

How to Develop the Foundational Numeracy Assessment Tool

Section 1: Introduction and Background

Why foundational numeracy?

Numeracy is the knowledge, skills, behaviours, and dispositions that students need in order to use mathematics in a wide range of situations. Mathematical concepts, knowledge, and skills include content categories like arithmetic, geometry, algebra, and the ability to perform procedural calculations, reason, interpret results, etc. (OECD 2019, 75).¹

Research has determined that children develop basic math skills even before receiving formal instruction (National Research Council 2001). Examples of basic math skills that seem to develop across cultures include counting, sense of quantity (more or less), shapes, sense of distance, and less structured ideas about addition and subtraction (EGMA 2014). Our definition of foundational numeracy builds on these initial math concepts and skills that children bring to school.

These basic math skills form the foundation of more advanced skills and concepts. In later stages, children are expected to use mathematical knowledge in a variety of contexts. As children move through the grades, they are expected to use physical materials and tools, various representations, and mathematical information to make decisions and arrive at a solution. The broad range of concepts and skills build on these foundational competencies such as the ability to count verbally, recognize numerals, identify quantity (more or less), and understand sizes, shapes, and patterns. Therefore, foundational numeracy can be defined as a collection of elementary mathematical ideas and skills, inclusive of knowledge of number sense, competence in counting, basic operations, and mathematical thinking.

In this note, we will explore what a foundational numeracy assessment is, and what are the guidelines to develop and adapt such a tool for different contexts.

What is the foundational numeracy assessment?

A thorough review of Pratham and ASER Centre's existing numeracy tools, curriculum textbooks, and global proficiency framework for SDGs (USAID 2020) was undertaken to assess and understand foundational numeracy. The aim was to develop an easy-to-use tool that enabled any assessor, instructor or teacher using the tool to get to know their children and help them to acquire foundational skills in numeracy with emphasis on basic number knowledge and operations.

¹ Internationally, the related term mathematical literacy is used in the OECD's Programme for International Student Assessment (PISA). It is defined as:
... an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged, and reflective citizens. (OECD 2019, 75). At the conceptual and implementation level, numeracy and mathematical literacy are very closely related constructs in terms of their core, underlying ideas (e.g., see Gal and Tout 2014)

The tool should be:

- **Easy to administer one-on-one with primary school children.** It is important to do an oral and face-to-face, one-on-one activity for children who are still in the process of acquiring foundational skills and may not be able to express themselves using pen or paper. The one-on-one interaction also helps the teacher/instructor to know the child better. Furthermore, it helps instructors and teachers to get a good sense of what the child can do easily and what she or he struggles with.²
- **Progressive** (meaning tasks ranging from easy to difficult) so that the highest level comfortably reached by the child can be marked. Data coming out of a progressive set of tools makes it easy for understanding and for tracking children's progress.³
- **Adaptive**, such that the instructor or teacher can move to a higher or lower-level task depending on whether the child can or cannot perform a task easily. This greatly reduces the time spent on administering the tool to each child.⁴
- **Helpful to the instructor or teacher for planning and conducting appropriate activities.** The data and the experience as a result of using the tool for a group of children could immediately be used for grouping (by level), designing activities, and tracking progress.⁵
- **Helpful to teachers for defining learning goals and for parents to understand them.** Children also begin to get a sense of the "ladder" they have to climb. Often, it is said, "what gets measured gets done."⁶

The foundational numeracy assessment tool

The purpose of the assessment tool is to assess the foundational math competencies that reveal children's abilities in foundational math content areas, which are critical in the early learning stages. The following table lists the content areas and competencies included in the tool:

Content Area	Competencies
Number Knowledge	1-Digit number recognition
	Quantity comparison (1-digit)
	2-Digit number recognition
	Quantity Comparison (2-digit)

² To learn more about how to administer the test, refer to the [resources](#) demonstrating the administration of the foundational numeracy assessment tool.

³ To learn more about assessment results and grouping children, refer to the [resources](#) on the foundational numeracy assessment tools.

⁴ Refer to the [assessor's copy](#) of the tool to understand the various tasks that should be presented to the children, based on their abilities.

⁵ Interventions such as Teaching at the Right Level (TaRL) use the assessment data to plan and conduct appropriate activities. To learn more about TaRL activities, refer to the resources on [TaRL](#).

⁶ Interventions such as TaRL use this assessment to define learning goals. To learn more about this process, refer to the resources on [TaRL](#).

Number operations	Addition (number problem)
	Subtraction (number problem)
	Subtraction (word problem)

The analysis of various country textbooks for early grades suggests other additional content areas such as geometry and data handling. However, this numeracy tool only assesses early mathematics learning with an emphasis on numbers and operations. These skills are key in building children's abilities to progress through more demanding content areas and concepts and have thus been included in the tool. The following content areas have been included in the tool:

- **Number Knowledge:** According to various studies, the construction of numerical knowledge in children between ages 3 and 9 follows somewhat similar paths of learning. Children's understanding of numbers and numerical activities takes a more formal shape once they are in school. For example, they come to associate a number with a set of objects.
- **Quantity discrimination:** It measures children's ability to make judgments about differences by comparing quantities in object groups. Quantity discrimination in kindergarten and first grade demonstrates a critical link to an effective and efficient counting strategy for problem-solving (Clarke et al. 2008).
- **Addition and subtraction:** These content areas are important for answering questions such as who has more, who owes what, or for calculating precise totals. Solutions for addition and subtraction story problems with young children require a fluent link between the number list and cardinality.

Children often follow the natural developmental progression to learn mathematical ideas and skills in their own way. They develop their level of thinking, moving from simple to sophisticated, mastering clusters of concepts and skills that are coherent and consistent with their thinking. The competencies and content areas included in this tool are part of this developmental progression. The guiding principle for developing the tool is to ensure that the assessment tool is short, simple, and easy to administer. Therefore, some competencies such as single-digit operations and sequencing, have not been included in the tool.

However, it is also important to note that the foundational numeracy assessment tool can be customized to include more levels based on local needs/realities. Therefore, based on the context, intermediary levels of competencies may be added within the tool if they can provide more information about the children's instructional needs. Teachers or instructors have the autonomy to add more levels while developing or adapting the tool. For instance, additional levels may be added to the tool to assess higher-order competencies.

Sample of a Foundational Numeracy Assessment Tool in English

Number Knowledge (1-9)				
Q1.				
5	7	9	2	
6	4	8	3	

Number Knowledge (10-99)				
Q2.				
46	77	60	38	53
84	62	91	25	19

Addition	
Q3.	
Q3a.	Q3b.
$\begin{array}{r} 38 \\ + 16 \\ \hline \end{array}$	$\begin{array}{r} 67 \\ + 29 \\ \hline \end{array}$

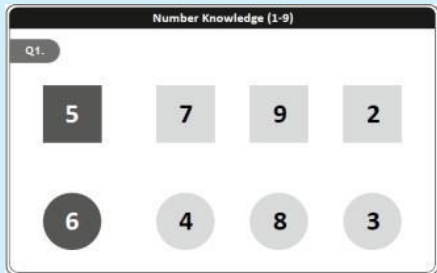
Subtraction	
Q4.	
Q4a.	Q4b.
$\begin{array}{r} 73 \\ - 28 \\ \hline \end{array}$	$\begin{array}{r} 80 \\ - 46 \\ \hline \end{array}$

Word Problem
Q5.
A shopkeeper has red and white balls. He has 86 balls in total. If the shopkeeper has 38 red balls, then how many white balls does he have?

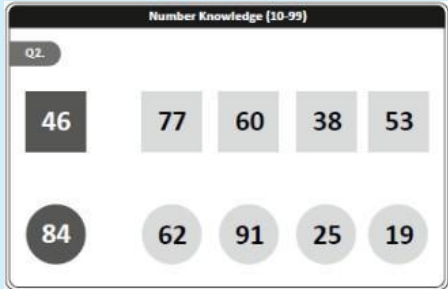
Section 2: Process to develop or adapt foundational numeracy assessment tool

This section explains:

- a) What each task in the numeracy tool is about
- b) Why the task is important
- c) How the items in the task should be developed
- d) How the tasks and items can be adapted for your context

Task	Examples of items	Details
Identifying and comparing 1-digit numbers	<div><div>Child's copy</div><div></div><div>Assessor's instructions</div><div><div>1a) Point to the question and ask the child- Point and read all numbers one by one.</div><div>1b) Point to the numbers given in boxes and ask the child- Which of these numbers is smaller than 5?</div><div>1c) Point to the numbers given in circle and ask the child- Which of these numbers is greater than 6?</div></div></div>	<div>What is this task about?</div> <p>This task assesses a child's ability to identify and compare 1-digit numbers. Often, in the early years of schooling, the primary focus is on building children's number knowledge.</p> <p>Number knowledge involves multiple skills like naming, sequencing, comparison of numbers, etc. While developing the tool, a variety of tasks with objects and numbers were used. However, for the ease and speed of administration and for what children are expected to do in school, the final form of the tool focused on number recognition. To keep the administration process simple and to keep the tool progressive, only tasks related to naming and comparison have been included in the tool.</p> <div>Why is the task important?</div> <p>The ability to count fluently and flexibly are core numerical skills. Cardinal number knowledge enables children to compare the exact magnitudes. Identification of written numerals enables children to perform tasks with verbal, written and number symbols. This is the basis of abstract and symbol-based math.</p> <div>Guidelines for item creation and adaptation</div> <ul style="list-style-type: none">• Each sample should include 8 numbers from the 1-9 range.• Numbers in the first row should be shown in a square box. The first number will be

		<p>compared with the other three numbers. There should be only one correct answer to the question.</p> <ul style="list-style-type: none"> Numbers in the second row should be shown in a circle. The first number will be compared with the other three numbers. There should be only one correct answer to the question. Instructions on the assessor's copy should be provided in the language the child understands. <p>Guidelines for scoring the task</p> <p>The learner gets full credit if she or he does the following:</p> <ul style="list-style-type: none"> Recognizes all numbers and names them correctly Identifies 2 as the number that is smaller than 5 Identifies 8 the number that is greater than 6 <p>There is no partial credit.</p>
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Task	Examples of items	Details
Identifying and comparing two-digit numbers	<p>Child's copy</p> 	<p>What is this task about?</p> <p>This task assesses a child's ability to identify and compare two-digit numbers. The primary focus in the early years of schooling builds on children's knowledge of quantities and numbers.</p> <p>Why is the task important?</p> <p>The number system uses symbols from 0 to 9. The combination of these digits is used to represent any number in the counting system. The position of individual digits (place value) determines the number values. This task assesses an important stage of concept development in mathematics.</p>

Assessor's instructions

2a) Point to the question and ask the child-

Point and read all numbers one by one.

2b) Point to the numbers given in boxes and ask the child-

Which of these numbers is smaller than 46?

2c) Point to the numbers given in circle and ask the child-

Which of these numbers is greater than 84?

Guidelines for item creation and adaptation

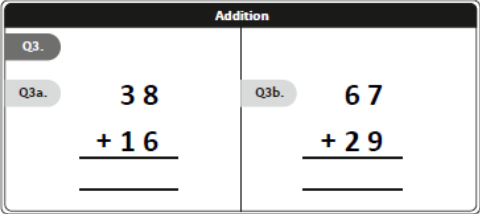
- The task should comprise 10 numbers in the 10-99 range. To cover all types of numbers, selected numbers should have a variety of digits at ones and tens places (e.g., 13, 54, 68), a mix of odd and even, a mix of big and small numbers. There should be one 'master' number (same number at the ones and tens of places.) E.g., 77, and one number that has 0 in the ones' place. E.g., 60. All samples should have different numbers.
- Numbers in the first row should be shown in a square box. The first number will be compared with the other three numbers. There should be only one correct answer to the question
- Numbers in the second row should be shown in a circle. The first number will be compared with the other three numbers. There should be only one correct answer to the question
- Instructions on the assessor's copy should be provided in the language the child understands.

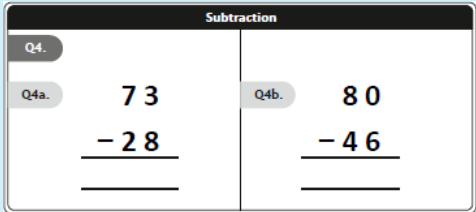
Guidelines for scoring the task

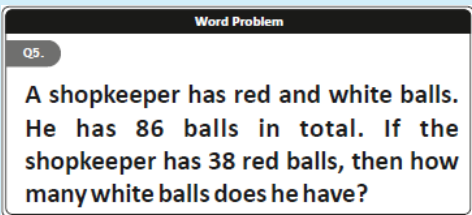
The child gets full credit if he/she does the following:

- recognizes all numbers and names them correctly
- identifies 38 as the number that is smaller than 46
- identifies 91 as the number that is greater than 84

There is no partial credit

Task	Examples of items	Details
<p>Adding two 2 digit numbers involving carrying</p>	<p>Child's copy</p>  <p>Assessor's instructions</p> <p>Ask the child to solve both the questions one by one. The child is at 'Addition Level' only if s/he answers both the questions correctly</p>	<p>What is this task about?</p> <p>This task assesses a child's ability to add two 2-digit numbers such that they have to apply the concept of carrying over. Analysis of early grade textbooks shows that children in most contexts are expected to do this task by grade 1 or grade 2. Handling 2-digit numbers meaningfully implies that the child is able to handle place value.</p> <p>Why is the task important?</p> <p>Number operations OR arithmetic (addition, subtraction, multiplication, and division) are elementary skills necessary for later math and generally in day-to-day functioning. Children have to be fluent in these skills on order to apply them in real-life scenarios.</p> <p>Guidelines for item creation and adaptation</p> <ul style="list-style-type: none"> • Each sample should have 2 additional questions. • For the first question, both numbers should be below 50. For the second question, one number should be above 50 and one below 50 (but above 9), such that the sum is still a 2-digit number. • Different numbers should be used, such that the numbers are different across questions and samples. • A context-appropriate format should be used to represent the questions: either vertical (as shown on the left) or horizontal (e.g. $38 + 16 =$). It is ideal to use a format that children are taught in early school years or a format that is commonly used in textbooks in a given context. • Instructions on the assessor's copy should be provided in the language the child understands. <p>Guidelines for scoring the task</p> <ul style="list-style-type: none"> • The learner gets full credit if he/she adds the two numbers, applying the rules for "carrying" correctly for both items • There is no partial credit

Task	Examples of items	Details
<p>Subtracting a 2-digit number with another 2-digit number, involving borrowing</p>	<p>Child's copy</p>  <p>Assessor's instructions</p> <p>Ask the child to solve both the questions one by one. The child is at 'subtraction Level' only if s/he answers both the questions correctly</p>	<p>What is this task about?</p> <p>This task assesses a child's ability to subtract a 2-digit number with another 2-digit number such that they have to apply the concept of borrowing. Analysis of early grade textbooks shows that children in most contexts are expected to do this by grade 2 or grade 3.</p> <p>Why is this task important?</p> <p>Number operations OR arithmetic (addition, subtraction, multiplication, and division) are elementary skills necessary for later math and generally in day-to-day functioning. Children have to be fluent in these skills on order to apply them in real-life scenarios.</p> <p>Guidelines for item creation and adaptation</p> <ul style="list-style-type: none"> • Each sample should have 2 subtraction questions. • There are two questions (items). In both questions, the larger number should be greater than 50 and the smaller number should be less than 50. • In one of the questions (items), the larger the number should have '0' the units' place • Different numbers should be used for these tasks, such that the numbers are different across questions and samples. • A context-appropriate format should be used to represent the questions: Either vertical (as shown on the left) or horizontal (e.g. $73 - 28 =$). It is ideal to use a format that children are taught in early school years. • Instructions on the assessor's copy should be provided in the language the child understands. <p>Guidelines for scoring the task</p> <ul style="list-style-type: none"> • The learner gets full credit if he/she subtract one number from the other, applying the rules for "borrowing" correctly for both items • There is no partial credit

Task*	Examples of items	Details
Solving a word problem involving subtraction with borrowing	<p>Child's copy</p>  <p>Assessor's instructions</p> <p>Keep the testing tool in front of the child and read aloud the word problem. You can repeat the question to the child once.</p>	<p>What is this task about?</p> <p>This task assesses a child's ability to understand and solve a real-life word problem. The word problem is read aloud to the child, so this task doesn't test a child's reading ability.</p> <p>Why is the task important?</p> <p>The purpose of learning math is to function effectively in day-to-day life, which means encountering and solving real-life problems. The real-life situation does not often arrive in the form of numeral tasks or equations. Hence, it is imperative that children develop an understanding of problems, comprehend them, and use procedural strategies to solve these problems. Word problems serve as a proxy to assess these skills.</p> <p>Guidelines for item creation and adaptation</p> <ul style="list-style-type: none"> • The word problem should involve a context familiar to children. • It should be written and read aloud in a language that the children are comfortable in. Note that the goal of this task is not to test a child's reading or listening comprehension ability, so the sentences should be simple to follow. • The design of the word problem should be such that the total or whole of something and a part is given. The other part needs to be calculated. For instance, part + part = whole, where one of the parts is missing. For more clarity, the problem is broken down into 3 sentences. • Minuend (a quantity or number from which another is to be subtracted) should be greater than 50 and subtrahend (a quantity or number to be subtracted from another) should be less than 50. • Instructions on the assessor's copy should be provided in the language the child understands.

* **Note:** Refer to the [resources on the foundational numeracy assessment tool](#) to see some examples of common mistakes. For more information on how to administer this tool, visit the [online resources](#) on the FLN resource hub.

		<p>Guidelines for scoring the task</p> <ul style="list-style-type: none">• The learner gets full credit if he/she identifies this as a subtraction operation and subtracts one number from the other, applying the rules for “borrowing” correctly• There is no partial credit
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