guidance can help children engage in complex forms of mathematics learning so that they realize their learning potential.
- It is not enough to have children engage in mathematical "play." They need stimulating mathematical activities, and in particular activities designed for low-income children.
- Mathematics curriculum should balance an understanding of basic ideas and procedures with the verbal expression of mathematical thinking (explanation and justification). Low-income children in particular need help in describing their mathematical thinking and making explicit their mathematical competence.

The program is built around a structured sequence of activities aligned with children's cognitive developmental progressions. Lessons take the form of games, activities with manipulatives, explorations, stories and a small amount of work writing and reading mathematics. Since the program was to be implemented in bilingual and low-resource areas, by teachers who often lacked specific training in early education or pedagogical content knowledge in mathematics, audio CDs were distributed to teachers to help them deliver standardized lessons. This decreased the burden on teachers and helped them complete the preschool math curriculum as laid out. In addition to initial training, teachers received training and in-class tutoring in how to use the interactive audio methodology.

CASE STUDY 3 (CONT.)

IMPACT: A randomized control trial involving some 3,000 students across 265 schools (131 treatment and 134 control schools) showed that after only five months children in treatment schools scored, on average, 16 points higher (almost a fifth of a standard deviation) than those in control schools. The achievement gap between low- and average-performing children (those in the bottom third) and high performers (in the top third) decreased by 7.5 percent. Low-resource outlying schools scored 21 points higher on average than outlying schools not in the program. The program improved math scores for both Guaraní- and Spanish-speaking children, with bilingual children showing the most improvement. Equally importantly, preschoolers whose teachers lacked specific training saw a greater improvement in scores than children whose teachers specialized in preschool education, showing the potential of interactive audio programs to close the experience gap between highly trained and less highly trained teachers.

The Tikichuela program has been sustained and expanded by the government of Paraguay. Grades 1-3 have been added, as well as a science component. It will also be implemented in Costa Rica and Panama, with support from the IDB. It was recently identified as one of the 100 most innovative education programs in the world by the HundrEd Initiative.

B2. High-Quality Texts and Materials

MAIN IDEAS

High-quality texts and materials provide critical support for successful program implementation.

Teachers need simple, clear, and research-based program guides that explain new instructional models and practices, as well as training and coaching, to help them implement the new instructional models effectively.

Learners need core primers and workbooks (literacy and numeracy) that align with discipline-specific instructional models of guided instruction and cover all the important content domains for their grade level.

Learners need additional resources to support their learning, including supplemental text for literacy, and manipulatives for numeracy.

Providing teachers and children high-quality texts and materials is important for increasing learning outcomes.

Essential Materials

The table below presents an overview of the essential instructional materials for literacy and numeracy:

Table 2: Essential Instructional Materials for Literacy and Numeracy

Material	Literacy	Numeracy
Teacher guides that contain…	• An outline of the progression and pacing of learning skills throughout the school year • Sample or model lessons for key skills that follow a scaffolded instructional model • Easy-to-use formative and summative assessment tools to measure progress with respect to grade-specific benchmarks • Sample remediation activities to address identified learning gaps	
Textbooks or workbooks that…	• Integrate skills and domains of literacy into clusters of activities and text • Contain decodable reading texts, keyed to the learning progressions • Contain sufficient volume and variety of texts to support children' reading development	• Make extensive use of mathematical models (objects, drawings, diagrams) to render abstract notions more accessible • Include open-ended, meaningful math tasks that can be solved in a variety of ways, or have multiple solutions • Make explicit connections between informal math understandings developed outside of school and the formal curriculum concepts • Provide children with multiple opportunities to practice new concepts and skills
Other	Leveled texts, supplementary readers or laminated story cards: • aligned with developmental progressions • with engaging, thought-provoking story lines • containing a balance fiction and non-fiction texts[11] • available in sufficient quantities	Grade-specific collections of essential, low-cost/no cost materials to represent or model important numeracy concept (counters, 10s bundles, addition/subtraction frames, geometric shapes, etc.[12]
Material	Literacy	Numeracy

[11] Nonfiction texts are particularly important for building children's vocabulary and their general background knowledge, both of which correlate with stronger reading comprehension in later grades.

[12] Classroom collections should specify the minimal quantities required per child. This will communicate the importance of manipulatives being used by children (as opposed to teachers) to represent numeracy concepts.

	Teacher read aloud stories, poems or other texts **to develop children's listening comprehension skills and develop interest in reading.**	Teacher read-aloud stories with math-related themes or embedded math problems **to engage children in authentic, meaningful problem-solving situations**
	Home-school reading and mathematics materials to extend the amount of time each day children spend reading/doing meaningful mathematics and provide a means of involving family members in young children's development (See section B6)	

Design Principles

Obviously, the specificities of learning in literacy differ from those of learning in numeracy, and those differences will affect the design of any essential materials. Nonetheless, high-quality and effective materials in both disciplines should:

1. Be written in simple, accessible and developmentally appropriate language and are culturally appropriate.
2. Align their content with evidence-based developmental learning progressions[13]
3. Align with the research base on how learning should be structured in each discipline
4. Provide children that with an opportunity to develop important, discipline-specific skills
5. Have children learn by solving or engaging in meaningful tasks
6. Emphasize the development of higher-order thinking skills
7. Promote the use of discipline-specific instructional models

The table that follows provides additional information about these principles and characteristics of high-quality primary grade literacy and numeracy materials:

[13] Developmental learning progressions describe the successively more sophisticated ways of thinking about a concept that children's thinking generally follow as they move from beginner to expert understanding. They describe "a picture of the path learners typically follow as they learn...a description of skills, understandings, and knowledge in the sequence in which they typically develop" (Masters & Forster, 1996). For an overview of developmental progressions for each domain, see Clements & Sarama, 2014.

Table 3: Principles and Characteristics of Quality Primary Literacy and Numeracy Materials

Principle/ Characteristic	Literacy	Numeracy
1. Are written in simple, accessible and developmentally appropriate language and are culturally appropriate	Core materials for children's learning in both literacy and numeracy need to: • Be written in language that is on par with independent reading levels for the target age • Provide tasks, stories, and activities that are within the specific context of the child (i.e., stories about familiar settings, people and activity, problems set in the context of the life of the child)	
2. Align their content with evidence-based developmental learning progressions	The starting point for the development of instructional materials in each discipline is the establishment of grade-specific scope and sequences that: • acknowledge key grade-specific learning outcomes or important skills at each grade level (see next point); • reflect the relative importance of different components or domains of literacy and numeracy at different grade levels[14]; • sequence skills coherently within domains (numeracy) or across domains (literacy), depending upon the discipline, and in accordance with how skills, understanding and knowledge typically develop in young children and, • incorporate a strong focus on development of the higher order thinking skills common to both literacy and numeracy (see Principle 6 below as well as Table 1 in appendix for common higher order thinking skills and their application in literacy and numeracy).	
3. Align with the research base on how to best structure learning in each discipline	• Reading skills are "nested." A child cannot read words if he or she cannot identify letters or the sounds they make. Because of the "nested" nature of reading skills, a single early-grade literacy lesson (or page of a textbook) usually has children working on skills associated with a number of domains (oral language, phonological awareness,	• Numeracy skills are not nested across different numeracy content domains. A child can develop strong skills related to number concepts or number operations without developing strong measurement or geometry skills. There is, however, a clear progression of skills within a single numeracy content domain.

[14] Phonological and alphabetic awareness are critical in year 1. As children progress, instructional time devoted to these two components decreases, and time devoted to fluency and comprehension increases. The same is true of numeracy. The bulk of the learning is early primary is devoted to three key domains: Number Concepts, Number Operations and Algebraic Thinking and Geometry, specifically spatial awareness.

Principle/ Characteristic	Literacy	Numeracy
Remember: Best practice for sequencing content in each discipline is unique.	alphabetic awareness…). Developing instructional materials that acknowledge the nested nature of reading supports the rapid acquisition of reading & literacy skills.	Because numeracy skills are not nested the same way literacy skills are, a numeracy lesson usually focuses on skills within a single domain. Subsequent lessons build on and extend children's learning of the targeted skills within the domain, according to clearly defined development progressions within that domain. That is why the learning modules or chapters of numeracy textbooks are usually each focused on a specific content domain.[15]
4. Provide children with an opportunity to develop important, discipline-specific skills	• Literacy instructional materials need to build in activities that will allow children to develop: • **Decoding skills to read and understand the written word** • **The ability to integrate new vocabulary**, using context clues and similar words • **Independent reading skills that lead to comprehension** • Skills to **listen and speak** to others with comprehension and meaning • **Strong fluency skills**	• Numeracy instructional materials need to build in activities that will allow children to develop: • **strong estimation skills** across the different domains • **strong number sense,** understanding of numbers, place value, magnitude of numbers, relationships between numbers, and how numbers are affected by operations • **strong conceptual understanding,**[16] that will allow

[15] Despite the fact that effective primary grade numeracy instruction is not "nested," primary grade numeracy teachers must make explicit attempts to make connections across the different domains, for example by having children measure the sides of different shapes or estimate and count the number of objects that will fill a given container.

[16] Conceptual understanding is defined as an understanding of mathematical concepts, their applications and the relationships between them. It cannot be learned by rote. Strong conceptual understanding is the basis for the development of procedural fluency.

Principle/ Characteristic	Literacy	Numeracy
	• **The ability to write** ideas in ways that the intended audience can understand	them to then develop procedural fluency[17] • **strong mathematical process skills, i.e.,** the higher-level thinking skills required to do mathematics (problem solving, reasoning, constructing viable arguments and critiquing the reasoning of others, connecting ideas and representing mathematical ideas or concepts with a variety of models)
5. Have children learn by solving or engaging in meaningful tasks **Remember:** If children are to become lifelong, engaged readers, writers and mathematicians, they need the opportunity to engage in authentic and purposeful learning situations.	• In literacy, this means reading engaging texts inside and outside the classroom or having children produce written texts that communicate their thoughts and ideas. Reading or producing interesting, engaging texts "helps learners understand that content literacy is worthwhile and meaningful to their lives," in addition to providing opportunities for learners to practice and improve their skills (Parsons & Ward, 2011). It helps children understand that writing is a communication tool, reinforces the relationship between print and the sounds of speech, and fosters an appreciation of the conventions of print.	• In numeracy, children need frequent opportunities to solve interesting problems or accomplish meaningful tasks related to their everyday life experiences - problems or tasks that have multiple solutions or that can be solved using a variety of strategies. These types of problems or tasks provide the backdrop needed for engaging children in rich numeracy discussions where they explain and justify their thinking and listen to the thinking of others (Franke et al., 2007).
6. Emphasize the development of higher-order thinking **Remember:** The design of instructional materials	• In literacy, care should be taken to ensure that children have access to increasingly challenging text context over time, and that teachers are able to develop and use higher-level questioning to support	• In numeracy, care should be taken to ensure that problems and questions contain a balance of more routine types of problems, which can be solved by applying a known formula or solution path, and

[17] Procedural fluency is the ability to apply known procedures, steps or formulas to solve problems or compute answers.

Principle/ Characteristic	Literacy	Numeracy
needs to acknowledge the importance of developing higher order thinking skills.	development of critical thinking skills.	more complex or non-routine problems that cannot be solved by the quick application of a formula or that require critical thinking skills.
7. Promote the use of discipline-specific best-practice instructional models	Instructional models help teachers understand how to organize learning in both disciplines and give them patterns to follow when planning or delivering instruction. A scaffolded or Gradual-Release Instructional Model should be used in both disciplines (see section on Teacher Knowledge below for a further discussion of discipline appropriate scaffolded or gradual-release instructional model)	

Materials for Dual Literacy-Math Programs

For programs that have a dual focus on literacy and numeracy, or where the same teacher is responsible for delivering literacy and numeracy instruction, designing materials that take all of these principles into account can be challenging. The task can be made easier by considering the following:

Teacher's guides

- Structure the guides for each discipline similarly, so that teachers can quickly and easily locate content they need;
- Use a common format for model lesson plans for each discipline. Although scaffolded or gradual release instructional models for literacy and numeracy are different, there are commonalities between the two that can be captured in a common lesson format.

Children's materials

- Ensure the font and font sizes of children's numeracy materials align with those used in reading materials. This is critical for the early grades, but increasingly less important as children move up the grade levels.
- Ensure the level of text difficulty in children's numeracy materials (words, sentence length, structure, etc.) aligns with that of children's reading materials. This will ensure that children can read and understand any essential numeracy text. This is critical at all grade levels. The texts used in

mathematics textbooks for a given grade level are often considerably above children's reading levels for that grade level (Barton & Heidema, 2002).

Programs that have a dual focus on literacy and numeracy can also maximize learning in both disciplines by leveraging literacy materials to strengthen numeracy skills, and vice versa. For example, the stories in teacher read-aloud books can serve as a springboard for presenting children with engaging, meaningful numeracy problem-solving activities. Anchoring numeracy problem-solving in stories helps make explicit the link between formal mathematics and the real-life situations presented in the stories.

To reduce the number of distinct stories produced for programs that have a dual focus on literacy and numeracy, the same story can be used for both literacy and a numeracy lessons, at different points in the school day or week, and for a distinctly different purpose in each case. During literacy lessons, for example, the story can be used to reinforce vocabulary or listening comprehension skills. During numeracy lessons, it can serve to provide children with a *rich* problem-solving situation that builds on or reinforces the numeracy learning outcomes they are studying. In each discipline, the instruction should follow the discipline-specific instructional models and practices.

Teachers should also understand that numeracy lessons and materials can also serve as an important vehicle for strengthening children's oral skills (explaining and justifying their answer), their reading comprehension skills or their ability to represent their thinking visually (using diagrams or drawings) and eventually with words. Finally, the most obvious synergy between how literacy and numeracy materials need to be used in the classroom is that they need to be used daily, as intended, by learners.

Of course, merely providing children with learning resources is not sufficient to increase learning outcomes (McEwan, 2014; Tilson et al., 2013b, cited in Kim et al., 2016). The next section addresses the training that must accompany the provision of materials in order for comprehensive literacy and numeracy instruction to be effective.

CASE STUDY 4

USING MATH STORIES IN COMMUNITY MATH CLUBS TO PROMOTE CONCEPTUAL UNDERSTANDING

SAVE THE CHILDREN

The starting point of Numeracy Boost's grades 1 to 3 math club program is a read aloud, where the volunteer reads a story about a math concept and follows up with an activity and discussion where children explore the concept. The math stories convey abstract concepts like place value in an engaging and relevant manner. A scripted curriculum guide and a math kit including manipulatives like dice, number cards, counters, and a number line, help the facilitator lead children in discussions on the targeted concept. Children then have time to practice though games and activities. A sample story called "How Long is your Foot" describes a group of friends buying new shoes and trying to measure their feet using stones. Children discuss pros and cons of standard vs non-standard units of measurement, and measure their own feet using different non-standard materials.

IMPACT: In Bangladesh, there has been a positive and significant association between participation in community numeracy activities and children's numeracy skills. In the four other countries where community numeracy activities have been implemented, the evidence is less definitive.

CASE STUDY 5:

USING READ ALOUD BOOKS TO ENGAGE CHILDREN IN PROBLEM SOLVING IN NIGERIA

FHI 360

The RANA project in Northern Nigeria created math-themed read aloud stories for teachers to use with their children. Each math read aloud story was accompanied by a picture, two highlighted vocabulary words, three listening comprehension questions, and a set of math activities related to the story theme and specific math content. A total of 24 math-themed stories were created, one for each week of the school year. Teachers benefited from a three-day workshop where facilitators modeled how to use the read alouds in the classroom. Teachers then had an opportunity to practice under the guidance of facilitators.

IMPACT: The math read alouds improved children's listening comprehension by 8.8% on average. They increased children's missing number identification scores 18 percent overall. The gains were greater for girls (25 percent) and for low SES children (34%). Word problem solving scores increased, on average, 21 percent.

TEXTBOX 7:
Specific Steps for Program Design

- Begin the instructional design process with the development of scope and sequence of skills for each grade level, aligned with developmental learning progressions for the discipline.
- Ensure the instructional materials reflect the nature of the instructional models needed for each discipline and that they allow children to develop important, discipline-specific skills, as well as higher level thinking skills.
- Ensure that the learning activities proposed are engaging and meaningful.
- Align technical specifications of literacy and numeracy print materials (font, font size, placement of text, etc.) to facilitate children's ability to read numeracy materials. Control the difficulty of texts so that children are gradually exposed to increasingly more difficult texts.
- Align the difficulty of texts in numeracy materials with those of literacy materials.
- In contexts where the same teacher uses the literacy and numeracy materials, develop a single, model lesson format that can accommodate the similarities as well as the differences between instructional models for each discipline;
  - maximize the synergies between the nature or format of the instructional materials or how they will be used in the classroom; and
  - consider organizing learning around similar resources, such as big books or read alouds; however, ensure that separate, developmentally appropriate learning activities are provided for each discipline, and that the proposed learning activities respect the instructional models and practices specific to each discipline (see Nigeria Case Study.)

B3. Effective Teachers and School Leaders

Sustained professional learning is most likely to result when the focus is kept clearly on improving student outcomes, when there are repeated and sustained opportunities to embed any learning in practice, when the promotion of new thinking about teaching takes account of existing ideas, and when an environment of professional learning and support is promoted by the school's leadership.

Timperley, 2008

MAIN IDEAS

Research proves that good teachers have more impact on children's learning than do particular curriculum materials, specific pedagogical approaches, or pre-designed, pre-packaged instructional programs.

Teachers' beliefs and attitudes, their knowledge, and the quality of the learning environments they create have a direct impact on children's learning outcomes. Teacher training programs will only be effective insofar as they succeed in assisting teachers to examine and, most likely, change/adapt their attitudes and beliefs.

Effective teachers are expert in three domains of knowledge: content knowledge, pedagogical knowledge, and technological knowledge.

Content knowledge is the knowledge of a subject area, for example, the ability to do mathematics, or in the case of literacy to be a critical, informed reader and writer.

Pedagogical content knowledge refers knowledge of the ways in which content in a discipline (literacy or numeracy) is organized, knowledge of effective discipline-specific instructional models and practices i.e., the instructional practices that correlate with increased learning outcomes in either literacy or numeracy, as well as being able to use them effectively.

Technological knowledge refers to knowledge of instructional materials needed to support learning in a discipline and how to use them effectively.

Learning outcomes are only enhanced when children have access to learning resources AND teachers receive training on the use of those resources (RTI, 2015, cited in Kim et al., 2016). Good teachers have more impact on children's learning than do particular curriculum materials, specific pedagogical approaches, or evidence-based or designed programs (Allington & Johnston, 2001; Darling-Hammond, 1999; Pressley, et al., 2001). Investing in good teacher education at both the preservice and in-service level is the most research-based strategy available to programs that are focused on improving children's learning outcomes (Allington, 2002). This has numerous implications for the design and delivery of comprehensive literacy and numeracy programming.

Teacher Beliefs and Attitudes

Teachers enter the classroom with a complex set of beliefs about literacy and numeracy teaching. Teachers' beliefs and attitudes, their knowledge and the quality of the learning environments they create have a direct impact on children's learning outcomes (McEwan, 2015; Rivkin, Hanushek & Kain, 2005; DeStefano et. al, 2012).

These beliefs act as filters through which teachers process instructional models or practices presented during preservice or in-service trainings (Schoenfeld, 1998, 2002). When the models or practices do not align with their existing beliefs about numeracy (or literacy) or how the discipline should be taught, teachers either reject the new instructional models/ practices outright or re-interpret them to align with their existing belief structures (Ernest, 1999; Schoenfeld, 2002; Speer, 2005; Hollingsworth, 1989). In the latter case, the result is instructional practices that have a thin, superficial veneer of the targeted practices, but where the teaching-learning process is not changed in any fundamental way. As a result, there is little change in children's learning outcomes.

TEXTBOX 8:
Problematizing The Familiar

Schoenfeld (2002) and Ball & Cohen (1999) maintain that in the case of numeracy, shifting teachers' beliefs is best accomplished by "centering professional learning in mathematical practice." That means having teachers either engage in numeracy learning experiences or watch video sequences of teachers teaching and then deconstruct and reflect on what was learned, how it was learned, and what that says about numeracy as a discipline, as well as about the teaching-learning process. To quote Schoenfeld, one needs to "problematize the familiar" so that teachers question their underlying assumptions about mathematics as a discipline, and by extension, how mathematics should be learned/taught.

Implications for teacher training Programs focused on improving children's literacy or numeracy skills need to challenge teachers' beliefs about how children learn and the instructional practices best suited to the development of strong skills (Kim et. al, 2016; Schoenfeld, 1998, 2002; Timperley et al., 2007). However, changing teachers' instructional practices is a difficult and complex process. Teacher training programs need to raise teachers' awareness of their consciously or unconsciously-held beliefs about reading or mathematics, and about what it means to learn to read or to do mathematics. Teacher training programs should help teachers examine how these beliefs impact their decision-making in the classroom, and by extension, children's learning outcomes. They also need to have teachers explore the beliefs underpinning the new instructional practices or models being proposed, and the how these beliefs result in different instructional decisions in the classroom. This is a necessary step in having teachers adopt them (Timperley et al., 2007).[18]

Providing teachers with literacy or numeracy learning experiences that contrast sharply with the traditional, procedural or rote activities many experienced as learners can help challenge their long-held beliefs about what literacy or numeracy is, how it should be taught, and the role of teachers and learners in the process. This can be a powerful catalyst for restructuring beliefs and subsequently increasing teachers' willingness to adopt new instructional models.

TEXTBOX 9: Implications For Program Design

Assess the beliefs and attitudes teachers bring to literacy or numeracy teaching to ensure they align with the discipline-specific instructional models or practices teachers are being asked to adopt.

In case of disconnect, build multiple opportunities in training programs for teachers to either experience learning via the targeted instructional practices or models, or to deconstruct videos of teachers using the targeted practices or instructional models in the classroom. Build in time for teachers to reflect on what was learned and how it was learned.

[18] See Platas (2015) for an example of a mathematical developmental beliefs survey for pre-primary teachers.

Types of Teacher Knowledge

Being a competent teacher involves developing a complex array of knowledge and skills. Diagram 3 below, based on Mishra and Koehler's 2006 model and modified originally for literacy by Kim et al., (2016), outlines the different knowledge bases teachers need to possess with respect to both literacy and numeracy.

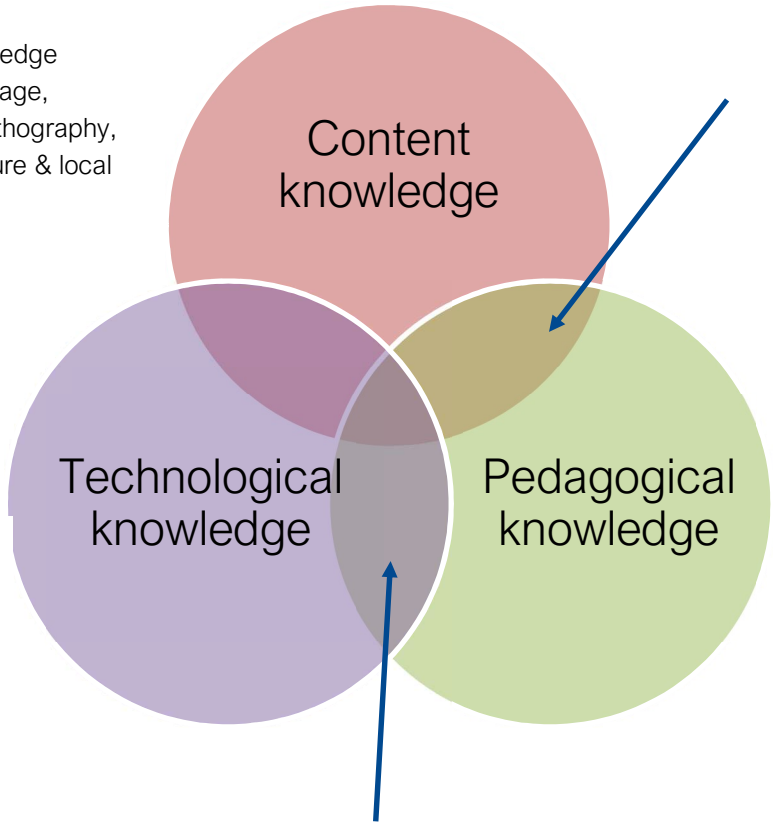
Diagram 3: Three Aspects of Teacher Knowledge for Literacy and Numeracy

Content knowledge

- Language knowledge (fluency in language, knowledge of orthography, language structure & local culture
- Knowledge of mathematics

Pedagogical content knowledge (or Mathematical Knowledge for Teaching)

- How children learn mathematics or learn to read
- How to best structure learning in literacy or numeracy classes
- Effective literacy or numeracy instructional practices



Technological knowledge

- How to use instructional technologies such as textbooks, blackboards, computers, etc. effectively

Pedagogical knowledge

- Classroom management
- How to engage and motivate children;
- Children's cognitive, socio-emotional and physical development

Technological pedagogical knowledge

- How to use literacy and numeracy technologies effectively to support children's learning

The three circles represent three large domains of knowledge: content knowledge, which can be thought of as "what to teach," pedagogical knowledge or "how to teach" and technological knowledge or "the tools used when teaching." Pedagogical content knowledge, or PCK, lies at the intersection of

content knowledge and pedagogical knowledge. It refers to the knowledge of how a particular discipline or content area is organized, as well as the instructional practices and models best suited to a particular discipline. Technological pedagogical knowledge, or TPK, refers to knowledge of how to use discipline-specific instructional resources (particular literacy or numeracy instructional resources) effectively.

In the following sections, we focus on these three aspects of teacher knowledge that are particularly important in becoming an effective literacy or numeracy teacher: content knowledge or CK; pedagogical content knowledge, or PCK; and technological pedagogical knowledge, or TPK.

2a. Teacher content knowledge - CK (or "what to teach in literacy and numeracy")

This domain of knowledge relates to teachers' knowledge of the discipline itself. Teachers who possess

Teachers cannot help children learn things they themselves do not understand.

Ball, 1991, p. 5

CK have a deep grasp of the skills and concepts that children need to learn. They have written and oral command of the language in which children are learning to read as well as an understanding of the structure of the language. In the case of numeracy, teachers understand the mathematical concepts they have to teach and can carry out procedures efficiently and accurately.

Teachers who possess CK also know how content in a discipline is organized. For example, they know the different literacy and numeracy content domains (see Table 1) and that "alphabetic awareness" refers to being able to recognize letters and the sounds they make and that algebra refers to the ability to recognize and describe patterns.

TEXTBOX 10:
Content Knowledge in Numeracy

Teachers who possess strong numeracy content knowledge can easily explain that 7 is an odd number, and that 8 is an even number AND they can explain what makes a number odd or even. This greatly differs from simply knowing which numbers are odd and even.

The extent to which teachers possess CK has a bearing on how they teach (Grossman 1990, Wilson & Wineburg, 1988) and on children's learning outcomes (Sadler et al., 2013; Hill et al., 2005). The stronger and more extensive teachers' CK, the better their children perform on academic assessments.

2b. Pedagogical Content Knowledge[19] (PCK) – (or "how to teach literacy and numeracy")

In the following sections, we examine three important elements of PCK:

- Knowledge of how the way content is organized in each discipline (content domains) affects how children's learning is structured;
- Effective discipline-specific instructional models
- Effective instructional practices that deepen learners' understandings in each discipline.

In each case, we examine PCK that applies equally to both disciplines as well as discipline-specific PCK.

Element One: Knowledge that the way content is structured affects how learning is delivered

Each discipline organizes content in different ways. Literacy content domains (see Table 1) include, but are not limited to, vocabulary, fluency, and comprehension. Well-known numeracy content domains include, but are not limited to, number operations, geometry, and measurement.

TEXTBOX 11:
To Nest Or Not To Nest

Whereas the skill domains of literacy are "nested," (i.e., they are interdependent and cannot be taught in isolation), those of numeracy are not. A child can develop spatial (geometry) or measurement skills, for example, without having first developed an understanding of number operations. Content knowledge allows a teacher to know which skill domains nest and which don't, and thereby enables a teacher to select materials and deliver lessons that are organized as a function of the characteristics of the skill domains of a given discipline (literacy or math).

They way in which content is organized in a discipline affects how instruction is delivered. For example, in Chapter A, we pointed out that the literacy domains are "nested." This makes intuitive sense; children cannot read words if they cannot identify the sounds letters make, and they cannot comprehend the ideas in written paragraphs if they can't fluently read sentences.

Early primary teachers must learn that literacy domains are "nested" and that this affects how they need to structure learning in the classrooms. Specifically, they must learn to carefully sequence and weave instruction across the different skill domains, (i.e., vocabulary, comprehension), rather than spending entire lessons only on the study of one domain. And they must have materials that are similarly "nested" to support this multi-layered instruction.

In contrast, in numeracy, teachers need to know that domains are not "nested" in the same way. Because of that instruction generally focuses on ONE numeracy domain at a time. However, teachers

[19] Pedagogical content knowledge, when used by mathematics educators, is often called Mathematical Knowledge for teaching. For the sake of simplicity, we have chosen to use the more general "pedagogical content knowledge" when referring to both disciplines.

do need to that the learning *within* a numeracy domain needs to be carefully sequenced, according to evidence-based and cognitively appropriate developmental trajectories specific to the domain. An essential part of numeracy PCK is, in fact, knowing the pedagogical sequence or cognitive pathways children follow as they move toward deeper or more expert understandings within a domain[20] (Wilson & Bertenthal, 2005; Clements & Sarama, 2014; Sarama & Clements, 2009; Hess, 2008).

So far, we've established that teachers with strong PCK: a) know how literacy and numeracy content domains are structured (nested or not) and the effect that has on instruction and b) know how, within a given domain, to sequence learning to respect evidence-based learning progressions. This is still not a complete listing of what teachers with strong PCK know. In addition to all of this, they also know the stages or phases of cognitive development through which children acquiring an ability in a given discipline progress.

For example, a literacy teacher with strong PCK will know that a typical student will progress from knowing that letters can represent words, at which stage he/she may jumble many letters together to form "words" that only he/she knows how to read, to knowing that letters represent specific sounds and must be sequenced and grouped in order to write words. At this stage he/she might be able to put together a simple sentence such as "I like cats". A numeracy teacher with strong PCK will know that young children's development of numeracy concepts proceeds through three sequenced phases or stages – Concrete, Pictorial, Abstract or Symbolic (CPA) (see discussion of CPA, section A).

Teachers with solid PCK related to learners' cognitive processes are able to recognize what stage/phase/step of learning a child is at in a given discipline and are able to explicitly guide his/her transition to the next phase or stage.

Element Two: Effective instructional models

Teachers with strong PCK know how to best present concepts to children (Ball et al., 2005, Ball & Cohen, 1999).[21] They know how to best structure learning in each discipline. That means they know the instructional model(s) best suited to each discipline, as well as the similarities and differences between discipline-specific instructional models.

An instructional model is a clear system of instructional guidelines based on specific and supported approaches to teaching. Effective instructional models are structured around research-based theories of learning, supported by implementation research that demonstrates effectiveness of the approach. Instructional models include clear information and guidelines for pedagogical approaches, and content.

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[20] There is a recent movement across jurisdictions to value depth over breadth when developing scopes and sequences for numeracy by focusing learning on key concepts in each domain. This provides learners with the time necessary to develop deep understanding. Curricula based on these principles have helped raise mathematics achievement around the globe (Thomas & Ward, 2001; Wright et al., 2002). See NCTM (2006) for an overview of key domain-specific concepts for different grade levels.

[21] The Learning Mathematics for Teaching (LMT) project at the University of Michigan has developed items to measure teachers' pedagogical content knowledge in mathematics, or their Mathematics Knowledge for Teaching, for three content areas: number concepts and operations; geometry; and patterns, functions and algebra. LMT items have been adapted for use in Ireland, Indonesia, South Africa, South Korea, Ghana and Malawi. See Cole (2011, 2012) for a description of their adaptation for Ghana and Kazima et al. (2016) for a description of the Malawi adaptation. Sample items from the assessment can be found at http://www.umich.edu/~lmtweb/files/lmt_sample_items.pdf.

Teachers must have strong pedagogical knowledge and skills, as well as content knowledge and skills, to be effective in implementing any instructional model.

Both literacy and numeracy use scaffolding-learning or **gradual-release instructional models**, moving children progressively towards stronger understanding until they are ready to apply their new skills or understanding independently. In a gradual-release model, the cognitive work involved in learning a new concept or performing a new task shifts slowly and intentionally from the teacher, who models the new learning outcome for the children, to the joint responsibility of the teacher and the children as they perform the learning outcome together, before shifting entirely to the children, who practice or apply the targeted learning outcome on their own, in a new context (Pearson & Gallagher, 1983). This model provides a structure for teachers to move from assuming "all the responsibility for performing a task . . . to a situation in which the learners assume all of the responsibility" (Duke & Pearson, 2002, p. 211).

In literacy instruction, the scaffolded, gradual-release instructional model for early primary classrooms follows the three stages: "I do, we do, you do," where the teacher begins by modeling a reading or writing skill, the teacher and the children then do the skill together, and then the children apply their knowledge of that skill independently, in a new context.

In numeracy instruction, however, scaffolded instructional models are usually problem-solving based. For example, children begin by using manipulatives, drawings, or diagrams to complete a numeracy task or solve a problem related to the targeted learning outcome ("You do"). They then share their solutions with the teacher and classmates during teacher-guided discussions.

During these discussions, the teacher encourages children to *compare their solutions and solution paths* and *explain and justify their thinking*, two critical activities for developing the mathematical process skills associated with strong numeracy. At the end of the discussion, the teacher models the targeted concepts or procedures for children ("I do"). The teacher-guided discussion, followed by teacher modeling, ensures that all learners develop a common understanding of the targeted concepts. The final step in the instruction model is having children apply the targeted concepts independently ("you do") to solve problems.

TEXTBOX 12: Teacher Activities During Guided Discussions

During teacher-guided discussions, teachers:

- reframe children's thinking,
- provide them with the terms or vocabulary they need to clearly explain their thinking,
- highlight the ideas embedded in children's answers, present alternative methods or ideas not suggested by the children and
- explicitly connect children's informal numeracy understandings to the formal one targeted in the lesson.

It should be noted that the carefully constructed, scaffolded problem-solving-based instructional model described above differs significantly from the "discovery model"[22] of mathematical instruction. Although

[22] Bruner (1961) defines discover learning as an inquiry-based, constructivist learning theory that takes place in problem solving situations where the learner draws on past experience and existing knowledge to discover facts, relationships and new truths to be

learners begin by engaging in problem-solving activities and build their new understandings on existing ones, the subsequent teacher-led discussion and teacher modeling infuses a strong element of direct instruction. The research evidence in mathematics favors a teacher-led explicit or direct instructional model over a pure discovery learning model (Kirschner et al., 2006).[23]

The textboxes below contrast the "I do, we do, you do" literacy scaffolded or gradual release instructional model with the problem-solving-based one often used in numeracy.

learned. Learners interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments.

[23] Alfieri et al. (2011) conducted a meta-analysis of 164 studies of discovery-based learning and concluded that "Unassisted discovery does not benefit learners, whereas feedback, worked examples, scaffolding and explicit instruction do." The authors recommend "enhanced discovery" (discovery with the types of explicit, rigorous guidance supports described in the problem-solving instructional model presented above) as the most effective approach to instruction in mathematics.

TEXTBOX 13:
Gradual Release Across the Two Disciplines

Literacy Scaffolded Learning Instructional Model	Numeracy Problem-solving-based Instructional Model
I do – Teacher models a skill We do – Teacher and children do the skill together You do – Children do or apply the skill independently	You do – Children do a problem selected by the teacher because it involves the targeted concept We do – Children explain and compare solutions during teacher-guided discussion I do – Teacher models concept for children You do – Children apply concept or skill independently

The large number of complex concepts and distinctions that a teacher must understand in order to have strong content knowledge in literacy and numeracy has multiple implications for the design of teacher training programs in both disciplines and/or for the delivery of programs that aim to reform instruction in both at the same time. A few of the major implications are summarized below.

Element Three: Effective instructional practices for each discipline

Teachers who possess strong literacy and numeracy PCK know the effective or evidence-based instructional practices in each discipline, i.e., the practices that correlate with increased learning outcomes in either literacy or numeracy. This includes instructional practices specific to each discipline, as well as those common to both.

Effective instructional practices common to both disciplines include the following:

1. **The use of explanation and justification to generate rich learning-focused child talk in the classroom (Muhonen, 2017; Lampert & Cobb, 2003).**

   Teachers do this when they ask children to: explain and justify their thinking and listen and respond to the thinking of classmates. When teachers make this a standard practice, children learn to question and confirm their assumptions. This deepens their grasp of concepts.

For example, in a literacy lesson, teachers might ask children to explain how they figured out how to read a new word or what a word means. Or, they might ask children whether they agree with a classmate's reading of a new word, or with another student's answer to a comprehension question.

In a numeracy lesson, teachers might ask children to explain how they arrived at an answer to a question, or whether they think a classmate's solution is correct. Children in classes where there is a high incidence of the type of numeracy "talk" where children explain their thinking or how they solved a problem, where they justify their answers and explain why they chose a particular strategy or what they think about the strategies other children used, develop stronger numeracy skills (Lampert & Cobb, 2003; Ball, 1993; Hiebert & Wearne, 1993). These types of numeracy talks allow children to reorganize and clarify material in their own minds, fill in gaps in their understanding, internalize and acquire new strategies and knowledge, and develop new perspectives and understanding (Bargh & Schul, 1980; Rogoff, 1991).

TEXTBOX 14: Simple Practices for Encouraging Explanation and Justification in the Classroom

Explanation and justification are encouraged when the teacher asks simple questions *(Why? How do you know?*) that foster higher-order thinking. Such questions "scaffold learners' engagement with the problem or tasks and create opportunities for learning high-level mathematics" (Boaler & Brodie, 2004; Kazemi & Stipek, 2001; Smith, 2000; Stein, Remillard, & Smith, 2007; Franke et al., 2009).

2. **Asking questions to foster children's higher-level thinking skills and giving them time to respond (Temmant et al., 2016; Zohar & Dori, 2003; Creemers & Kyriakides, 2006).**

Not all questions are equal. Cognitively demanding questions like those in Textbox 15 foster higher-level thinking in both disciplines, and by extension, increase learning outcomes. Introducing teachers to a common, high-level thinking questions that apply equally to both disciplines and numeracy can help teachers understand the commonalities of effective instruction in the two disciplines.

TEXTBOX 15: Five Simple Questions that Foster Explanation, Justification and Higher-Level Thinking Skills

How did you get that answer?

How do you know?

What do you notice about…?

How is this the same or different from…?

How else could you have… (solved that problem, figured out what the word means…)?

Caution: It should be noted that classroom practices are culturally situated (Clarke et al., 2006, cited in Kaur et al., 2013, p. 1.) It may be more challenging to implement practices 1 and 2 above in cultures where it is inappropriate for children to collaborate with teachers in the construction of understanding. It may also be challenging when children are learning in a language they do not speak fluently.

3. **Providing children with daily independent practice and monitoring their work (Rosenshine, 2010, 2012).**

   Children's learning is reinforced when they have time to apply in new or original contexts the concepts presented in a lesson. Children should have time each day to apply independently the literacy and numeracy concepts they have learned and get direct and individualized feedback from their teacher.

4. **Using children's errors to extend learning and correct misunderstandings.**

   Teachers in both disciplines need to listen to children's errors and appreciate that those errors represent a window into children's misunderstandings and a valuable tool for correcting them (Ball 1993; Walshaw & Anthony, 2008). When faced with children's errors, teachers need to ask questions to uncover what they have misunderstood. As children explain and justify their thinking, misconceptions or incorrect responses emerge.

   Teachers are more apt to value and address misunderstandings if they know and are able to recognize important misconceptions children at each grade level develop about literacy or numeracy topics—and if they know how to best address these misconceptions in the classroom. Teachers who possess this type of PCK are more effective in the classroom (Timperley et al., 2007; Blank & de las Alas, 2009; Shulman, 1986).24

5. **Using appropriate instructional practices to help children develop automaticity and/or fluency in both disciplines.**

   Fluency, (or automaticity), correlates with improved learning outcomes in both disciplines.

TEXT BOX 16: Automaticity In Reading

Automaticity refers to effortlessness and lack of conscious awareness… the ability to recognize letters, sounds and words accurately and immediately upon seeing them, without expending attention or effort…. It is important as it allows children to access and retrieve quickly information needed for reading and writing.

Kim et al., 2016, p. 12

TEXTBOX 17: Fluency In Numeracy

In numeracy, fluency is defined as "knowing how a number can be composed and decomposed and using that information to be flexible and efficient with solving problems" (Fosnot & Dolk, 2001).

Computational fluency is an essential life skill. Up to 80 percent of the mathematical computations performed in non-technical settings, such as the exchange of money or the determination of times and distances, are done mentally (Reys & Nohda, 1994).

[24] For examples of problems that can help teachers understand the misconceptions children develop around key primary numeracy concepts, see http://www.umich.edu/~lmtweb/files/lmt_sample_items.pdf.

Many readers may be familiar with oral reading fluency, or ORF, which, in literacy instruction, strongly correlates with reading comprehension across languages (del Valle Catalan, 2016; Fuchs et al., 2001; Hudson, et al., 2009; Jenkins, Fuchs, et al., 2003; Kim, 2015; Kim et al., 2014; Kim et al., 2010; Piper & Korda, 2011a – all cited in Kim et al., 2016). However, not all readers may realize that teachers must support learners' fluency (or automaticity) development across all literacy skill domains (letter naming, letter writing, word reading, spelling, and text reading (ibid).

Teachers need to know the specific instructional practices that help children develop fluency/automaticity in each of the literacy domains; for example, having children reread words in isolation or in connected texts or having them re-read the same texts several times to increase their speed and accuracy (Kim et al., 2016). Teachers who do not know how to structure and lead repeated practice activities do not have strong literacy pedagogical content knowledge.

CASE STUDY 6:

BUILDING TEACHERS' PCK/MKT IN GHANA

SCHOOL TO SCHOOL INTERNATIONAL

Data collected during the planning phase of the USAID-funded Ghana Learning Initiative Early Numeracy Pilot revealed that early grade teachers' conceptual understanding of key topics addressed in early primary was incomplete. In addition, they had less than positive perceptions of their mathematical abilities, or of mathematics as a discipline. They also viewed mathematics as a series of rules, steps or definitions to be memorized and applied, and they believed that the teacher's primary role in early grade numeracy classes was to explain these rules, steps or definitions clearly. It was evident that unless these perceptions and attitudes were challenged, teachers would not be able or willing to implement the new instructional practices as intended. To address this, the weekly school-based in-service sessions started with teachers working in pairs to solve an engaging, often open-ended problem related to a key concept in early primary, and then comparing their solution and their method for solving the problem. In a follow-up study conducted at the end of the year, teachers identified the weekly problem solving as the most powerful professional development activity in the year-long program, and the activity that best helped them understanding new ways of teaching and learning.

IMPACT: In a random control trial carried out in year 2 of the pilot, grade 1 children scored anywhere 5% higher than children in control schools on traditional Early Grade Mathematics Assessment measures and 21% better on higher-level thinking skills (reasoning, justification, explanation). For grade 2 children, the difference was virtually the same, 4% and 21%, respectively. There was a significant and positive difference in favor of the treatment group for both grade levels.

Fluency in numeracy: Teachers with strong numeracy pedagogical content knowledge understand that fluency with basic facts, or mental computation, is essential for continued achievement in mathematics. Children who do not have computational fluency spend precious short-term memory

trying figure the answers to simple computation, leaving inadequate short-term memory capacity for problem solving.

Teachers need to know the specific instructional practices that help children develop computational fluency. They must know that the basis of computational or procedural fluency[25] is a strong conceptual understanding of the number system—not memorization. Children begin developing this understanding when they use manipulatives to explore the different ways that quantities can be composed and decomposed; for example, that 6 can be represented as 2 and 4 or 5 and 1. Children who are able to represent quantities in equivalent ways can use that understanding to develop computational fluency. For example, children who have a flexible understanding of number quantities know that when faced with a difficult addition problem like 8 + 6, they can replace the 6 by 2 + 4 and create an equivalent addition that is easier to solve; 8 + 2 + 4, or 10 + 4.

Research shows that children who use computational strategies grounded in a conceptual understanding of the number system score higher in numeracy assessments (Gray & Tall, 1994). Lower-achieving children rely on memorization, a far more ineffectual and inefficient strategy (ibid).[26]

The instructional practices that support the development of strong computational fluency are very different from those used to develop automaticity or fluency in literacy. Teachers who possess strong pedagogical content knowledge know this.

TEXT BOX 18:
Developing Fluency with Numbers

The best way to develop fluency with numbers is to develop number sense and to work with numbers in different ways, not to blindly memorize without number sense (p 3). [Teachers must be taught] that an over-emphasis on memorization as a means of developing fluency, as opposed to number sense, can in fact inhibit children's mathematical development.

[25] The National Council of Teachers of Mathematics (2014) defines procedural fluency as "the ability to apply procedures accurately, efficiently, and flexibly; to transfer procedures to different problems and contexts; to build or modify procedures from other procedures; and to recognize when one strategy or procedure is more appropriate to apply than another."

[26] See Boaler, 2015 for a discussion of the role of fluency in mathematics and research-based methods for developing fluency in young children.

CASE STUDY 7:

Extending Conversations in Kenya

RTI International

The Tayari program in Kenya focused on improving early grade literacy and numeracy results. As the same teacher was responsible for teaching both subject areas, it was important to introduce an integrated approach that highlighted some of the commonalities between good literacy and numeracy instruction. The program identified and emphasized a set of core instructional strategies that apply equally across the two disciplines to help teachers recognize that similar strategies can be used across disciplines. One of the core strategies during the first year of implementation was "extending conversations." This allows the program to introduce teachers to some of the higher-level thinking skills common to literacy and numeracy, as well as create spaces in numeracy lessons for children to explain and justify their thinking.

In the case of literacy, teachers were taught how to ask children follow-up questions during the daily oral "news telling" activity. In numeracy, training focused on teaching teachers how to probe children's thinking with "how" questions during problem solving activities (e.g., "How did you get that answer?" "How did you know that you should do that?"). By using a common theme of "extending conversations" in both early grade literacy and numeracy classes, teachers were able to better see some of the similarities between effective instruction in the two disciplines. At the same time, the program was able to acknowledge and honor the specificities of each discipline.

IMPACT: Longitudinal randomized control trial results showed the program had statistically significant effects on certain numeracy tasks (producing sets, identifying numbers, naming shapes) but no initial effects on oral and mental addition. The Tayari program improved numeracy outcomes by 0.31 standard deviations in the control model (p-value < .05) and by 0.29 standard deviations in the base model (p-value .07) (Piper et al., 2018).

Discipline-Specific Instructional Practices: Numeracy Spotlight

Throughout this paper, we have maintained a practice of discussing discipline-specific information by starting with literacy and then addressing numeracy. In this case, however, we will focus only on numeracy. Those seeking information on discipline-specific instructional practices in literacy should refer to the Global Reading Network Landscape Analysis in Reading Instruction (Kim et. al., 2015).

While there is no single "best practice" in numeracy (Sitabkhan & Platas, 2018), research does show that in addition to the above practices, the two practices that follow are central to effective numeracy instruction:

- **Making explicit connections between informal and formal mathematics:**

  Young children come to the classroom already "doing" mathematics, whether in games with friends or chores at home (Saxe, 1991; Davis & Ginsburg, 1993; Guberman, 1999; Khan, 1999; Clarke et al., 2006; Bodovski & Farkas, 2007; Sitabkhan, 2009, 2015; and Taylor, 2012). For example, they enter primary knowing how to add objects together because they have done so while playing. There is a large body of evidence documenting the mathematics that children learn outside of school, often referred to an informal mathematics, or out-of-school mathematics (Saxe, 1991; Davis & Ginsburg, 1993; Guberman, 1999; Khan, 1999; Clarke et al., 2006; Bodovski & Farkas, 2007; Sitabkhan, 2009, 2012; and Taylor, 2012).

  The mathematics that children learn in school is often referred to as formal mathematics, or school mathematics. Instruction should aim to connect children's informal mathematical knowledge with the formal knowledge they learn in school. For example, children may know how to add objects together through play. In school, they learn how to represent the act of addition using using number symbols and an equation. It is important that teachers explicitly make the connection between formal addition processes introduced in school and the adding children do informally when playing or in the market. This helps children make sense of and develop a deep understanding of the numeracy concepts explored in school.

- **Using manipulatives and diagrams to represent numeracy concepts:**

  The next section, Teachers' technological pedagogical knowledge, addresses this practice in greater detail.

TEXTBOX 19:
Synergies Between Effective Literacy and Numeracy Practices

Teachers who implement the "best practices" described in this section, i.e., who encourage their children to represent their thinking with models, diagrams and symbols, and then to verbally compare solutions and solutions paths and justify/ explain their choices and their thinking, will create oral language-rich learning environments. This in turn reinforces children's language skills, and by extension, their reading and writing skills,

2c. Teacher Technological Pedagogical Knowledge (TPK, or "using literacy/numeracy teaching tools")

Providing teachers with learning materials has a relatively small impact on children's learning outcomes (McEwan, 2014; Tilson et al., 2013b, cited in Kim et al., 2016). Learning outcomes only improve when teachers use them correctly. For the purposes of this paper, we will refer to knowledge about how to use literacy and numeracy learning materials effective in the classroom as "technological pedagogical knowledge" or TPK

TEXTBOX 20: A Note on the Term "Technological"

Technological pedagogical knowledge (TPK, in this paper) uses the term 'technological" broadly. When we hear that term in daily life, we think of items such computers, mobile phones, online platforms, apps, drones, self-driving cars, or robots. Presumably, of course, teachers could employ all of these in their literacy and numeracy instruction someday, (although the use of drones could prove challenging). More frequently, however, the word "technological" in this context alludes to print materials and tangible manipulatives that teachers are most likely to have in their classrooms. So, while "technological" here can include teaching tools like software programs to help develop vocabulary or an online app that a teacher asks learners to use to play numeracy games, it is neither restricted to electronic or digitized devices nor meant to direct attention away from the paper and print resources teachers must learn to use to be effective in their classrooms.

Literacy TPK

Teachers at all grade levels need to understand how to use textbooks and supplementary reading materials (classroom libraries in a box, library books, other recreational reading materials, etc.) effectively to support children's learning. In addition, early primary teachers need to know how to use the following materials to develop children's reading fluency, vocabulary and comprehension skills.

Teacher read aloud books – These are stories or texts that the teacher reads aloud to children to develop their listening comprehension and vocabulary skills, as well as increase their interest in reading. Teachers need to learn how to do a powerful read aloud (reading clearly, at an appropriate pace and with expression) and how to use the read aloud text to develop listening comprehension and vocabulary skills.

Decodable texts – These are carefully controlled texts containing words that the children have learned to decode. For instance, if one-syllable words such as *hat*, *cat*, *bag*, and *pig* have been taught, then the decodable texts would contain these and other already taught words (Kim et al., 2016). Teachers need to understand the role of decodable texts in building children's ability to read words, and to read them fluently.

Leveled texts – Leveled texts are texts are that are organized by levels of difficulty, from easiest (short, few words, short sentences) to most difficult (longer, more words, more words per sentence, more complex sentences, etc.). They contain words children have already learned how to read, as well as new words. Children are paired with texts that best match their reading level. As their reading skills improve, they gradually move to increasingly more difficult texts.

Numeracy TPK

In the case of numeracy, teachers at all grade levels need to understand how to use textbooks effectively. In addition, they need to know the following:

- The importance of manipulatives, drawings and diagrams in explaining or representing abstract numeracy concepts, and how to use them effectively in the classroom – Manipulatives (objects), drawings, diagrams, or symbols are used to make abstract numeracy concepts more concrete and easier for children to understand. Representing concepts with objects or drawings helps children hone their mathematical thinking skills and helps them think and reason in more meaningful ways (Stein & Bovalino, 2001). Accurate, meaningful use of manipulatives has been associated with learning gains in children's ability to count (Clements, 1999), understand place value (Phillips, 1989), compute (Carroll & Porter, 1997) and problem solve (Clements 1999; Krach, 1998).
- Merely putting objects or manipulatives in the hands of teachers or children does not improve learning. Learning results improve when manipulatives are used purposefully, accurately and under the guidance of a teacher trained in how to use them effectively (Carbonneau, et al., 2013; Clements & Battista, 1990; Clements, 1999; Sugiyama, 1987; Suydam, 1984). Being able to represent a numeracy concept accurately, is part of the specialized knowledge that numeracy teachers need to develop (Ball et al., 2008). They also need to understand of the importance of having children represent a single numeracy concept with a variety of manipulatives, for example, representing the quantity 4 with counters, fingers, straws, blocks, diagrams, and eventually symbols. Children who can do this have a strong conceptual understanding of the quantity "four". Finally, teachers need to understand the importance of putting manipulatives in the hands of children and having them use the manipulatives purposefully and accurately to represent their understanding.

Case Study 8:

Training Teachers to Manage, Distribute and Use Learning Materials in Kenya

RTI International

The USAID-funded Tayari pre-primary program in Kenya developed literacy and numeracy teaching and learning materials for pre-primary classrooms, in close collaboration with the Kenyan Institute of Curriculum Development as well as the Ministry of Education. Teachers received training and in-classroom follow-up support on how to use the materials effectively. One of the two core strategies introduced during the first year of implementation was how to manage, distribute and use new literacy and numeracy instructional materials. This included facilitators modeling how to use key literacy and numeracy materials; for example, how to gather local materials to use as counters during mathematical games or how to use real objects to explain a new word. By emphasizing the similar, important role that materials (in this case objects) play in early grade literacy and numeracy classes, the Tayari program was able to reinforce the similarities between effective literacy and numeracy instruction without sacrificing an understanding of the specific and different ways materials can and should be used in literacy and numeracy.

3. Effective School Leaders

Teachers' instructional practices have significant impact on children's learning outcomes in both literacy and numeracy, and in other disciplines (McEwan, 2015; Rivkin, Hanushek, & Kain, 2005). In classrooms where teachers use more effective teaching and learning practices like those described in the previous sections, children learn more.

The second greatest impact on pupils' children's learning outcomes is the leadership provided by school principals or head teachers. Children in schools where head teachers adopt effective leadership practices have higher learning outcomes that children in schools where head teachers do not (Seashore Louis et al., 2010; Leithwood et al., 2004). The total effect of school leadership on children's learning accounts for about a quarter of total of all school effects on children's learning outcomes (Leithwood et al., 2004).

School leadership practices associated with improved learning outcomes, when viewed through the lens of literacy and numeracy, include (Seashore Louis et al., 2010.):

TEXTBOX 21:
The Role of Leadership

There seems little doubt that both district and school leadership provide a critical bridge between most educational-reform initiatives, and having those reforms make a genuine difference for all learners. Efforts to improve (leadership) recruitment, training, evaluation and ongoing development should be considered highly cost-effective approaches to successful school improvement.

Leithwood et al., 2004, p. 14

Establishing a clear focus across the school on improving literacy and numeracy learning outcomes (Leithwood et al., 2004; Robinson et al., 2008). School leaders should have a clear understanding of best practices in literacy and numeracy, and specifically of the instructional models being implemented in the school. While school leaders do not need to have the depth of understanding and knowledge of teachers, being able to recognize when an instructional model is being implemented as intended is critical to being able to advise teachers, monitor their commitment to the instructional program, and identify and respond to school-level program implementation issues.

Setting and communicating expectations around literacy and numeracy learning. This includes communicating directly to pupils and parents grade-specific benchmarks children are expected to meet and working with teachers to reinforce the message that all children have the capacity to be good literacy and numeracy learners (Leithwood et al., 2007; Robinson et al., 2008). When school leaders are able to speak to the goals and importance of learning in both literacy and numeracy, teachers, parents, and children understand that the purpose of the school is instructional (as opposed to operational) and that all stakeholders are committed to children's learning. This can create a strong learning culture in the school, not only for children but also for adults, necessary for long-term sustainability of positive change.

Ensuring that teachers use evidence-based literacy and numeracy instructional practices. While school leaders wear many "hats" in their work, the hat of "instructional leader" is most critical to ensure that all teachers reach toward their most effective practice, and all learners are given an equitable opportunity to learn in a quality environment. Frequent, focused classroom observations can help identify practices teachers are struggling with and potential remediation activities to reduce their struggle.

Ensuring that teachers use instructional materials effectively. Once again, frequent, focused classroom observations can help pinpoint and address challenges. Additionally, the school leader holds operational responsibility for the school and program implementation. This includes responsibility for the receipt, housing, distribution, and use of resources effectively and efficiently, and in ways that ensure regular hands-on use by children as an integrated part of the instructional model implementation.

TEXTBOX 22:
Dual Focus Yields Results

In Mozambique, an intervention program with a dual focus on the teaching of component reading skills and school management improved children's reading skills more than an intervention program focused only on the teaching of component reading skills (Raupp et al., 2015, cited in Kim et al., 2016).

Monitoring children's learning outcomes to ensure they are meeting expected benchmarks and that appropriate remediation activities are put in place to remedy identified learning gaps. While the school leader does not hold primary responsibility for individual child achievement (this is the role of the teacher), the leader, along with teachers, does hold responsibility for children's performance in the school. By regularly monitoring class-level performance through use of continuous assessment data, both formal and informal, school leaders can identify teachers in need of additional coaching and support, and grade levels within the school where learners may be systematically struggling. This kind of regular investigation and reflection encourages all school staff to use a data-responsive approach to instruction, ensuring that any problems with program quality are addressed in a timely manner, and that all learners are kept on track toward meeting instructional goals on time.

Ensuring teachers have access to and participate in professional development to improve children's learning outcomes, including school-based professional learning communities and mentoring and coaching activities (Leithwood et al., 2004). When school leaders seek out, share and encourage professional development participation for their teachers, they have a significant impact on the professional culture of the school. By emphasizing the importance of ongoing teacher learning, school leaders send the message that instructional improvement is a journey, not a destination, and that all teachers will be held to a high standard of quality.

Establishing strong school-community-home partnerships so parents and the community are aware of and involved in efforts to improve literacy and numeracy outcomes (see section 3.6 about extending learning outside the classroom). Parents are one of the most important partners in a child's education. In many developing contexts, the traditional relationship between the school and home may not have a positive history. It is important that school leaders not only welcome the community into the school as a general support network, but also set up structures so that parents

are regularly and actively involved in determining and understanding what is taking place in classrooms, and their child's success relative to skills and knowledge development.

4. Nature, Dosage and Duration of Teacher and School Leader Trainings

Nature of teacher and school leader training - Teachers and school leaders need professional development opportunities that demonstrate for them how to use evidence-based practices and give them opportunities to practice using them under the guidance of a trained facilitator.

The **dosage** of trainings provided to teachers and school leaders, defined as the frequency and intensity of the training, matters. So does the **duration** of the trainings, defined as the total number of hours of training. Both have an impact on participants' ability to implement the targeted practices, and by extension, on children's learning results (Moore et al., 2017).

Training programs need to be of sufficient dosage and duration so that each group develops a deep understanding of the practices and actions required to improve children's literacy and numeracy skills. Although there is no definitive research on the minimum dosage or duration of training required to produce the desired effect in a given context, research does confirm that one dose of an intervention is not sufficient; one-day workshops do not provide the depth of understanding necessary to affect change (Boller et al., 2004, Winton & McCollum, 2008, cited in Moore et al., 2017).

TEXTBOX 23:
The Role of Professional Development

…Meaningful professional learning that translates to changes in practice cannot be accomplished in short, one-off workshops.

(Darling-Hammond et al., 2009)

Professional development that is sustained, offering multiple opportunities for teachers to engage in learning around a single set of concepts or practices, has a greater chance of transforming teaching practices and student learning.

(Darling-Hammond et al., 2017)

It stands to reason that in a context where teachers' content, pedagogical content, and technological knowledge in either literacy or numeracy is weak, and/or where school leaders do not both comprehend and apply the principles for effective leadership evoked here, the dosage and duration of trainings needs to be greater than in contexts where that is not the case.

TEXTBOX 24:
Ideas for Program Design

Teachers need training and coaching that:

- Is aligned between pre-service and in-service, addressing all aspects of teachers' CK, PCK and TPK in literacy and in numeracy.
- Helps teachers understand the different domains of literacy and numeracy, differences in how content is organized across these domains, and how those differences impact content organization within a lesson or across a series of lessons.
- Includes focused work on how to develop and use materials whose design follows the research base regarding the degree of nesting recommended for study of the skills domains of each discipline.
- Enables teachers to master implementation of two similar but distinct gradual-release models for instruction (literacy and numeracy)
- Provides explicit and clear instructional routines—those that serve student progress in both disciplines, as well as those that are specific to either literacy or numeracy—as a feature of teacher training programs
- Links to the specific materials and texts teachers will have available, which, in turn, need to be structured to facilitate the use of the evidence-based instructional strategies the understanding of which make up a teacher's pedagogical knowledge
- Places a heavy emphasis on how to use to use new literacy and numeracy instructional materials (see section 3) in the classrooms. This includes how to use teachers' guides, how to manage instructional resources in the classroom, how to use simple formative and summative assessment tools to monitor and interpret learners' progress with key skills, as well as how to implement simple but appropriate remediation strategies.
- Provides teachers with multiple opportunities to implement the activities and instructional models outlined in the guides, under the guidance of trained facilitators. This type of scaffolding will ensure that teachers have the skills and confidence to use the new materials as intended in the classroom.
- Focuses on identifying low or no-cost manipulatives to represent key concepts (counters, bundles of straws or sticks, geometric forms, etc.). Provides time and space for teachers to practice using these manipulatives to accurately represent concepts, under the guidance of facilitators with expertise in this area. (See section 3.3 for a discussion of numeracy-specific instructional materials.)

School leaders need training and support to:

- Focus on clear, simple, manageable and evidence-based school leadership actions that correlate with improved outcomes in both literacy and numeracy, including how to support teachers to use the new instructional models and materials as intended
- Track and monitor the quality of teaching taking place in classrooms, and support continuous progress on the part of teachers
- Monitor teacher program implementation and student progress on a regular basis, using simple tools, to intervene with teachers and or learners who are struggling to achieve results.

TEXTBOX 24 (CONT.)

School leaders need training and support to:

- Focus on clear, simple, manageable and evidence-based school leadership actions that correlate with improved outcomes in both literacy and numeracy, including how to support teachers to use the new instructional models and materials as intended
- Track and monitor the quality of teaching taking place in classrooms, and support continuous progress on the part of teachers
- Monitor teacher program implementation and student progress on a regular basis, using simple tools, to intervene with teachers and or learners who are struggling to achieve results.

Teacher and leadership training should be:

- Of sufficient duration to allow for knowledge acquisition, skills development, and practice with applying new learning
- Supported by ongoing mentoring and coaching to ensure fidelity of implementation, development and application of new skills, and creation of capacity to implement, gather data, reflect, and revise program implementation at all levels in the school

5. Coaching and Mentoring

Coaching or other expert scaffolding can support the effective implementation of new curricula, tools, and approaches by educators (Gallagher et al., 2008, Penuel et al., 2011, Roth et al., 2011). … Teachers who receive coaching are more likely to enact desired teaching practices and apply them more appropriately than those receiving more traditional professional development (Showers et al, 1996, Neufeld & Roper, 2003; Knight, 2004, Kohler et al., 2007).

MAIN IDEAS

Coaching is a formalized process that engages teachers in job-embedded professional development, while mentoring is a more informal mutual professional relationship developed to support instructional quality over an extended period of time.

Coaching and mentoring have been found to improve teacher practice and are related to improvements in student performance.

Coaching and mentoring both take a variety of forms, and there is no set recommendation about the dosage of coaching and mentoring that work best.

Coaching and mentoring processes and content should be designed to directly target key program components and student skills.

Coaching is the process by which teachers and school leaders are supported in continuously improving their practice, through formal and informal job-embedded professional development. Coaching takes many forms, including

- small group teacher knowledge-building sessions
- lesson planning and lesson review
- classroom observation with feedback
- model teaching/co-teaching
- individual counseling on instructional struggles

Mentoring is a part of a larger coaching process, and is usually an individualized and informal process, where a more experienced and knowledgeable practitioner mentors an individual over time, creating a long-term expert and apprentice relationship that is of benefit to both. In mentoring relationships, the impetus for interaction is less driven by a coach or a program model, but instead is a mutually initiated relationship grounded in discussions and work on improvement of instructional practice.

There is some evidence that children in classes where teachers participate in coaching or mentoring programs score higher than children in classes whose teachers do not have access to coaches (Tilson et al., 2013, cited in Kim et al., 2016). However, coaching alone does not necessarily lead to improved outcomes (Gamse, et al., 2008; Bean et al., 2010, cited in Pierce, 2014). Teachers are more likely to implement new practices – and as a result children's learning outcomes are more likely to improve – when they benefit from a combination of face-to-face training and follow-up coaching or mentoring (see textbox 25).

TEXTBOX 25: Effectiveness of Coaching

One of the seminal studies on coaching (Joyce & Showers, 1982) found that teachers who attend infrequent professional development activities implement about 20% of the practices presented. When that training is accompanied by ongoing coaching or mentoring, that percentage increased to 80% to 90%. These findings were confirmed by a recent South African study (Cilliers & Taylor, 2017), which found that a coaching program improved learning proficiency by 0.25 standard deviations. In contrast, a tradition training program without a follow up coaching component had a far smaller and statistically insignificant impact of 0.11 standard deviations.

Nature of coaching and mentoring programs: As mentioned early in this paper, educational interventions that are narrowly focused on improving teacher-learner interactions in the classroom have the greatest impact on children's learning outcomes (Conn, 2014, cited in Evans & Popova, 2015; Crouch & DeStefano, 2017; Popova et al., 2018). It then follows that coaching and mentoring programs should focus on those elements most likely to improve the quality of the classroom learning environment. This includes the teacher's effective use of instructional models, instructional practices, instructional resources and classroom instructional time. Providing coaches with simple, manageable tools – including classroom observation tools – keyed to these critical classroom elements can assist coaches in identifying instructional strengths, as well as specific, actionable areas for improvement. One example is the Classroom Observation Toolkit, developed and distributed by the Global Reading Network.

Two coaching activities that correlate with improved learning outcomes are:

- **modeling**, where a coach demonstrates how to use an instructional practice or resource, often because the teacher has used it incorrectly (Biancarosa et al., 2010; Kim et al., 2011; Neuman & Cunningham, 2009; Neuman & Wright, 2010) and
- **performance feedback**, where a coach presents a teacher with data on her/his instructional practices, generally after observing a lesson (Cornelius & Nagro, 2014; Scheeler, Ruhl, & McAfee, 2004; Solomon, Klein, & Politylo, 2012; Stormont et al., 2015, cited in Pierce, 2014). Specific, actionable feedback is so effective in improving teaching practices, and by extension children's learning, that it has been labeled by some researchers as an evidence-based practice (Fallon et al., 2015).

Dosage and duration: Just as dosage and duration are important factors in the efficacy of teacher training programs, the amount of time coaches spend working one-on-one with teachers has a bearing on the extent to which they change their practices. This in turn, has an impact on children's learning outcomes.

Frequent mentor or coach visits in Kenya, for example, produced higher learning outcomes than less frequent ones (Piper & Zuilkowski, 2015). Learning outcomes were higher in schools where a single coach supported 10 schools as opposed to 15 (Ibid.). In Liberia, when the coach-to-school ratio increased from 4 to 12 between pilot and scale-up, reducing the number of school visits each coach could make, children's learning results declined correspondingly Gove, Korda Poole, & Piper, 2017).

Although the children's learning results are linked to the level of coaching support received, more research is needed to determine the dosage required, in a given context, to generate desired improvements in children's learning outcomes (Piper & Zuilkowski, 2015).

TEXTBOX 26: An Example of Coaching via Modeling

A coach who is helping a Kindergarten teacher understand how to deliver a lesson intended to build children's phonological awareness might prepare a lesson, review it with the teacher in advance, provide the teacher with a checklist of things to look for during the lesson, and then review the checklist with the teacher after the coach has delivered the model lesson, using a meta-cognitive reflection process (thinking aloud about his/her thinking).

TEXTBOX 27: Further Evidence of Coaching Effects

Interventions involving long-term teacher mentoring or in-school teacher coaching produce a sizeable (albeit not always significant) effect on student learning, at 0.25 standard deviations.

(Conn, 2014, cited in Evans & Popova, 2015)

CASE STUDY 9:

Implementing School-based Numeracy Coaching in Ghana

School to School International

At the request of the Ministry of Education, the USAID-funded **Ghana Learning Initiative Early Numeracy Pilot** implemented a school-based peer coaching program for early grade numeracy. Teachers were recruited from each pilot school to train as peer coaches and trained on the new instructional model and materials. Schools ended one hour early once a week to allow K1 to Grade 3 teachers to participate in coaching sessions led by the peer coaches. The weekly sessions engaged teachers in authentic problem-solving activities to build their mathematical knowledge for teaching, as well as their first-hand understanding of the new instructional model. The sessions also focused extensively on the accurate use of models (objects, diagrams) to represent foundational numeracy concepts. In addition to training, coaches received coaching guides outlining how to structure and organize each session, and a collection of videos demonstrating how to use locally resourced manipulatives accurately.

IMPACT: In a random control trial carried out in year 2 of the pilot, grade 1 children scored 5% higher than children in control schools on traditional Early Grade Mathematics Assessment measures and 21% better on higher-level thinking skills (reasoning, justification, explanation). For grade 2 children, the difference was virtually the same, 4% and 21%, respectively. There was a significant and positive difference in favour of the treatment group for both grade levels.

6. Continuous Student Assessment that Informs Practice

MAIN IDEAS

Formative assessment is critical to support effective decision-making in the classroom, and should be simple to administer.

Summative assessment is important to provide benchmark information for schools and teachers at periodic intervals.

Teachers must be trained to conduct both formative and summative assessment.

Formative and summative assessment are both necessary to inform improvement at the student, school, program, and national level.

Assessment should not be the only driving factor or success measure for learners, teachers, schools, or programs.

Assessment data should be used to inform quality and decision-making for other program aspects and components of the MOSAIC.

In Chapter A, we stressed the fact the education reforms, including those that are comprehensive and address elements of systemic function, are most effective when they are learning-focused. And one way to make them more learning-focused is to regularly collect information, (i.e., data) on learners' actual progress in acquiring the skills needed to become increasingly literate and numerate (see chart in part one for full descriptions).

A central tenet of comprehensive learning-focused literacy and numeracy interventions programs is the use of data-driven assessments. Children whose teachers assess their performance on a regular basis, and with respect to performance standards and benchmarks, have improved learning outcomes (Piper & Korda, 2011, cited in Popova et al., 2018).

Learning gains are greatest when information on student performance is used to guide future instruction and identify remediation efforts at the class or individual learner level (Black & William, 1988). For that reason, intervention programs should consider providing teachers with reliable but simple to administer and interpret tools to identify learning gaps with respect to key skills. Each tool should be accompanied by simple but specific remediation activities to address specific learning gaps identified.

Formative assessment tools are tools that are specifically designed for teachers to use quickly and easily on an ongoing basis in the classroom. They may be used to gather baseline data on all learners when they first come into the classroom, to determine student readiness, and to guide decisions that lie within the other MOSAIC components, such as the decision about what level of text is best suited as a beginning point for learners, or what types of pedagogical approaches are most suited for learners at a specific level.

They are also used on an intermittent basis, during instructional and student activity time, to "spot check" learners on specific skills that have recently been addressed in the classroom. This allows teachers to identify several things: 1) the need to revisit concepts with the entire class, due to a general lack of uptake, 2) the need to form small groups for remediation during activity time, to support a smaller number of learners who are at risk of falling behind, and 3) the need to implement intensive instruction with individual learners, or even recommend learners for further testing, if teachers believe there is some cognitive or physical disability that may be interfering with student learning. Formative assessment tools should be simple and straight forward. They also should be quick to use in the classroom.

In literacy, EGRA-like assessment tools are highly useful for teachers, and include things like the following:

- Pictures for student discussion, to measure oral language and oral fluency
- Short passages read aloud by the teacher to measure auditory comprehension
- Simple letter/sound association identification lists to measure graphophonemic awareness
- Lists of frequently used words, aligned with the scope and sequence for phonics instruction, to measure the learners' ability to decode words and/or recognize expected sight words
- Short passages, leveled appropriately for the student, to measure both silent-reading comprehension and reading fluency

In mathematics, EGMA-like assessment tools that include things like the following:

- Random number lists or charts, to measure children's ability to recognize letter symbols
- Lists of paired numbers, to measure children's ability to recognize larger or smaller quantities
- Single-digit additions and subtractions to measure children's fluency with basic facts
- Double-digit additions and subtractions to measure children's mental computation fluency
- Pictures of shapes of different sizes and orientations, to measure children's ability to identify different shapes

- Increasing or decreasing number sequences, with missing numbers to measure children's ability to recognize number patterns
- Simple word problems to measure children's problem-solving skills

These tools are helpful in determining whether children are meeting minimum expectations and identifying children who need additional support.

For both literacy and mathematics, teacher training and coaching must integrate understanding of continuous assessment, provision of continuous assessment tools, and time to practice how to use them. In addition, teachers must be trained and supported to be able to manage the scope of work required to regularly assess learners, particularly in settings with overly large class sizes, and should be encouraged to use continuous assessment data in flexible ways.

This flexibility is key to create a responsive learning environment—one where teachers are well aware of student learning strengths and needs, and have the skills and latitude to respond to those needs with adapted instruction, alternative materials, and additional support.

In addition to regular continuous assessment, summative assessment is important. Summative assessment is the periodic formal assessment of all learners in the classroom, not integrated into instruction, but rather set aside from the instructional time. Summative assessments may be implemented at the end of a large body of learning, on a term-to-term basis, or at the end of a school year – annual "exams" usually developed and administered within the government system.

While formative assessment is designed to customize instruction to meet the needs of individual learners, summative assessment is intended to measure a cumulative set of data regarding the learning of a group of learners. And, while it does not provide the "instant teachable moment" data needed by teachers on a daily basis, it does provide a broader and longer-term snapshot about the efficacy of the program being implemented, the skills of the teacher, and the impact of the program on the student group.

Summative assessment data are useful for a variety of purposes:

1. Teachers can reflect on their long-term practice success.

2. Teachers can measure mastery of a related set of skills or content for individual students.

3. Schools can determine those learners who are failing to thrive and may need additional intensive supports over a longer period of time.

4. School leaders can track and monitor the overall success of the program implementation in their schools (see School Leader section for more information).

5. Families and the community can understand the strengths and needs of the local school where their children attend and learn.

In addition to these locally relevant purposes for summative assessment, it also provides ministries of education and implementing partners with critical large-scale data from which they can draw

conclusions about all aspects of their programs. Summative assessment data can provide decision makers with a picture of progress with respect to grade-level benchmarks and/or allow them to evaluate the impact of interventions or innovations. They can inform other decisions that have been made or need to be made, such as the following:

- the impact of, or need for, new instructional resources
- the impact of teacher training, coaching, and practice on student performance (when data are compared to data gathered from training and coaching of teachers)
- the secondary impact of educational policies on student learning
- the impact of targeted school leader strategies (when performance data are compared to data gathered from training and coaching of school leaders)

It is important to note that both formative and summative assessment provide a wealth of information about practices and progress for the individual student, at the classroom and school level, and even at the regional and national level. However, assessment data should not be the sole driving factor that influences practice. Schools and teachers must take into account context, individual differences and needs, teacher strengths, resource access and use, and a variety of other factors to make the best decisions possible about next steps for the individual student and next steps for the program as a whole. When assessment is the sole driving factor for instructional change, and the sole indicator of instructional success, schools and teachers may inadvertently narrow instruction too far, focusing only on those types of skills and assessment strategies used in formal assessment. This can have an unintended consequence of limiting the depth of instruction, and the capacity of the student to learn and think in a variety of ways for a variety of purposes.

7. Regular Practice Outside of School

Given that school-based approaches alone have not proved sufficient to reach the goal of widespread reading proficiency among early grade children in many developing countries, broadening the scope of literacy interventions beyond the school is a necessary step.

Kim et al., 2016, p. 58

MAIN IDEAS

Sufficient time for practice is not always available in school.

Out-of-school practice time must be learning-focused and of high quality.

Home-school partnerships, when targeted on key skills development, can be effective.

Community-based after-school programs, when of high quality, support both practice and development of new skills.

Regular practice outside of school is the final component of the MOSAIC to be discussed here. It has been included as a critical program element for four reasons:

1. The total time learners spend practicing skills in context correlates well with their achievement (Allington, 2014; Cunningham & Stanovich, 1998; Krashen, 2004). In low- and middle-income contexts, time for instruction and in-school practice can be limited for a variety of reasons. Policies do not always support sufficient time, or government finances do not allow for single session school days (due to overcrowding or a lack of teachers or schools). Additionally, studies of allocated versus actual instructional time have revealed that up to two-thirds of available instructional time in low- and middle-income countries can be lost to the late start/early ending of the school year and school day, unanticipated school closings, teacher and student absenteeism, and poor management of classroom time (Bruns & Luque, 2014; Schuh Moore et al., 2012, cited in Crouch and DeStefano, 2017). The time allocated for literacy or numeracy lessons can also be compromised when teaching time is spend on non-learning activities or ineffective teaching practices (Abadzi, 2007; Bruns, De Gregario, & Tau 2016; Schuh Moore et al., 2012, cited in Crouch and DeStefano, 2017).

2. Even if the time allocated for school-based learning is used effectively and efficiently, children in low-resource countries typically spend less than 15% of their waking time in classrooms (Friedlander et. al, 2018). Limiting literacy and numeracy learning to the classroom setting ignores that fact that children have significant time outside of the school day than can be leveraged to reinforce or extend learning.

3. Attempts to improve learning results in low-resource countries that have focused exclusively on school-based interventions (teacher training, materials distribution, etc.) have not always produced satisfactory or consistent results (Pritchett, 2013; Samoff, 2012, cited in Dowd et al., 2017, Friedlander et. al, 2018)[27]. That is because children's experiences both inside and outside school impact their learning (Hess & Holloway, 1984; Snow, Burns, & Griffin, 1998, cited in Friedlander et al., 2018). Learning gains are greater when interventions extend learning opportunities beyond the classroom (Frieldander et al., 2018).

4. Even in low-resource environments where access to reading materials and readers is limited, there is a correlation between literacy practices in the home and children's reading skills (Chansa- Kabali, Serpell, & Lyytinen, 2014; Dowd, Wiener, & Mabeti, 2010; Friedlander, 2013, 2015; Wagner, 2018, all cited in Friedlander et al., 2018)

One effective means of extending learning beyond the school or classroom—improving the literacy or numeracy ecology in the home or community and at the same time increasing the total amount of time children spend reading or doing numeracy—is to have children engage in literacy and numeracy learning-focused activities outside of the school day, either at home with family members, or as part of community-level events.

This section looks at two complementary activities to extending literacy and numeracy learning beyond the school-day: family-based activities implemented through home-school partnerships and community-based activities.

Family-based activities implemented through home-school partnerships: UNESCO (2017) has identified family learning or intergenerational approaches as one of the critical means of improving literacy and numeracy learning outcomes. Such programs, when focused on improving learning outcomes, have immediate as well as longer-term benefits for both children and adults (Brooks et al., 2008; Carpentieri et al., 2011; Hayes, 2006; NIACE, 2013; Ofsted, 2009; Tuckett, 2004, cited in UNESCO 2015).[28] One means of implementing family or intergenerational learning is through simple **home-school partnerships**

[27] Frieldander et al. (2018) reference a meta-analysis of 77 world studies undertaken by McEwan (2015) that found a significant but very small effect size for school-centric interventions, arguing that the results suggest that no such interventions have demonstrated consistent gains and that attempts to significantly improve learning outcomes must build in both school and out-of-school learning-focused initiatives.

[28] For more information on intergenerational literacy and numeracy programs, see Hanemann et. al., 2017. Learning together across generations: guidelines for family literacy and learning programs. Available at: http://unesdoc.unesco.org/images/0024/002484/248446E.pdf.

where children take literacy or numeracy-related activities to do with family members (see examples in the table below).

Table 4: Content-Specific Home-School Activities

Literacy Home-School Activities	Numeracy Home-School Activities
Home reading book – Taking home a simplified primer each night with engaging literacy-related activities to do with family members **Book of the week** – Providing teachers with book collections or banks of child-friendly reading materials and allowing children to take home a single book multiple times to read with a family member (being read to, or reading to); Encourage children to re-read the book multiple times to reinforce skills **Letter lists** – making lists of items in the home environment that begin with (or simply include) target phonics instruction letters (written or drawn by learners, or by family members) **Word work** – using student-made word cards to practice sight word recall and decoding at home with a family member **Tell me a story** – engaging in oral story-telling and re-telling at home (told by learners or family members)	**Home numeracy book** – Taking home a simplified math workbook each night containing games and other simple activities to extend the learning happening in the classroom **Math games** –Taking home, on a rotating basis, a simple laminated math game to play with family members to reinforce classroom learning **Shape treasure hunts** – Making lists or drawings of objects in the home, outside of the home or in the community that have a particular shape. **Number treasure hunts** – Finding examples of a given number in the home or outside, for example, pairs of objects for the number 2, objects that come in groups of 3 for the number 3, etc. Children can draw the objects and write the corresponding numeral next to the drawing. For older children, number treasure hunts can include figuring out "how many" there are of something, for example how many doors in the village or how many stones in front of houses **Skip counting** – Practicing oral counting by ones, twos, threes, etc. **"Where is" game** – Play where is…with objects in the home to practice spatial vocabulary (above, behind, next to, etc.)[29]

[29] See https://nzmaths.co.nz/sites/default/files/Year1SupportingYourChildsLearning_maths.pdf for sample of home-school numeracy activities that can be modified for low- and middle-resource environments.

In such programs, teachers are typically provided with appropriate materials and trained in how to implement family outreach activities to raise parents and family members' awareness of the importance of supporting learning at home and of the types of activities they can do in the home, with the resources provided, to reinforce children's learning. In a pilot program implemented in Rwanda (Friedlander et. al., 2018), a series of seven ninety-minute workshops were organized over a three-month period for adult family members in 237 villages to train them on home-based literacy-related activities, including shared reading. Children in villages where the home-based literacy-related activities were implemented increased their reading comprehension levels (effect size of .33), their oral comprehension levels (effect size .35) and their reading fluency (effect size of .28). They were also significantly more likely than children in the control group to be promoted. More importantly, children in the home-school program had stronger reading skills than children in schools where literacy-improvement interventions focused solely on school-based factors.

TEXTBOX 28: Extending Learning Opportunities

If we are serious about substantially improving school achievement in LDCs, we must continue exploring, developing, and evaluating programs that extend learning opportunities beyond the school day.

Friedlander et al., 2018, p. 27

TEXTBOX 29: The Community

The community should be regarded as another critical enabling environment—a setting that can be galvanized and supported to encourage children's learning.

Dowd et al., 2017, p. 45

Although home-school programs hold considerable promise for extending the amount of time children spend reading or doing mathematics, and for bringing family members into the learning process, the results of home-school programs have not always mirrored those attained by the Rwanda program referenced above. Moore et al. (2017) point out that the highest effect size of home-school literacy programs range from 0.1 to 0.3, with most in the 0.1 range. As Moore points out, more research is needed to determine why home-school programs have not had more of an impact on learning outcomes. Community-based programs These programs, generally implemented by trained community volunteers, provide another opportunity to increase the amount of time children spend reading or doing mathematics. In literacy, community-based activities often include:

- group story reading activities, where the community volunteer reads stories to children and conducts follow-up activities to strengthen their comprehension and/or vocabulary;
- group reading skill activities, where the community volunteer plays a series of games with children, or has children play games together, to strengthen specific reading skills (phonological awareness, letter recognition, letter-sound association, etc.);
- pair reading or buddy reading, where younger children are paired with children in upper primary. The older children read to the younger ones or listen to them read;
- make and take sessions where children build literacy-related materials to use with other children or at home;
- read-a-thons where children compete to read as many books as possible during a set time frame; and

- community book banks where young children take home materials from the local mini-library.[30]

A seven-country study conducted by Save the Children (see Dowd et. al., 2017) revealed that in seven out of 12 sites, children's participation in community-reading activities correlated positively and significantly with improved reading skills across all skills measured (effect size between 0.06 standard deviations and .99 standard deviations, depending upon country).[31]

The principle of community-based programs can be extended to numeracy, with children engaging in:

- group problem-solving activities, based on intriguing, real-life problems, where they compare solutions and solution paths;
- numeracy games linked to specific numeracy outcomes in the curriculum;
- numeracy buddy activities, where younger children work with older children on numeracy-related problems or games; and
- make and take sessions, where children build materials needed to represent numeracy concepts and then use them to represent their understanding of these concepts (bundles of 10 sticks and single sticks to represent numbers to 99, for example).

Although there has been less research into the impact of community-numeracy activities on children's numeracy skills (see Case study that follows), the opportunity to engage in rich numeracy-related learning activities outside of school holds the promise of extending children's learning beyond the limits of the classroom.

Importance of rich, cognitively challenging literacy and numeracy activities In both home-school and community-based programs, learning outcomes are more likely to improve if the activities are learning-focused and cognitively demanding, as opposed to merely raising children's awareness of or interest in a discipline. Although the latter are important, they do not necessarily result in improved outcomes.

[30] See Dowd et. al. 2017 for a description of the types of community-based activities used in the Literacy Boost program.

[31] It should be noted that the study did not control for the level of children's participation in the community-based activities. For that reason, the authors stress that they cannot conclude that the community enabling environment causes reading gains. Children who chose to attend the community activities may have had a substantially different profile than those who did not attend. The program also did not control for fidelity of implementation, so some children may have benefitted from more community-based activities than others. For these and other reasons, that authors restrict their findings to correlation rather than causation.

CASE STUDY 10:

Encouraging Math Talk at Home and in the Community

Save the Children

Save the Children's early grades math approach recognizes that classroom-based instruction alone is not enough to support children's math understanding. Their approach increases children's opportunity to learn by enriching the environment outside of school, through math clubs, math at home, and community-wide math festivals.

In the community, Numeracy Boost offers monthly sessions designed for those in a young child's life to use with their children at home. Activities reinforce foundational math topics that children learn in the classroom and show that math is useful, relevant, and most importantly, can be enjoyed and done by all. Most of the activities require no materials, and those that do use materials that can be found around the home. Each family receives a one-page sheet that includes pictorial reminders of how to do the activity, why it's important for children to learn those skills, questions to ask while they play the activity, and other similar activities they can try.

IMPACT: In Bangladesh, there has been a positive and significant association between participation in community numeracy activities and children's numeracy skills. In the four other countries where community numeracy activities have been implemented, the evidence is less definitive.

8. Monitoring, Evaluation, Research and Learning (MERL) Activities

Finally, all program interventions, including those based on the MOSAIC framework need to be supported by a rigorous, collaborative and consultative monitoring, evaluation and research/learning (MERL) process that provides valid, reliable data on children's progress with respect to performance standards (see section 3.4 earlier), evaluates the effective of different programmatic inputs in achieving their targeted outcome, and tracks fidelity of implementation at the class and school level. The MERL agenda needs to be developed within a planned[32] or an emergent theory of change.[33] [34]

[32] A "planned theory of change" views change as moving from an initial state to a final outcome in a structured and predictable manner. Theories of change that are planned generally outline a series of clearly defined assumptions and a set of related steps that will lead to the final, desired outcome. Planned theories of change assume that the environment in which the change operates is well known and therefore the specific steps needed to arrive at the final outcome can be pre-defined.

[33] An "emergent theory of change" works from the perspective that the environment is not well defined. Therefore, the steps needed to arrive at the final outcome are not necessarily clearly identifiable at the outset and will need to be changed or adapted as more information is gathered. Emergent theories of change are adaptive and responsive.

[34] See USAID December 2016: An Analysis of Theories of Change in USAID Solicitations for Education Programs in Crisis and Conflict Affected Environments, Education in Crisis and Conflicts Network for a discussion of planned versus emergent theories of change. Available at: https://eccnetwork.net/wp-content/uploads/12.16.A.TheoryofChange.Final_.pdf.

CHAPTER C:
Issues to Consider When Designing Comprehensive Programs

MAIN IDEAS

Young children need to exit the primary level with strong foundational skills in both literacy and numeracy.

Implementing comprehensive learning-focused programs that address all of the components identified as critical to improving children's learning, and in an effective, well-articulated and synergistic manner, hold the greatest possibility of achieving that goal.

Achieving this can be challenging even in well-resourced contexts; in contexts where resources are scarce, it is particularly challenging.

1. Using the MOSAIC to Identify Gaps and Opportunities with Respect to Each Component

The MOSAIC framework is a powerful tool for designing comprehensive literacy and numeracy programs. It can assist in determining the gaps within and across the six components, as well as the level of resources that need to be directed to each discipline. An initial situational analysis **can help key stakeholder and actors to gain an understanding of the educational landscape, including** the extent to which the core systems necessary to support literacy and numeracy interventions are in place and functional, or the extent of government decision-makers' commitment to putting them in place and ensuring that they become functional. From that analysis, priorities can be determined. This is critical for the success of the intervention and even more important for eventual sustainability.

The following considerations can serve as a starting point for a collaborative situational analysis that can help inform how best to distribute resources across different MOSAIC components depends upon.

- **Existing component gaps in both disciplines.** In any education system, and at any point in time, some of the MOSAIC components may be functioning well while others are not. There may be gaps in some of the following: policy and assessment; evidence-based scopes and sequences; instructional models; essential instructional materials; teacher and school-based leadership training; classroom, school, district, regional and national assessment programs; out-of-school learning programs; and coaching and mentoring programs.
- **The relative importance of each gap in creating barriers to improved learning outcomes, in both disciplines.** It important to identify existing gaps and the interrelated nature of these gaps, before designing a program. This includes identifying which gaps appear to be the most important contributors to gaps in children's learning: the policies, processes, and tools that are or are not in place and functioning. An integral part of this analysis is determining whether existing resources are sufficient, even if not ideal, to support learning. Some items, for example textbooks or supplemental reading books, can consume a considerable percentage of available resources. Before directing resources to these items, it is worth considering the relative return on investment.
- **The resources and structures available to fill the most important gaps, in both disciplines and whether they are sufficient.** A component-based situational analysis can help identify areas where there are few existing government structures or resources to support a key MOSAIC component. If gaps are identified in an important area, but Ministries of Education either do not have sufficient resources to fill the gaps, or if existing resources are already stretched or overloaded by other donor initiatives, it may be necessary to envision other ways of addressing the gaps. Strategic choices need to be made so that already-stressed systems are not further overloaded.

  The situational analysis should look beyond Ministry of Education resources to families and community resources. Both constitute a rich resource for supporting children's learning. Part of the situational analysis should involve working with government and local authorities to identify simple means of extending literacy or numeracy learning outside of the school day. If the decision is made to use home-school programs, resources should be directed to ensuring that family members know the specific actions they can take to support their child's literacy/numeracy development and are provided with the tools or materials needed to implement those actions.

  Existing government policies, systems and priorities, that can be leveraged to address gaps in both disciplines. This has a direct link to both accountability and governance: governments are more apt to hold themselves accountable for implementing actions identified as necessary to address the learning gaps if the actions proposed align with government priorities and/or if they can be implemented using existing structures and systems. It is essential to understand the government's level of commitment to creating new structures or leveraging existing structures to support literacy and numeracy interventions or putting in place the accountability systems needed to monitor implementation and progress before defining an intervention.

- **The extent to which actions proposed to address gaps could be scaled up, regionally or nationally, with existing government resources and systems and/or support from other donors.** Prior to

determining where to direct resources, consideration should be given to whether the proposed actions or interventions can be supported with existing, in-country resources.

- **The extent to which resources directed to different components of the MOSAIC are sufficient to leverage their interconnectedness to improve learning outcomes in both disciplines.** It is important to assess the relative weighting of resources directed to each component to ensure that resources are sufficient to support related interventions in other components.

  For example, if teacher or school leadership training programs (effective teachers) are to be effective, so that teachers use instructional materials effective (instructional materials), they need to be accompanied by a strong school-based coaching or mentoring program (coaching and mentoring). Such a program should focus on actions linked to improved learning outcomes in each discipline, namely use of instructional models, practices and materials. Coaches should be provided with simple, manageable tools to help them identify specific strengths and areas for improvement, and simple strategies for addressing the latter. Coaches should focus their activities on modeling and giving specific, targeted feedback.

Using the MOSAIC framework as described above can help drive the collection of important information about the gaps and opportunities to improving learners' literacy and numeracy with respect to each component.

2. Distributing Resources Across the Two Disciplines

In addition to identifying how to best distribute resources across the various MOSAIC components, stakeholders need to determine how to best distribute resources across the two disciplines with respect to each component. It may be that all six components need investment in both of the disciplines to deliver a comprehensive program. However, it may also be the case that some components are already firmly in place for one or both disciplines, and that resources can be focused on the components that are not in place.

Unfortunately, there is no definitive single algorithm for distributing resources across the six components or across the two disciplines to ensure optimal learning outcomes. This is because the distribution of resources needs to reflect the particular needs and priorities of a country with respect to literacy and numeracy, and the institutional, structural, management and pedagogical resources the country has – or does not have – to support an ambitious literacy and numeracy agenda.

That said, the following five considerations may help in the decision of how best to distribute resources across the two disciplines:

1. **Children's literacy and numeracy learning results.** Data-driven assessments can and should reveal the extent to which children are leaving both the early and later primary grades with the skills they need to support their continued learning. The extent to which all children's performance in each of the disciplines aligns with minimal grade-specific performance standards or benchmarks can help uncover learning gaps. Such assessments should also identify the specific learning gaps with respect to each discipline as well as whether, for each or both disciplines, the learning gaps are more significant in certain regions of the country or for certain subgroups. This latter analysis is important for distributing resources equitably across the country, so that **all** children have an equal chance of meeting minimal grade level expectations in both disciplines. Concrete knowledge about children's learning gaps can be triangulated with information from a MOSAIC-based analysis on investment gaps and opportunities to derive a potential set of action steps for improving learners' literacy and numeracy outcomes.

2. **The relative significance governments assign to learning gaps in each discipline.** For a variety of reasons, governments may assign more importance to learning gaps in one discipline than another or may have existing public commitments to improve children's performance in one specific area. Aligning initiatives with existing government priorities can facilitate access to the institutional and systemic resources necessary to carry out a successful intervention program. This, in turn, may ensure greater sustainability and scalability of interventions. Care should be taken, however, to ensure that government representatives are aware of the research on the relative importance of both disciplines to children's eventual learning trajectories. If ministry counterparts are not aware that success in both literacy and numeracy in the primary grades is an important prerequisite for long-term academic success, it is important to encourage their understanding of this important fact.

3. **The degree to which existing Ministry policies and strategic plans are supportive of attempts to improve learning outcomes in one or the other discipline.** This is linked to item 2 above. Ministries may have initiatives in place or be already committed to introducing policies that will support improved learning outcomes in one or both disciplines. Or they may have identified one or both disciplines as a priority in their Education Sector Strategic Plans (ESSPs), and outlined the measures and inputs required to meet that goal. Strategically aligning resources with existing commitments can increase sustainability and ownership.

4. That said, it may be necessary to stress with stakeholders the importance of children developing strong skills in both of these disciplines. It is less of a question of either/or when it comes to literacy and numeracy but more of a question of ensuring that both disciplines are strengthened, and that the interventions targeted for each discipline are paced accordingly, so that key indicators in literacy and numeracy are met.

TEXTBOX 30: Providing Research and Data

Part of the process to determine the level of government support to one or both disciplines is to provide them with research on the relative importance of each discipline in children's later learning trajectories, as well as data on how well children in their jurisdiction are performing with respect to grade-specific benchmarks.

5. **The existing donor landscape, including relative level of donor support to each discipline.** Missions should explore the extent to which existing donors are providing targeted support in the two disciplines, and the nature of those interventions, prior to determining where to best direct resources. Options to consider include directing resources to complement or leverage the work being done by other donors in a given discipline or directing resources to the underserved discipline. Resources need to be directed strategically, so that identified gaps are filled without oversaturating the system or introducing programmatic duplication.

6. **The existing Ministry landscape, including structural resources available to support the development and implementation of programs in one or more disciplines.** Ministries may have resources that can be directed to support enhanced interventions in one or both disciplines. It may also be the case that due to the extensive focus on literacy over the past decade there may be more resources and structures already in place in a country to support that discipline than there are for numeracy. In such cases, it may be necessary to provide more funding to numeracy to bring the level of support up to that directed to literacy.

7. **It is also important to assess the extent to which existing systems or structures can be leveraged to support interventions in both disciplines, so as to not overload or stress capacity levels or create system saturation**. Thought should be given to the following challenges and synergies when designing comprehensive programs with a dual focus on literacy and numeracy:

   - **The human and financial resources available to support improvement in teachers' instructional practices in both disciplines is finite and needs to be judiciously managed**. Resources available for teacher training in early grade literacy programs are usually quite limited and less than desired. Decreasing even further the number of literacy-training days to accommodate numeracy training is not an optimal solution. At the same time, adding additional training days for numeracy-specific training can be challenging due to policy limitations, limited windows of opportunity for teacher training, and limited teacher absorption capacity. This dilemma can be addressed, at least to some extent, by focusing on commonalities between instructional approaches in the two disciplines. However, missions and governments must be conscious that if training is not of sufficient duration or dosage, the ability of teachers to implement new instructional models or materials as intended will be compromised.

   - **The similarities and differences between effective literacy and numeracy instruction.** In many instances, the same teacher teaches literacy and numeracy. Stressing discipline-specific instruction models, while at the same time highlighting instructional similarities between the two disciplines, may minimize teacher-change fatigue and ensure a greater uptake of effective instructional practices in both disciplines.

CHAPTER D:
Informing the way Forward: An Initial Research Agenda in Primary Grade Numeracy

Over the past decade, the international community has learned a great deal about how to design and implement effective early-grade literacy programs in LMIC environments. Although there is still considerable work to do to identify and address factors that prevent the learning gains achieved in small pilots from being replicated at national levels (cf. Crouch & DeStefano, 2017; Moore et. al., 2018; Graham & Kelly, 2018), the evidence-base for the design, delivery and monitoring of early grade literacy programs is considerable and growing. The same cannot be said of early-grade numeracy. A recent, comprehensive review of numeracy strategies in documented interventions in LMICs over the past 25 years yielded 1,484 numeracy-related documents (Sitabkhan & Platas, 2018). However, only 24 described quasi-experimental or random control studies of effective strategies for PreK – Grade 3 numeracy.

As more international donors recognize the interconnectedness of early grade literacy and numeracy, there is the potential for more funds to be directed to this area. This speaks to the need for a more extensive and systematic evidence base on the design and delivery of effective early-grade numeracy programs in LMIC contexts, as well as on programs that have a dual focus on literacy and numeracy. Producing an extensive, comprehensive evidence base will require a collaborative approach and the involvement of the broader international community. The topics listed below propose an overall framework for an initial research agenda.

- Programs that integrate math and literacy in early grades – studying programs that provide dual models in concert with one another, examining the ways in which those models are developed and delivered, studying common approaches that are applied and results of those approaches; and exploring ways to synchronize approaches and resources.
- Teachers' application of specific, key evidence-based numeracy instructional strategies in low- or middle-resource environments – use of manipulatives and other forms of mathematical modeling, explanation and justification, and connecting informal and formal numeracy understanding. Documenting and describing how teachers in different contexts interpret and use these strategies to allow the international community to gain a better understanding of what effective instruction looks like in LMIC environments.
- Problem-solving instructional models that – 1) allow for exploration and multiple solutions; 2) support children's explanation and justification; 3) encourage children to use multiple representations, including manipulatives, to represent their thinking but at the same time; 4) are simple to implement and 5) provide enough structure that teachers can easily follow them and implement them in all lessons.
- Teacher interpretation and application of problem-solving instructional models – including elements that they are able to implement with fidelity and those that prove more elusive (and why). There is

also a need for more research on how teacher implementation of different models evolves as they gain more experience, or as their understanding of effective, evidence-based numeracy instructional practices deepens.

- Evidence-based means of increasing teacher's Mathematical Knowledge for Teaching (MKT) in both pre-service and in-service programs – including the following: the depth and breadth of training needed to produce improvements in practice; the nature of the training; and different models of delivering such training within existing training delivery structures.
- Teacher attitudes and beliefs towards teaching mathematics – including self-efficacy, the extent to which beliefs and attitudes impact instructional decision making, and how to best challenge beliefs and attitudes that may serve as barriers to the adoption of new instructional practices.
- The interplay between language and the development of numeracy skills in early primary – especially in multilingual environments where many children learn in a language they do not speak or understand fluently, where children and teachers may not speak the same language, and/or where mathematics vocabulary terms either do not exist in a given language or are not known by the teacher.
- Instructional practices that encourage children's explanations and justifications – although there is a significant research base on what this looks like in high-resource, learner-centered classrooms, less is known about what explanation and justification looks like in cultural environments where learners do not collaborate with adults, and particularly teachers, in the development of understandings.
- Effective use of manipulatives and other models to represent abstract concepts – and how to improve the accuracy of their use. There is a need to identify models currently used in the classroom to represent abstract concepts and how they are used, as well as how to best support teachers in using models carefully and purposefully. This includes how to procure and manage classroom materials.
- Effective use of technology – there is a need to identify best practice in technology use in mathematics instruction, and the resultant impact on teachers and learners.

Finally, in order to inform future programmatic choices, researchers should be encouraged to design projects that include a dual focus on: 1) measuring/documenting teacher practices, and 2) measuring children's learning outcomes. This would allow an examination of the correlation between teacher decision-making in the classroom and children's learning, increasing understanding of what effective instruction looks like in LMIC environments.

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GLOSSARY

Term	Definition
Abstract Phase	The abstract or symbolic phase refers to the phase of conceptual understanding where children are able to represent a mathematical concept with symbols. It follows the pictorial phase.
Algebraic Thinking	Algebraic thinking refers to recognizing, analyzing patterns and making generalizations about these patterns, studying and representing relationships, and analyzing how things change.
Alphabetic Awareness	A young student's awareness of the letters, and letter names, of the alphabet
Assessment	The process of monitoring and gathering data about student learning, including continuous and summative assessment, and formal and informal assessment
Automaticity	The ability to automatically respond with a process or response; for example, the ability to know that 2 + 2 = 4, or the ability to read words without decoding
Benchmarks	A commonly-accepted set of goals for specific grade levels
Coaching	The process of supporting teachers with job-embedded professional development, targeting evidence-based teacher learning needs
Comprehensive Programs	Programs that include all necessary elements for successful implementation (see MOSAIC for more discussion)
Concrete Phase	The concrete phase refers to the phase of conceptual understanding where children are able to represent a mathematical concept with objects.
Context	The specific situation in which children are learning (language, culture, geographic, etc.)
Decodable Text	Text that is keyed to specific letters and sounds, used with emerging reader (those just learning to read), and targeting only letters and sounds already mastered by the student; the first step in reading text
Domains	Areas of learning, for example the domain of mathematics and the domain of reading
Dosage	The frequency of exposure to information or an activity
Duration	The total number of hours of exposure to information or an activity

Enabling Policies	Policies that increase opportunity to improve educational programs and results
Evidence-based Programs	Programs that are firmly based on concrete evidence of what has worked in the past, in a similar context
Formative Assessment	Assessment conducted by the classroom teacher, intended to provide immediate informal evidence to assist in instructional decision-making
Foundational Skills	The early skills developed in primary grades that serve as a foundation for future more complex skills development
Framework	A guiding structure for development and/or implementation
Gradual Release	An instructional approach designed to release responsibility for learning to the individual student over time; for example, I do, We do, You do
Graphonemic Awareness	The awareness that letters have specific sounds; addressed within phonics instruction
Fluency	In reading, the ability to read correctly, at an appropriate pace, and with appropriate tone to demonstrate comprehension In mathematics, fluency refers to the ability to carry out operations or procedures efficiently, accurately, flexibly, and appropriately. Children who are fluent in mathematics are able to choose flexibly among methods and strategies to solve contextual and mathematical problems, understand and are able to explain their approaches, and are able to produce accurate answers efficiently.
Inclusive	Ensuring that all learners have equal access to quality education, regardless of perceived differences (language, gender, culture, disability, etc.)
Learning-focused Programs	Programs that are designed for all program elements to focus on the learning goals stated for participating learners
Leveled Text	Text that is written at a level specific to the developmental growth of the student; sets of leveled text provide text that gradually increases in difficulty as the student's skills progress.
Literacy	The combined instructional domains of Reading, Writing, Speaking, & Listening
Manipulatives	Objects used to represent abstract numeracy concepts. For example, when three bottle caps are used to represent the quantity "3," the bottle caps are manipulatives.
Mathematical Models	Representations of mathematical ideas or relationships

Mentoring	A type of coaching, where skilled and less-skilled form a partnership for mutual professional growth
Model Teaching	The process of having a coach or master teacher model for another teacher in his/her classroom to demonstrate a specific approach or lesson
MOSAIC	One framework that is useful to design, implement and monitor instructional programs
Number Concepts	Understanding numbers, ways of representing numbers and relationships among numbers
Number Operations	In primary mathematics, number operations refer to the mathematical processes of adding, subtracting, multiplying and dividing.
Number Relationships	Number relationships is one of the key mathematical principles or "Big Ideas" in primary mathematics. It refers to understanding how numbers are interconnected or related. For example, knowing that 8 is twice 4, or half as big as 16. It refers to knowing that 16 is a little bigger than 15 but a lot bigger than 2, or that 8 is the same as 6 + 2.
Number Sense	An intuitive or innate ability to perceive, process and manipulate numbers, to attach meaning to numbers and number relationships, to understand the magnitude of numbers as well as the relative magnitude of numbers, and to use logical reasoning for estimation.
Number System	A system for representing numbers of a certain type (for example, base 10 numbers, binary numbers, roman numbers); A collection of numbers and the operations on those numbers.
Numeracy	Being able to reason with numbers and other mathematical concepts, and to apply these in a range of contexts to solve problems. Number and number operations, geometry, measurement, data analysis/probability and algebra are distinct domains of numeracy
Pedagogy	The instructional approach used in the classroom
Phonemic Awareness	The ability of learners to be able to hear and manipulate sounds in oral language
Phonics	A sub-domain of Reading instruction that develops graphophonemic awareness
Phonological Awareness	The awareness that written letters have specific sounds

Pictorial Phase	The pictorial phase refers to the phase of conceptual understanding where children are able to represent a mathematical concept with pictures, drawings or diagrams. It follows the concrete phase.
Predictive Relationship	When one factor accurately predicts a specific effect on another factor; for example, print awareness has a predictive relationship with future comprehension
Print Awareness	A student's awareness of the components and correct use of text (cover, spine, pages, top to bottom, left to right)
Read-Aloud	A book that is read aloud to learners, usually to directly model specific reading skills and behaviors
Scaffolded Instruction	An instructional approach that intentionally gradually releases learners to independent use and practice of skills (see gradual release)
Scalable	Designed to be able to be scaled up to larger implementation over time
Spatial Awareness	Spatial awareness refers to a person's recognition of how he or she, or an object, interacts with a space. It involves being able to interpret spatial information and use it in an organized, systematic way for planning movement. It also involves being able to fit items or shapes into an environment, for example, being able to put smaller shapes together to build a larger shape, or being able to see the relation of forms and objects with each other.
Sub-Domains	Specific skill or content sets within a content domain; for example, Comprehension is a sub-domain of Reading, which is a sub-domain of Literacy
Sub-Skills	Small discrete skills that together form a larger applied skill
Summative Assessment	Formal assessment, conducted periodically with all learners (classroom, school, region, or country) to determine mastery of learning, and to evaluate long-term program quality and impact

APPENDIX A:
Higher-order Thinking Skills and Examples of Their Application in Early Grade Literacy and Numeracy Classes

Skill	Literacy Having children…	Numeracy Having children…
Summarizing	• Tell the main idea(s) of a text or story in their own words • Identify the problem in a story and how it was solved.	• Explain how they solved a problem (the solution path they used)
Inferencing and drawing conclusions	• Use clues in a word, or in a text, sentence, or illustration, to infer or deduce the meaning of a new word • Use what they know about letter-sound combinations to explain how to read a new word • Answer inferential-type questions that require them to find supporting facts or clues in the text or in their own background knowledge base (e.g., *How do you know Shema was tired?* Or *How do you know the story doesn't take place in the dry season?*)	• Examine a series of triangles of different sizes and forms on the board and use the commonalities between the figures to create the definition of a triangle. • Explain how they know a given answer is correct or not
Sequencing	• Retell the events of a story in order, or reorder a series of pictures or sentences to align with the events in a story or text • Identify what happened in the beginning, middle and end of a story • Use flowcharts and story maps to sequence the events of a story	• Sequence a series of numbers in increasing or decreasing order and justify the answer • Sequence items by their length, mass, or volume • Sequence items to make a repeating pattern

Skill	Literacy Having children…	Numeracy Having children…
		• Identify the missing numbers in a sequence or increasing/decreasing number pattern and justify the answer
Comparing and contrasting	• Explain how the shapes of two letters (or two words) are the same and different • Explain how two characters in a story are the same or different • Use Venn diagrams to identify what camels and elephants have in common and what is different between the two	• Explain the rule used to sort objects into two groups • Sort objects into groups and explain the rule for doing so (what the objects in each group have in common) • Explain how two shapes or objects (or numbers) are the same or different
Connecting to background or prior knowledge	• Children look at the title of a story, or the illustrations, and predict what the story will be about based on what they see and their prior knowledge • Children identify what they know about a nonfiction topic before they read the text	• Explain where they have seen a particular numeracy concept used outside of school, or when they have used it themselves
Problem solving	• Identify strategies they can use to help them read (or understand) an unfamiliar word or to help them understand the ideas in a text	• Identify different strategies they can use to solve mental computations • Identify different strategies they can use to solve problems