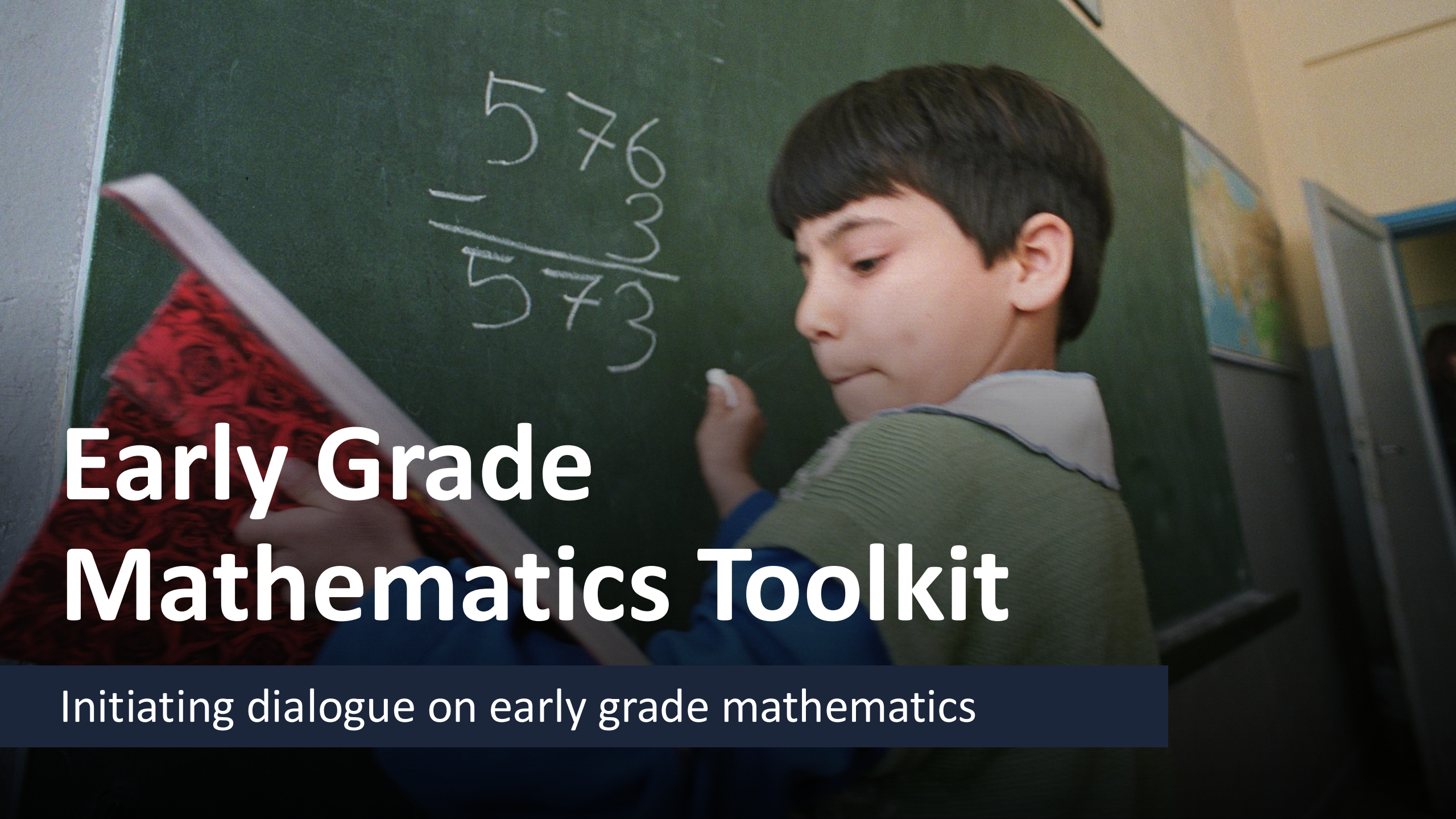


Early Grade Mathematics Toolkit

Initiating dialogue on early grade mathematics

Introduction

Purpose: Assisting meaningful dialogue around early grade mathematics, with the goal of improving learning outcomes in client countries

Scope: Eary grade mathematics (pre-primary and primary schooling)

Key Definitions:

- Foundational numeracy/numeracy: the experience of learning mathematics in primary school, and the knowledge and skills gained through mathematics instruction in primary school
- Early grade mathematics: all aspects of the teaching and learning of mathematics in primary school.

Presentation outline

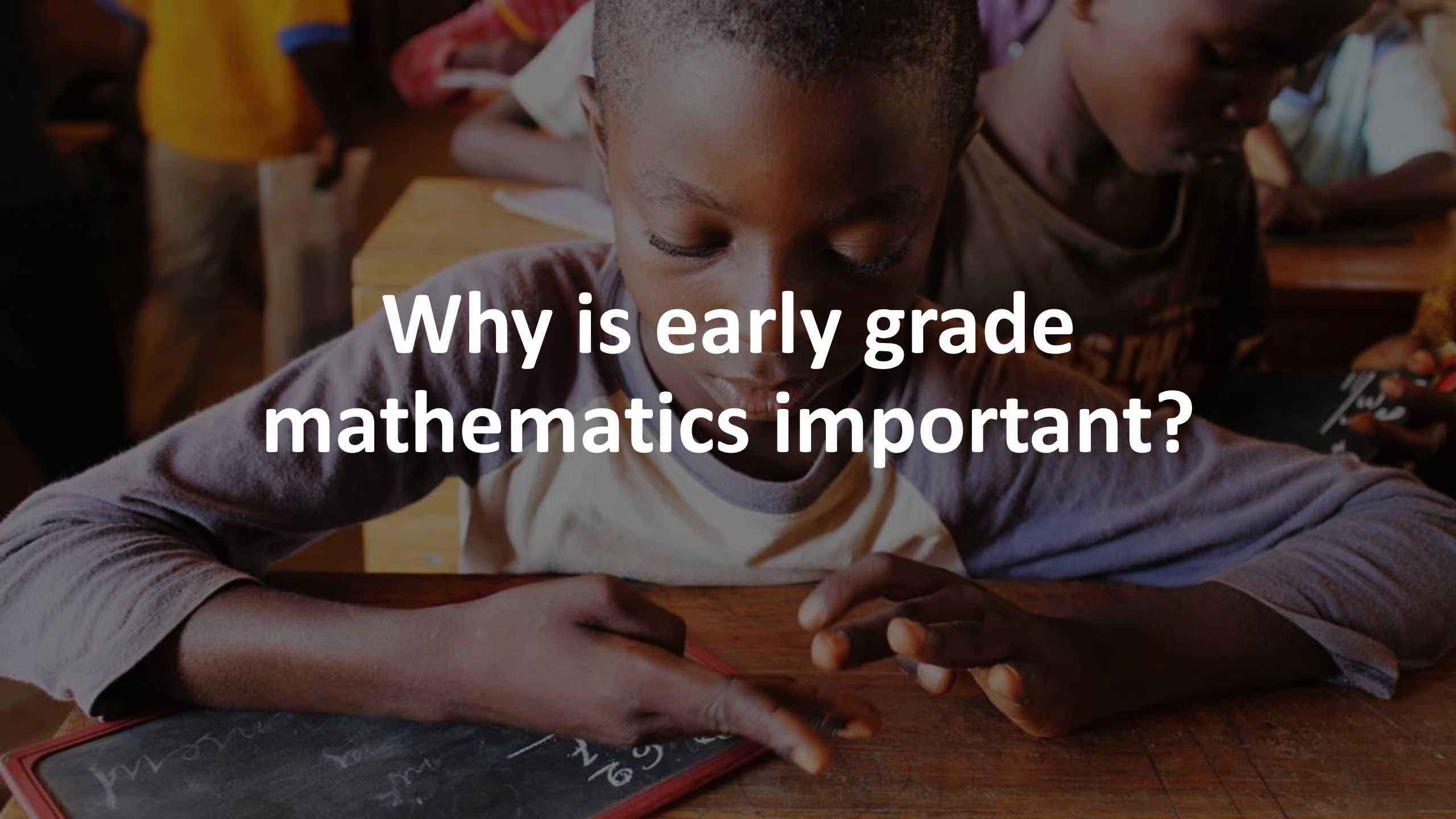
Why is early grade mathematics important?

What constitutes a high-quality early grade mathematics program?

How should early grade mathematics be taught?

How should progress in early grade mathematics be measured and monitored?

How has early grade mathematics appeared in World Bank operations?



Why is early grade mathematics important?

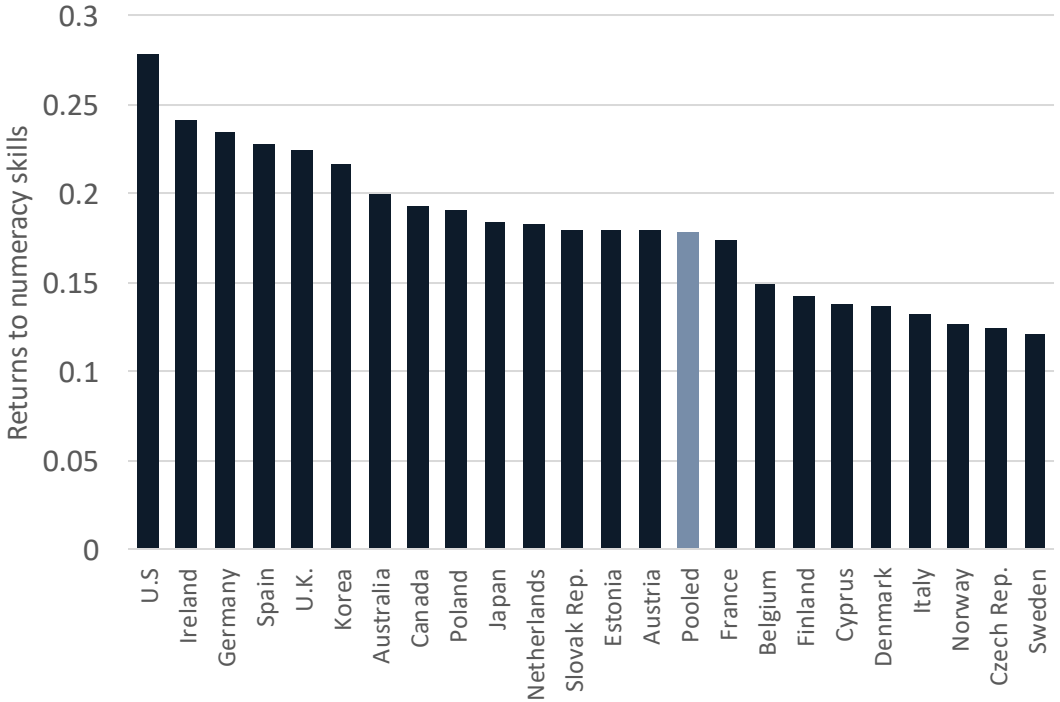
Math knowledge and skills are essential to quality education and human capital accumulation

Success in other academic subjects	Math proficiency is needed for subjects like natural and social sciences, engineering, digital skills, economics, business administration
Persistence in school	Math serves as a pre-requisite for additional learning
Measure of intellectual ability	Numeracy and quantitative reasoning as measures of intellectual ability Proxy for general academic and cognitive capacity
Access to tertiary education	Standardized tests/high-stakes examinations that test math ability Examples: China's Gaokao, Brazil's ENEM

Numeracy skills are linked to productivity and higher earnings

- Estimates suggest that each additional year of schooling increases an individual's earnings by 10%
- Returns on learning significantly outweigh returns to schooling
- High-quality measures of returns to specific skills conducted through the Program for International Assessment of Adult Competencies (PIAAC) consistently identify numeracy as the skill with the highest return

Returns to numeracy skills around the world



Returns to Skills for Alternative Skill Measures

Alternative Skill Measure	Pooled Estimation Coefficients
Numeracy	**.178 (.003)***
Literacy	.171 (.003)
Problem Solving	.143 (.003)

**The coefficient for numeracy in the pooled estimation suggests that a one SD increase in numeracy skills is associated with an average increase in hourly wages of 17.8% across the 23 sampled countries.*

Source: PIAAC, 2015

Numeracy skills are increasingly applicable in technology-intensive labor markets

Mastery of mathematics is associated with improved critical thinking, logical reasoning, and analytical skills

These skills are increasingly valuable in technology-rich work environments and labor markets

Jobs in business and economics, social and natural science, engineering, information technology and artificial intelligence require strong math knowledge and skills

The value of these skills is expected to grow with the increasing presence of AI-related production inputs in the workplace

Numeracy skills are linked with economic growth

- Multi-country analyses and migrant studies have identified numerical skills as major determinants in economic development
- Aggregate math knowledge and skills are linked to high levels of capacity for technological innovation
- They represent the “skills and knowledge needed to effectively absorb, master and improve existing technologies, and to create new ones”
- Evidence from the US suggests that a society’s innovation capacity has a significant positive impact on its economic growth

Numeracy skills are valuable for informed citizenship, political participation and other aspects of daily life

Understanding and interpreting current events and the political choices related to these

Understanding aspects of democracy (e.g., voting and electoral representation) that could allow for more active and informed civic participation

Managing household and daily life, through budgeting, informed choice etc.

Strong early math skills may predict later academic achievement

Later academic outcomes

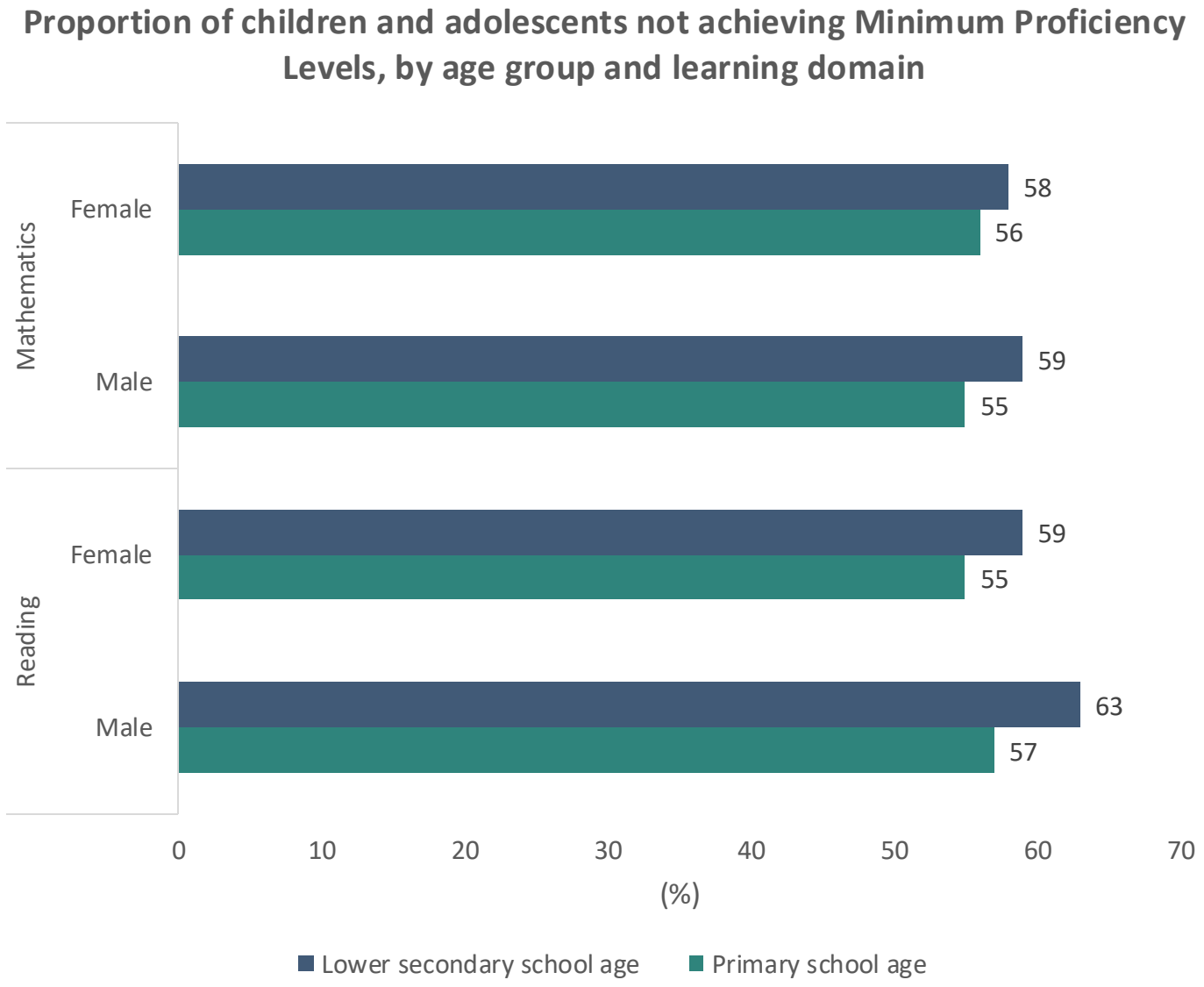
- Foundational mathematics skills positively impact secondary school learning outcomes and completion rates
- Math equips students with the foundational knowledge needed to succeed in higher-level subjects such as science, ICT and advanced mathematics

Links with literacy

- Early numeracy skills may provide an earlier indicator of students' literacy abilities.
- Struggles in early numeracy skills may be useful as an early warning on potential difficulties for students in literacy.
- Math instruction is not a substitute for literacy instruction; predictive power linked to cognitive abilities (working memory) that affect early math ability before they impact early literacy.

Learning outcomes for numeracy in LMICs are persistently low

- The relevance and importance of numeracy have not translated into robust learning outcomes in numeracy in LMICs
- Shares of students lacking proficiency are consistent with measures of Learning Poverty



Source: UNESCO Institute for Statistics, 2017

What constitutes a good early grade mathematics program?

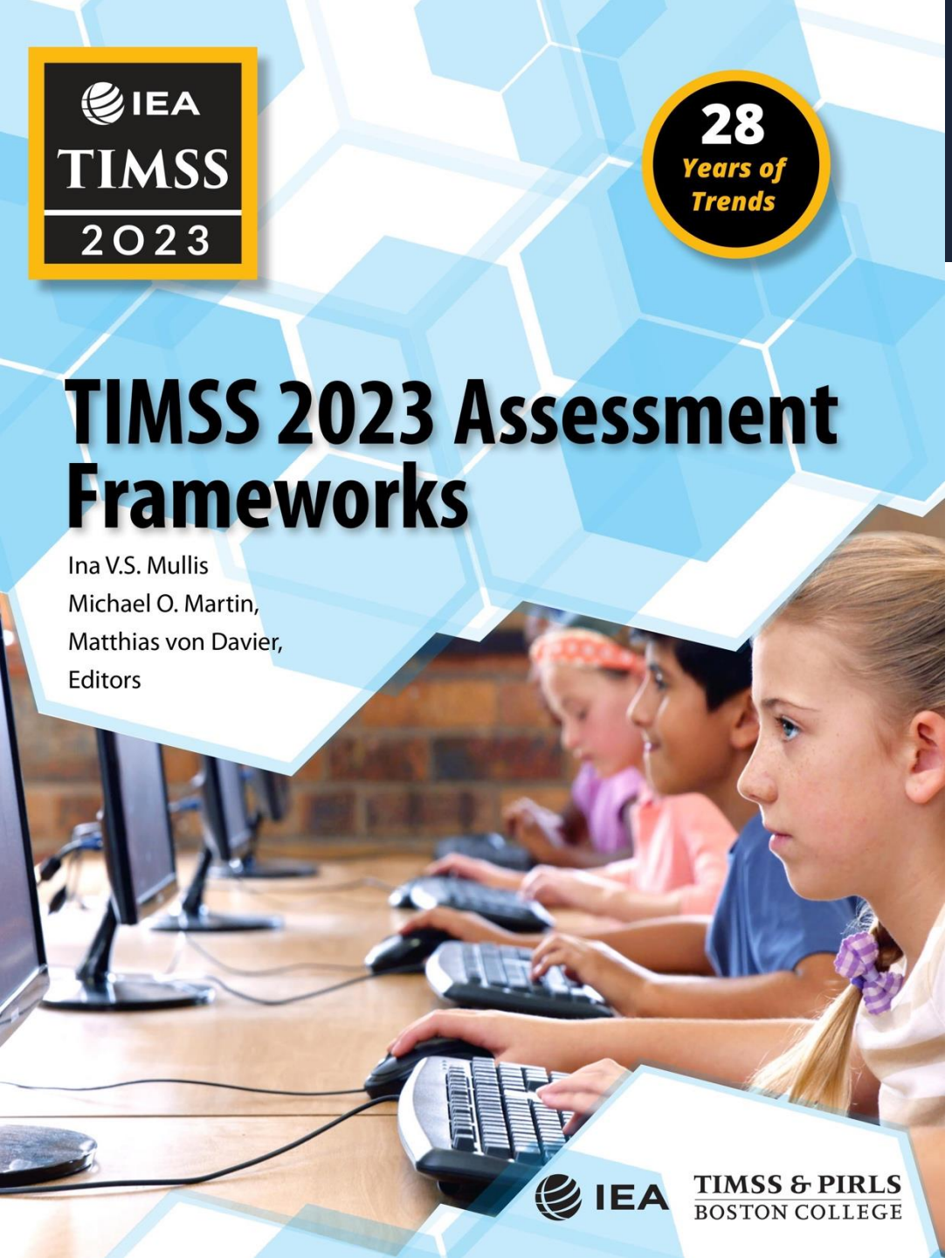
Teach important mathematics

A good early grade math program teaches important math content starting from the most basic concepts

The knowledge and skills students need to improve and continuously succeed in successively more advanced mathematics

Foundations of the mathematics skills that will be used in various aspects of students' daily lives at various stages

Pays attention to developing good habits, attitudes, knowledge, and skills for mathematics learning

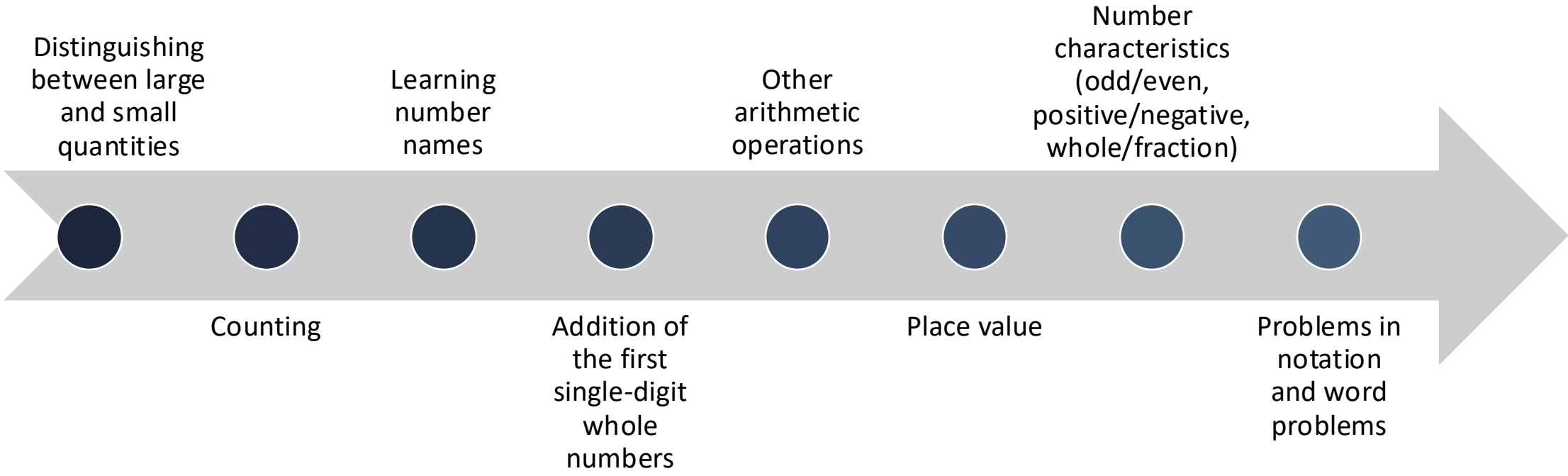


An international consensus on early grade mathematics content

- Consensus on content for mathematics at early grades is arguably much higher than for any other school subjects – TIMSS is the best example of this consensus
- Representatives of dozens of countries routinely gather to agree on what math should be included in the assessment
- Their mandate is to include only those topics which are part of the curricula of all or most test-taking countries.
- The TIMSS framework for 4th grade mathematics is the most comprehensive statement of the consensus on early grade math content and includes:
  - Number and arithmetic operations
  - Geometry
  - Measurement
  - Data

Number and arithmetic: toward “number sense”

- Good programs seek to promote conceptual understanding and procedural fluency with facts about numbers and arithmetic.
- Possessing good skills in this domain is often called having “number sense”
- Developing numbers sense should be a primary goal of early grade math programs, with ample class time being devoted to it.



Geometry

- Students should recognize and know the basic characteristics of straight and curved lines, and figures such as circles, squares, rectangles, and polygons
- Perimeter and area combine arithmetic, magnitude, and shape
- Construction, position, and direction are often taught, along with the difference between regular and irregular figures

Measurement and Data

Key measurement topics typically include:

- Length
- Capacity
- Volume
- Time
- Temperature
- Currency
- Early familiarity with distance

Basic data display and interpretation concepts are taught using:

- Pie charts
- Bar graphs
- Venn diagrams

Other topics typically included in most mathematics curricula

Algebra (or, “pre-algebra”): focuses on rudimentary patterns and the basics of ratios (like percentages) as pre-cursors to functions and proportions

Rudimentary statistics: overlaps with data representation and interpretation

Rudimentary probability: basic concepts in word problems

- These topics are preparatory in nature: the give students the very first steps toward math concepts they will study in future grades
- For example, early grade algebra (or “pre-algebra”) usually focuses on pattern recognition, skip counting, and word problems that get at the very basics of functions.

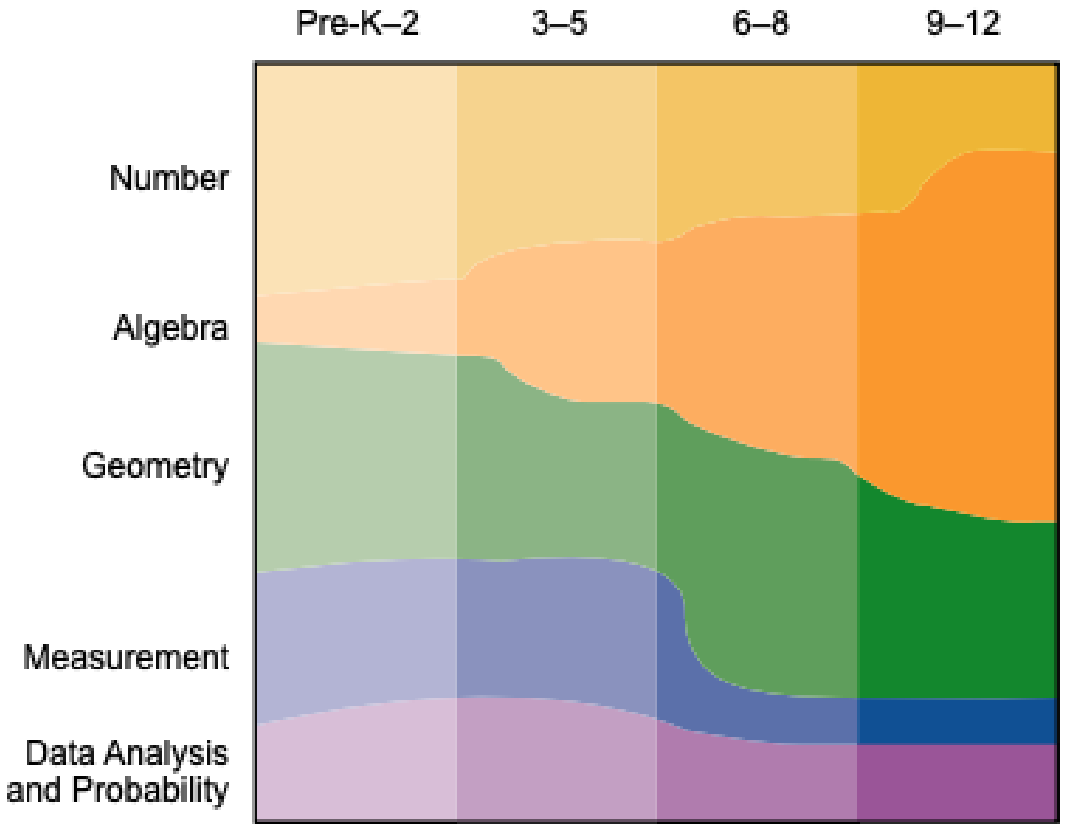
The TIMSS Low International Benchmark defines minimal expected proficiency by fourth grade

Low International Benchmark	
400	Students have some basic mathematical knowledge. They can add, subtract, multiply, and divide one- and two-digit whole numbers. They can solve simple word problems. They have some knowledge of simple fractions and common geometric shapes. Students can read and complete simple bar graphs and tables. Students can recognize basic measurement ideas. They can recognize and visualize common two - and three-dimensional geometric shapes. Students can read and complete simple bar graphs and tables.

Source: IEA, 2019

- States what students should know and be able to do if they are to continue to progress as math learners
- Formulated with consideration of success in TIMSS at 8th and 12th grade, and, by extension, with generally, "being on track" to continue to master school mathematics adequately
- Expected performance for number and arithmetic, geometry, measurement, and data

Content progressions are important to consider in developing mathematics curricula.



Source: National Council of Teachers of Mathematics, 2000

- For any selection of topics, emphasis should reflect explicit learning goals both by grade and across the school experience of mathematics
- Some topics may receive more focus initially
- The hierarchical nature of mathematics means that basic or antecedent concepts must be taught first
- Research shows that mastery of early concepts promotes more and more efficient learning of later content

Repetition with increasing complexity promotes mastery

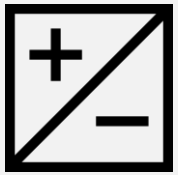
- Math concepts are learned over time, with repeated exposure and practice, in ways that are not strictly linear
- Mastery emerges when learning opportunities within a topic are spaced and concepts are revisited repeatedly
- Small increments in complexity and scaffolding permit higher levels of understanding and more sophisticated mathematical thinking
- This principle, “spiral mathematics,” has been shown to be more effective than “massing”, in which single topics are addressed over one extended time without breaks or later revisiting

Mathematics learning is not essentially linear

- Developing a secure grasp of early mathematical ideas takes time, repetition, and practice
- Students may not always show a full grasp of the underlying concepts or be able to show that knowledge in all contexts even if they "know" the material well sometimes.
- New concepts in progressions should be introduced when earlier concepts have been “mastered” but doing this well is always a judgment call

“Developmental progressions” offer useful guidance for teachers but are not recipes.

Mathematics is exquisitely sensitive to instruction and builds upon consolidation in memory of relevant prior learning.



Mastery of each concept needs to be checked, and performance may be expected to vary up and down from day to day and week to week.

Developmental sequences in arithmetic learning reflect average performance and may often reveal some “typical errors” that students commonly make as they seek to grasp concepts.

Not all children go through the same learning sequence, at the same time, or with the same duration in terms of how long it takes them to learn and retain conceptual and procedural knowledge.

A balanced approach to developmental progressions and common errors should keep students moving forward in their learning at speeds they show they can handle.

Examples of a specific learning progression for number knowledge

Core Area	The child can:	The child is ready for the next step when they:
Subitizing (small-number recognition)	▪ Immediately recognize the total number of items in a collection and label it with an appropriate number word. ▪ Construct precise concepts of one, two, and three when presented with many different examples of a quantity labeled with the same number word (e.g., two eyes, two hands) as well as non-examples labeled with other number words (e.g., three cars).	▪ See one, two, or three objects (for example, stickers) and can immediately—without counting—state the correct number of stickers.
Meaningful object counting	▪ Count in a one-to-one fashion and recognize that the last word used while counting is the same as the total (the cardinality principle).	▪ Can count by pointing and assigning one number to each object: "One, two, three, four, five," and recognizing that the total is "five."
Counting-based comparisons of collections larger than three	▪ Use meaningful object counting to determine the larger of two collections (e.g., "seven" items is more than "six" items because you have to count further).	▪ Can count to determine which is the larger collection (e.g., "nine" bears is more) when shown two different collections (e.g., nine bears and six bears).
Mental comparisons of close or neighboring numbers	▪ Efficiently and mentally determine the larger of two adjacent or close numbers (e.g., that "nine" is larger than "eight")	▪ Can answer questions such as, "Which is more, seven or eight?" and can make comparisons of other close numbers.
Number-after equals one more	▪ Conclude that any number in the counting sequence is exactly one more than the previous number.	▪ Recognize, for example, that "eight" is one more than "seven.

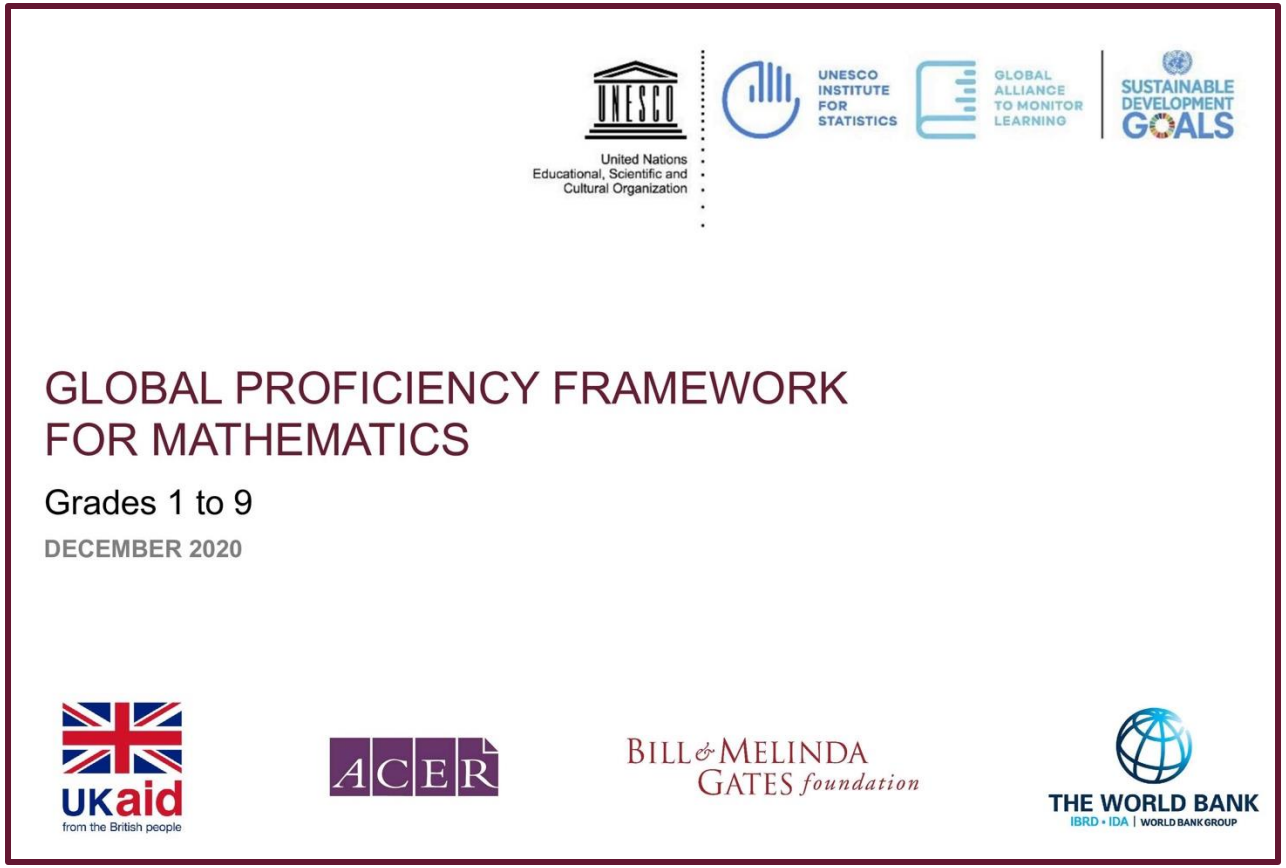
Source: Frye et al., 2013

Less content can mean more learning in early grade mathematics

- Students require substantial amounts of instructional time to internalize new mathematical concepts and practice new skills that will allow them to reach increasingly more complex learning objectives
- Avoid overloading the content of early years mathematic programs
- This enables teachers to match the pace of instruction to the pace of their students' learning

Using progressions in the Global Proficiency Framework

- Describes highly detailed progressions and defines proficiency from grades 1-9, like TIMSS but with greater specificity and granularity
- Identifies four performance levels on highly defined subtasks for all topics
- Not research-based findings
  - Judgment-based distinctions, based on rational analysis and the experience of the authors, not research
  - Draw on the authors' knowledge of "common expectations countries have for learner performance in mathematics synthesized from more than 50 countries around the globe"
- Policymakers may wish to use these tools with awareness of the origins of the information they present

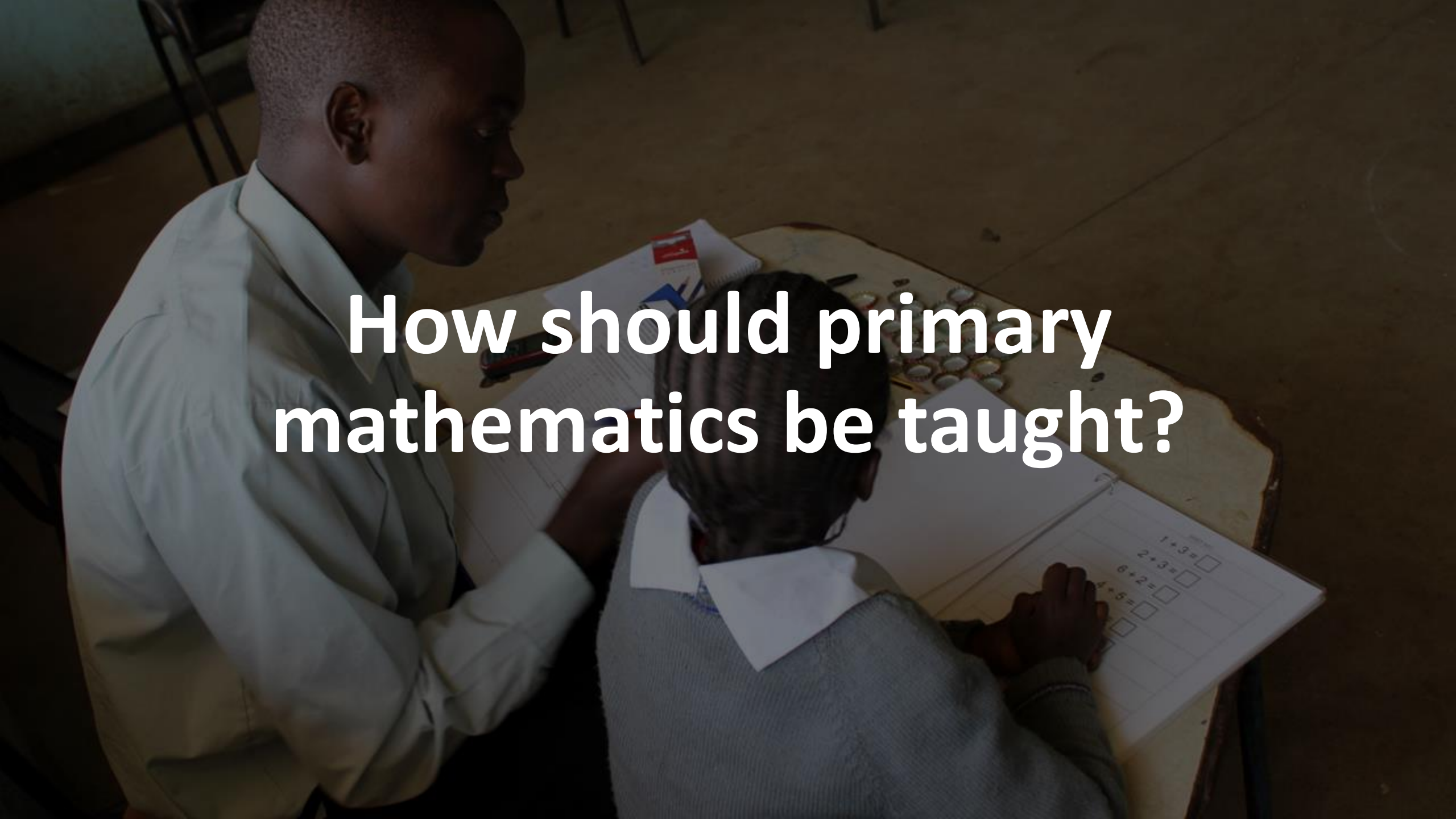


Are simpler curricular frameworks better?

- Alignment between curriculum standards and classroom instruction and assessment can be a key driver for learning gains. It is helpful for education systems, schools, and teachers to clearly understand what they are expected to be teaching, and why they are teaching it.
- However, evidence shows that curricular expectations, which are well-intentioned but sometimes overambitious and unclear, are often far from classroom realities.
- Curricular frameworks and statements of standards should provide clarity on three core aspects for early grade mathematics:
  - What students should learn (concepts, skills, attitudes, and more)
  - When (or at what time or age) they should have learned this piece of knowledge by
  - To what level should they be able to understand or master the content in question

Having sufficient instructional time for mathematics matters.

- Emerging research confirms the intuitively appealing idea that student achievement in mathematics is positively associated with instructional and practice time
- Measures of instructional time and time-on-task are essential data points for decision-making but are rarely available.
- Systematic observations and data collection for these variables allow for answering key questions on the efficiency and effectiveness of early grade mathematic programs.


How should primary mathematics be taught?

Seek Content mastery + helpful attitudes and mindsets

- Accumulating content knowledge is a core goal of mathematics education, but it is not the only goal.
- Pedagogical choices should promote children's content mastery as well as the helpful attitudes and mindsets for mathematics learning.
- Positive attitudes and mindsets promote content learning, which in turn can improve attitudes in a virtuous circle. Negative attitudes and mindsets can do the opposite.

Attention is key to mathematics learning

- Attention is strongly related to growth in mathematics from preschool to school age and throughout schooling
- Difficulties in attention have been associated with less response to mathematics interventions, low academic achievement, drop out, and poor post-secondary outcomes

Pedagogical choices should promote maximum student attention.

Engagement and persistence	Meta-analysis shows the relationship of engagement to academic achievement is moderately sized, but also influenced by several factors
Growth mindset	Limited evidence, but there may be some benefit for certain groups of students, such as those who struggle with learning
Avoiding mathematics anxiety	Evidence shows a moderately negative relationships between mathematics anxiety and performance
Avoiding gender biases and stereotyping	There are no intrinsic, gender-based differences in mathematical abilities, Gender disparities stem from sociocultural influences
Positive attitudes and play	Positive attitudes toward mathematics can support mathematics attainment Can be developed through encouraging language, praising learners, and learning through play.

The bidirectional relationship of attitude and mindset with content knowledge.

- Attention, engagement, an absence of mathematics anxiety, and mindset are all positively associated with mathematics achievement.
- However, the nature of these relationships may be bidirectional, involving self-reinforcing cycles that may be either “virtuous” or “vicious.”
- Research showing that interventions focusing exclusively on attitudinal improvement without appropriate emphasis on mathematics content mastery have not consistently resulted in increased mathematics achievement
    - Embedding some of these factors within mathematics instruction may have promise for some children with or at risk for mathematics difficulties.

The impact of teachers' attitudes

- Teachers' attitudes have shown to influence students' ability to succeed in mathematics.
- The attitudes of teachers influence approaches to classroom instruction and student attitudes.
- In classrooms where teachers have a positive attitude toward mathematics, learners also develop more positive attitudes

The literacy-numeracy nexus

- Early literacy and numeracy skills are highly inter-related and positively influence each other in later learning
- The importance of early literacy skills to the development of both early and late mathematical competencies necessitates key considerations for numeracy instruction.

Teaching mathematics in second languages rather than the mother tongue may impede learning.

Children can be supported in mathematics learning by being encouraged to use correct mathematics language.

Literacy materials can be used to strengthen numeracy skills, and vice versa.

Practice is important for mathematics learning

- Practice, whether included during class time as part of instruction, or outside of class hours, correlates with student performance and achievement.
- Practice should be distributed over time and involve more than one concept or operation (that is interleaving).
- The selection of practice exercises will ideally be appropriate for the students based on the particular point in their learning trajectories.
- Practice itself need not only involve speeded retrieval practice; can also be conceptual in nature.

Teaching should foster both conceptual understanding and procedural fluency.

Conceptual understanding

- The comprehension of mathematical concepts, operations and relations," or an integrated and functional grasp of mathematical ideas.
- Helps students understand (a) why mathematical ideas are important; (b) in which contexts they prove useful; and (c) how the concepts connect to other concepts they already know.

Procedural fluency

- Allows understanding to be applied to computation and calculation, an important aspect of mathematical thinking and problem-solving.
- Automatizing foundational mathematical knowledge frees processing resources so that the child can devote attention and thinking skills to solving more complex problems

Conceptual and procedural knowledge co-develop in a bidirectional fashion. Therefore, choosing activities that promote one versus the other makes little sense

Procedural fluency with conceptual understanding

- Learners who can retrieve number facts accurately and quickly are better able to focus their cognitive resources on other aspects of problem-solving.
- However, rote memorization without understanding is not learning. The pace of a student's computational abilities may not be reflective of their understanding of mathematical concepts if such is driven by memorization of procedures.
- High performing learners use computational strategies grounded in conceptual understanding. Research has found that high performing learners tended to use computational strategies grounded in a conceptual understanding of the number system, not by relying on memorization

Multiple representations can be helpful for learning.

Relies on the idea that learning may be slower, but retention is improved through contextual diversity.

Learning mathematical concepts is aided when both verbal and visual representations are used; however, there are specific rules to be followed so these different representations do not compete for attentional space

While this tool does have evidence behind it, there may be some nuance to who it is most effective for and when.

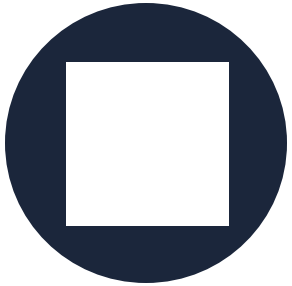
Critical thinking and problem-solving skills emerge and evolve in mathematics through achievement.

- Unless students are challenged to continually improve their content and procedural knowledge across a variety of formats, their abilities may not rise above the level of solving routine problems with single or obvious solutions.
- Both critical thinking and problem-solving skills depend on the ability to perceive or uncover the underlying structure of a mathematics problem, and to recognize fundamental concepts embodied in different formats. These skills emerge from long engagement with conceptual understanding and procedural fluency in specific subdomains.
  - They are not separate skills that can be taught separately from the content and procedures they embody.
- Providing students with a diverse sets of challenges in mathematics promotes the development of broader skill sets and abilities to apply knowledge.
  - Providing students with a diverse sets of challenges in mathematics promotes the development of broader skill sets and abilities to apply knowledge. This could involve presenting students with problems with the same underlying structure in various formats, or of distinct types of mathematics-related skills.

There is a role for self-explanation and classroom discussions in learning new mathematical concepts.

Explanations of thinking have a moderate level of evidence for learning across many domains

Children who naturally self-explain score higher on mathematics achievement tests, but the literature is mixed



The use of worked examples or partially worked examples with self-explanation may be useful in the beginning stages of learning new mathematics concepts

Learning is boosted when teachers rich, non-routine problems are followed by opportunities for students to explain their thinking

Teaching and learning materials are essential for primary mathematics instruction.

Textbooks for mathematics should be thoughtfully designed and distributed to all students.

Teacher guides should be designed to enable direct, explicit, systematic, and cumulative instruction.

Ensuring that teaching and learning materials reach teachers and students requires an effective book supply chain.

Should be designed using an evidence-aligned scope and sequence. They should provide students with opportunities to both tackle unfamiliar problems, independently and collaboratively (in pairs and small groups), and to engage in hands-on activities when learning new concepts.

Concrete manipulatives can be important components of mathematics teaching and learning materials.

- Manipulatives are physical objects such as beads, counters, pebbles, and geometric shapes that students can touch and move
- Mathematics domain matters. At present, the use of manipulatives is most beneficial for learning the concepts of fractions.
- Greater perceptual richness (for example, using animal figures instead of blue blocks) can negatively affect learning
- Direct, guided instruction when using manipulatives is important

The Concrete-Representational (Pictorial)-Abstract (CRA/CPA) method.

The use of concrete manipulatives is the first component of a commonly used instructional strategy for children with math difficulties, called the CRA/CPA. In this method, children are taught a concept using concrete objects (e.g. tens blocks), then move to similar problems using representations (e.g., a drawing of base 10 blocks) and finally to problem solving using symbols or numbers.

The value of "informal" math learning and its relationship to perceived relevance.

- It is a stylized fact that children math better when they perceive its relevance to the "real-world" and to non-school situations and settings. Some examples of informal mathematical knowledge and potential relationships with formal math knowledge include: sharing a sliced pizza, which might later translate into division.
- It is appealing to think that informal math knowledge shows developmental continuity with related formally taught math concepts. If this were the case, informal knowledge could be a high yield target for early instruction.
- Currently, however, the evidence is more general; that is, informal mathematical knowledge is predictive of general math achievement in the transition to formal schooling. More longitudinal and experimental (intervention) studies are required to determine if informal and formal mathematical knowledge are related.

High-quality teacher preparation and ongoing support for mathematics is not well defined

- **Teacher content knowledge levels affect their teaching and student learning.**
  - The extent to which teachers possess content knowledge has a bearing on how they teach and on children's learning outcomes
- **The design and effectiveness of teacher education programs for mathematics vary greatly across countries.**
  - Most teacher education programs struggle to create a shared understanding on what constitutes mathematics and how it should be taught. These differences in beliefs lead to inconsistent teaching practices
- **A collective understanding of how best to design teacher professional development for mathematics is still developing.**
  - High-quality research on professional development in low-income country education systems and in fragile or conflict-affected regions is still growing, with early insights suggesting that context matters considerably

Effective classroom-based assessment can significantly improve learning outcomes.

Teachers require assessment instruments and practices to do understand each student's level of knowledge and performance and adjust classroom practices accordingly

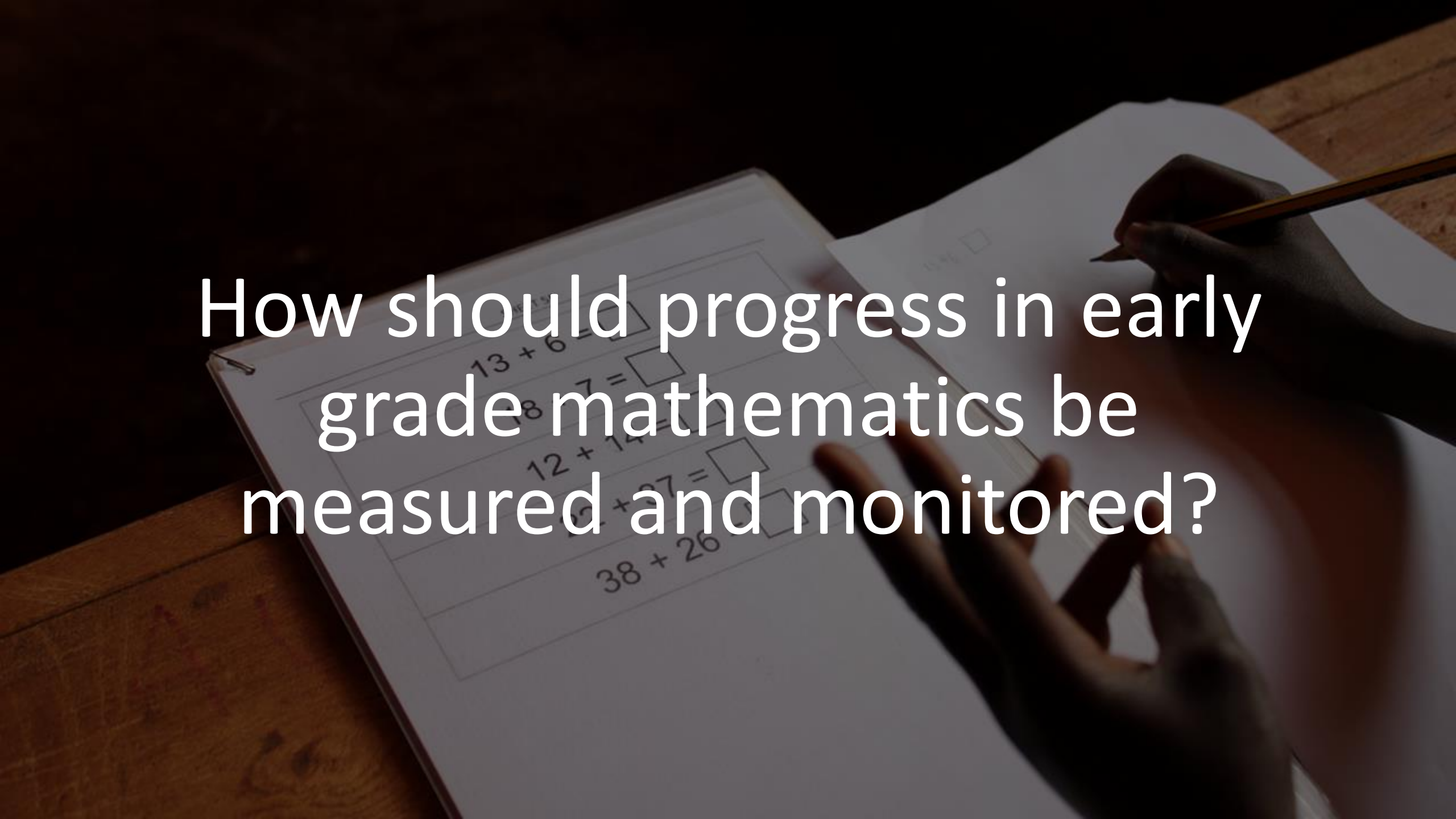
Classroom assessment can help guide teachers in improving their instructional strategies

While most countries have assessment policies, these often do not explicitly address classroom assessment

Simple assessments should be aligned with the prescribed pedagogical approach and broader frameworks for student promotion

Technology for mathematics teaching and learning

- Given barriers to entry and risk for widening inequities, it is not clear that ed-tech interventions will always achieve higher learning gains than other interventions.
- Self-led learning software is one of the more prominent applications of educational technology for mathematics, with consistently medium-to-large effects on learning
- Ssuch digital learning platforms often do not target all skills equally: a review of 23 mathematics applications used at the primary level revealed an emphasis on procedural fluency and speeded practice rather than conceptual understanding and other advanced mathematic skills.


How should progress in early grade mathematics be measured and monitored?

Assessment and benchmarking center on two fundamental questions.

How well are students learning what they are meant to learn?

- Provides information on how well students understand curricular content, and/or are acquiring the abilities and attitudes
- Lends itself to assessments that both test and report on specific tasks

How well do they perform relative to peer or comparator student groups?

- Provides information on how well students do with respect to the performance of other groups of students
- Lends itself to assessments that aggregate knowledge and skills into single score

Match the assessment instrument to the information needed.

Norm-referenced assessments

- Often large-scale assessments that may be standardized to be comparable across contexts
- Use score scales that indicate relative performance
- Little or no information on performance on specific tasks
- Regional (PASEC, SEACMEQ) or international (TIMSS)

Curriculum-based ("criterion-referenced") assessments.

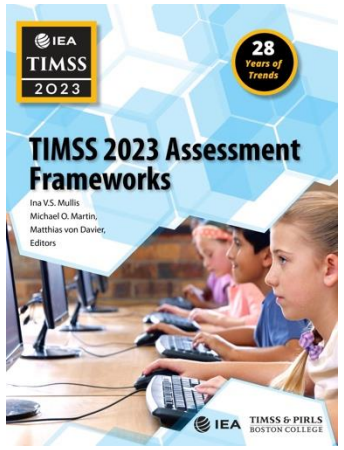
- Assess the extent to which the target population has mastered an identified set of learning goals or content
- Includes:
  - Assessment of average skills levels in groups and cohorts.
  - Diagnostic tests of individual learners/progress monitoring instruments.

What do policymakers want or need to know?

- Meaningful interpretation of assessment results depends on well-defined content and learning goals, along with clearly defined performance standards
- Snapshots of performance are not as helpful as repeated measurements that allow learning trends to be identified
- Granular, in-depth, real-time data on individual student progress, garnered by classroom teachers, can support instruction and policy-making

Internationally comparable large-scale assessments can signal the alarm

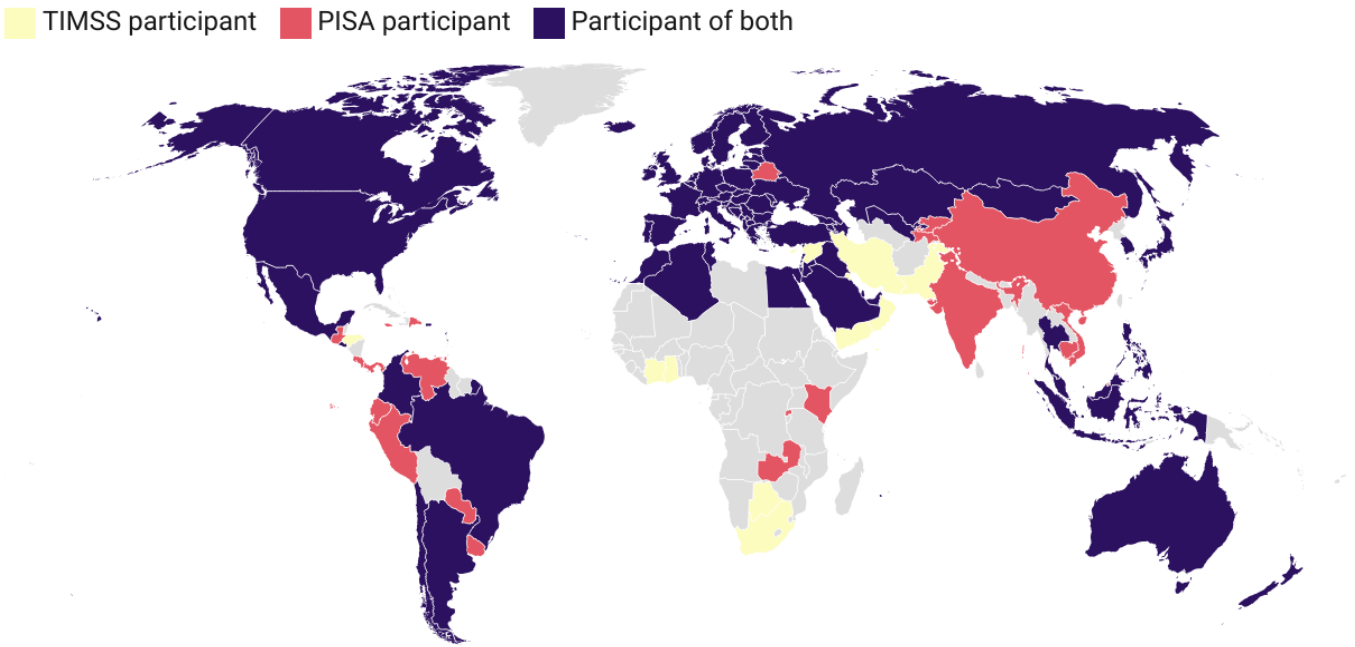
- Evidence suggests that learning data provides education systems with an initial “wake-up” that can help kickstart successful reforms
- Such assessments also provide opportunities to increase the comparability of learning outcomes over time with other countries
- Impact of these assessments is often limited when not properly communicated and actioned upon by education actors



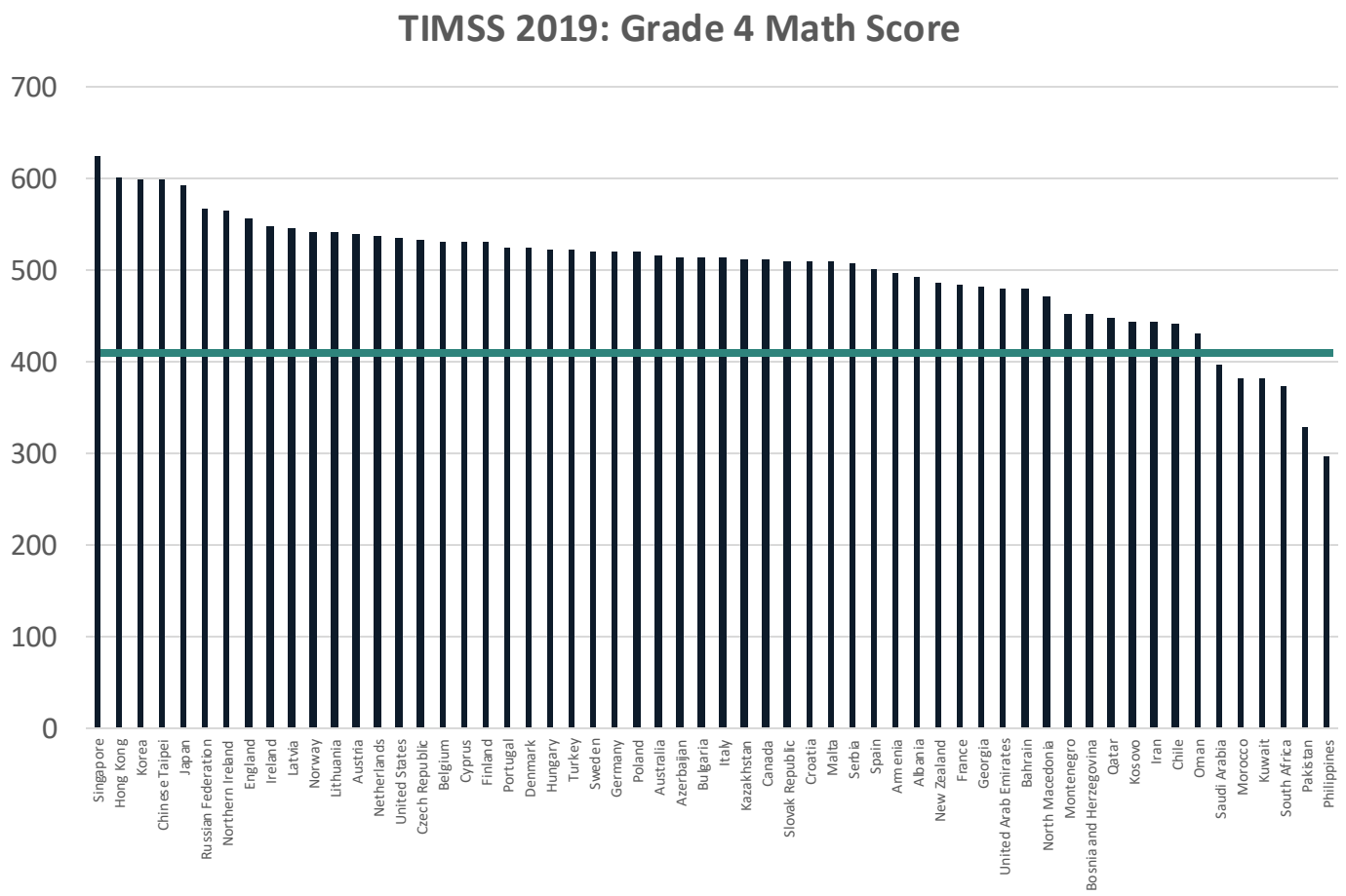
PISA

IEA LaNA

However, participation in international assessments of mathematics is skewed, both regionally and by income level



LMICs consistently score at the bottom of international assessments for mathematics

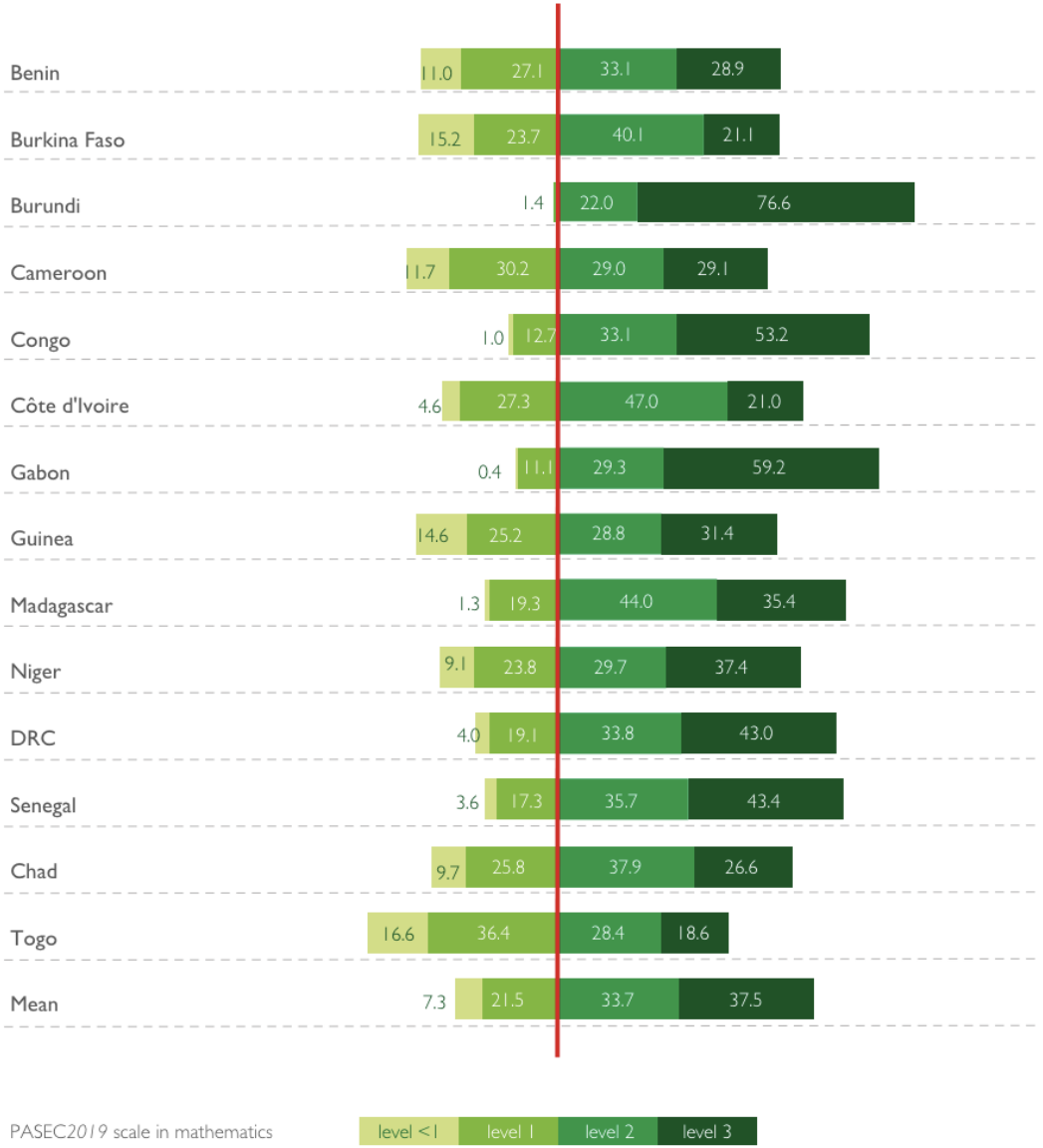


- Approximately 91% (29 of 34) of participating, non-OECD jurisdictions scored below the OECD average for mathematics in the 2022 PISA
- Between 1995-2019, only 18 LMICs have had mean scores above 400 on Grade 4 mathematics in the TIMSS assessment

Regional assessments provides a clearer picture of the performance of students in LMICs

- Regional assessments are school- and sample-based, group-administered, standardized assessments
- Examples include:
  - LLECE
  - PASEC
  - PILNA
  - SEA-PLM
  - SEACMEQ

Percentage of Grade 2 students per mathematics proficiency level, PASEC 2019



Source: PASEC, 2024

The benefits of participating in large-scale testing are limited

Benefits

- Knowing where students stand compared to their peers in other countries.
- Scores have optimal validity and reliability.
- Provides ability to report on SDG 4.1.1.

Limitations

- The cost of participating is substantial
- Only occur every few years
- Most of the test items are not released, besides, a few “released items” which are publicly disclosed.
- Limited selection of participating grade levels

Individually administered criterion-referenced tests

Criterion-referenced tests provide open and granular information about student performance on specific mathematical tasks.

- School-based, sample-based, one-on-one assessments
- While psychometrically robust, not always built on sophisticated quantitative scoring techniques; i.e. many do not adjust scores for item difficulty
- Do not aggregate scores into a single scale score

The Early Grade Mathematics Assessment (EGMA)

- An oral assessment and individually administered to students by trained assessors, with a focus on numbers and operations
- Consists of six subtests that, taken together, produce a snapshot of children's knowledge fundamental in early grade mathematics

Community-based mathematic assessments

- Conducted orally at the household level by community volunteers
- Usually quick and easy to administer, and target both in- and out-of-school children of a wide age range.
- Examples include ASER and Uwezo

Other surveys that include some mathematic assessment tasks include MICS and SDI

Test scores present different types and amounts of information

Scale scores aggregate overall student performance on an assessment

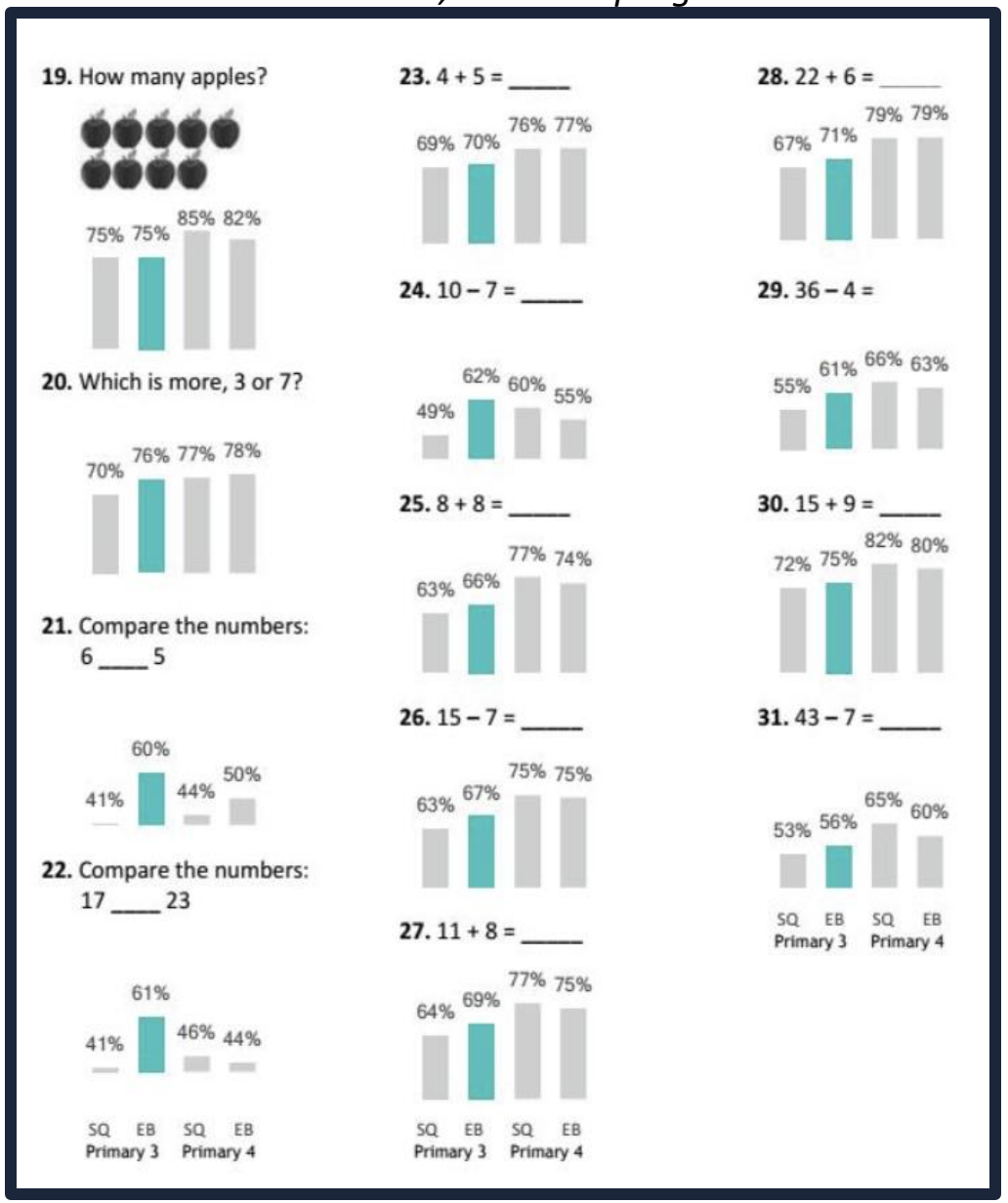
- Scale scores can be the same for different combinations of skills
- Example: A score of 410 on TIMSS

"Percent correct" scores indicate how students perform on a specific question

- Include item-level analysis
- Both policymakers and teachers can use information to shore up necessary skills
- Example: 87% of students were able to provide the correct answer for "10-7 = __?"

Assessments reporting in these ways provide varying degrees on information in performance level description.

Example of item-level performance on a mathematics assessment, EdoBEST program



Source: Cantrell and others 2019

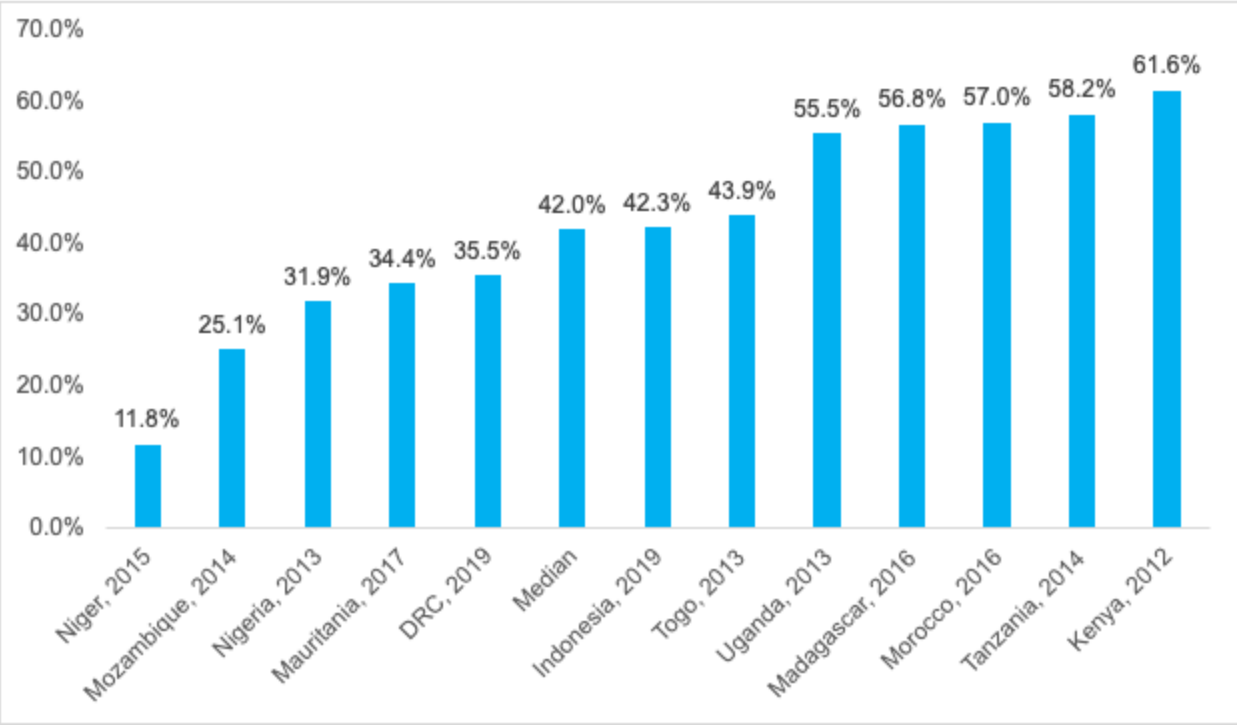
Student assessments reveal poor mathematical skills among students in LMICs

SDI mathematics assessment

- Eighteen SDI surveys have been conducted in 13 countries between 2010 and 2019
- Average score for Grade 4 students of 42.0 per cent

Sixth round of MICS

Average performance of fourth grade mathematics assessment on SDI survey



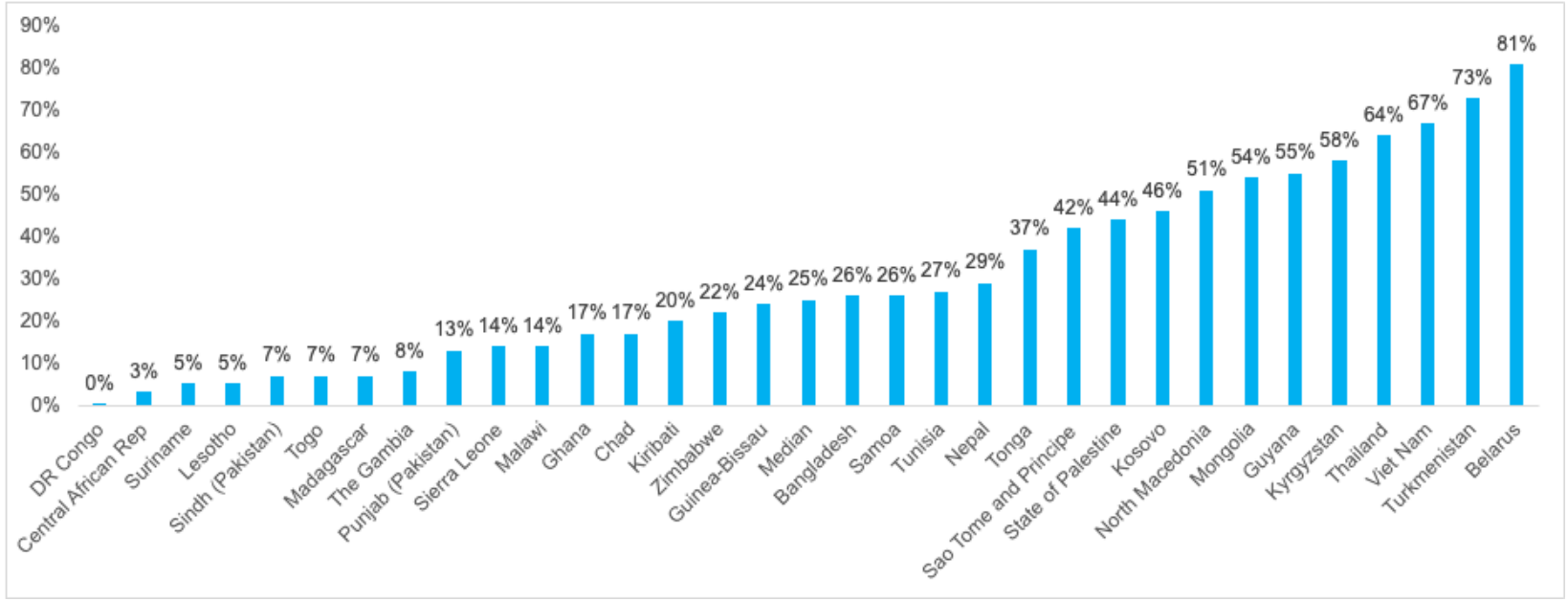
Student assessments reveal poor mathematical skills among students in LMICs

SDI mathematics assessment

Sixth round of MICS

- 34 participating LMICs
- Median value of 25 per cent of students showing foundational numeracy skills

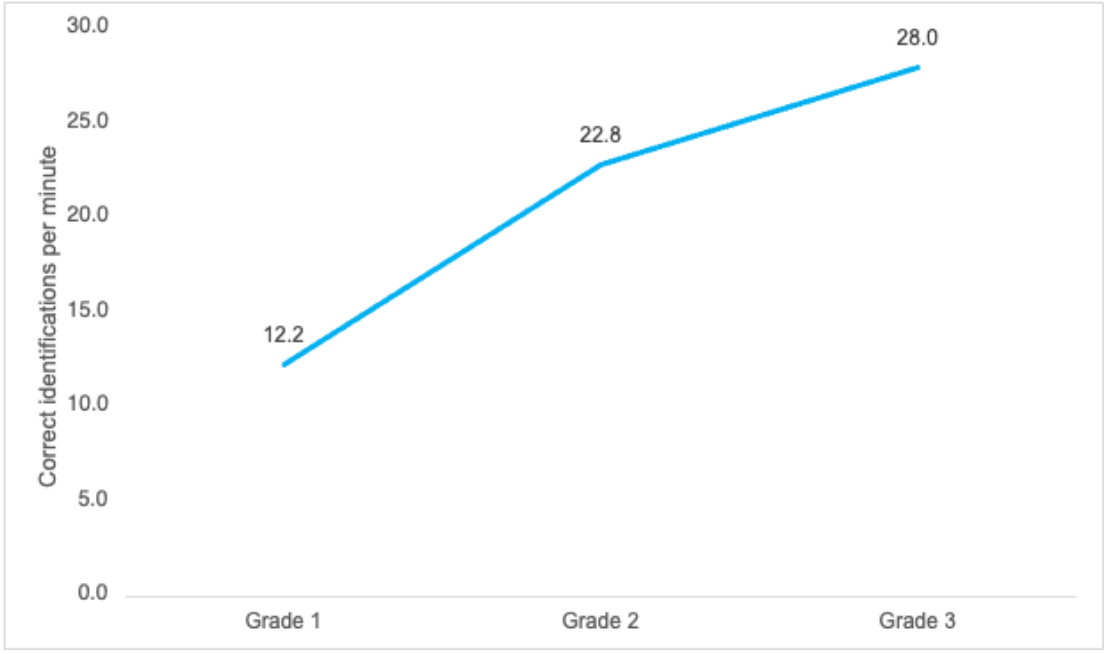
Share of students attaining minimum mathematics proficiency on MICS6 survey



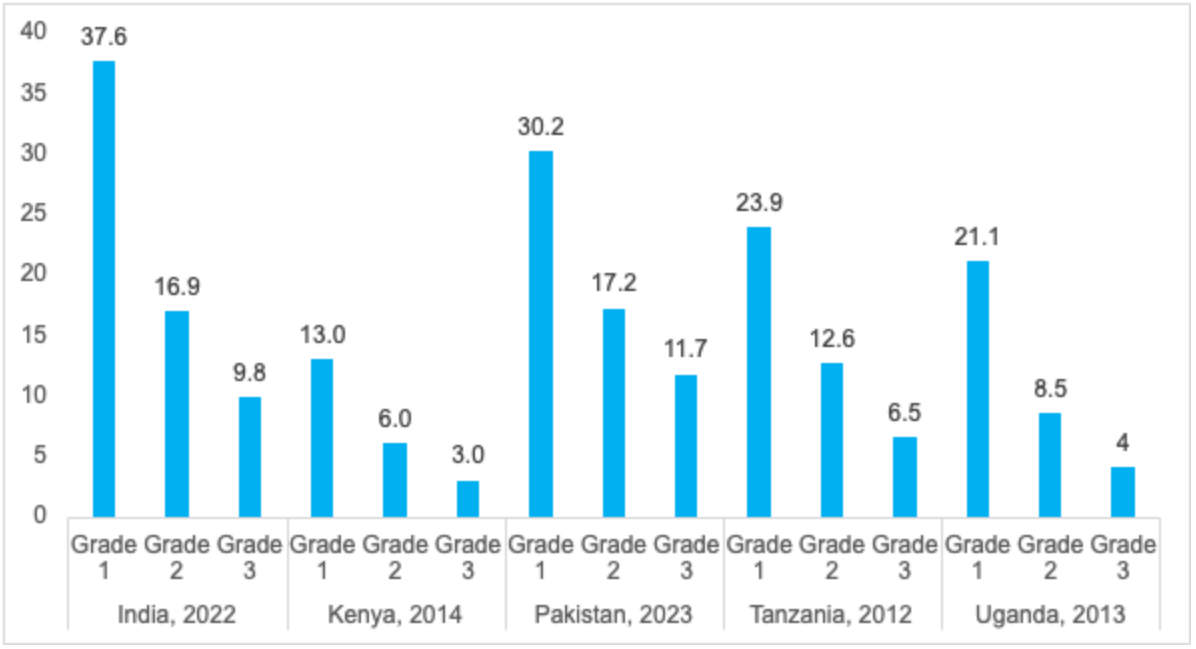
Number recognition and discrimination

- A majority of students are able to identify single-digit numbers within their first year of primary schooling, identifying 12.2 numbers per minute on average
- A sizeable proportion of students are still innumerate, and can't recognize numbers, after three years of primary
- A majority of students don't gain proficiency with single- and double-digit number discrimination until Grade 4

Average number of correct items per minute on number identification EGMA sub-task



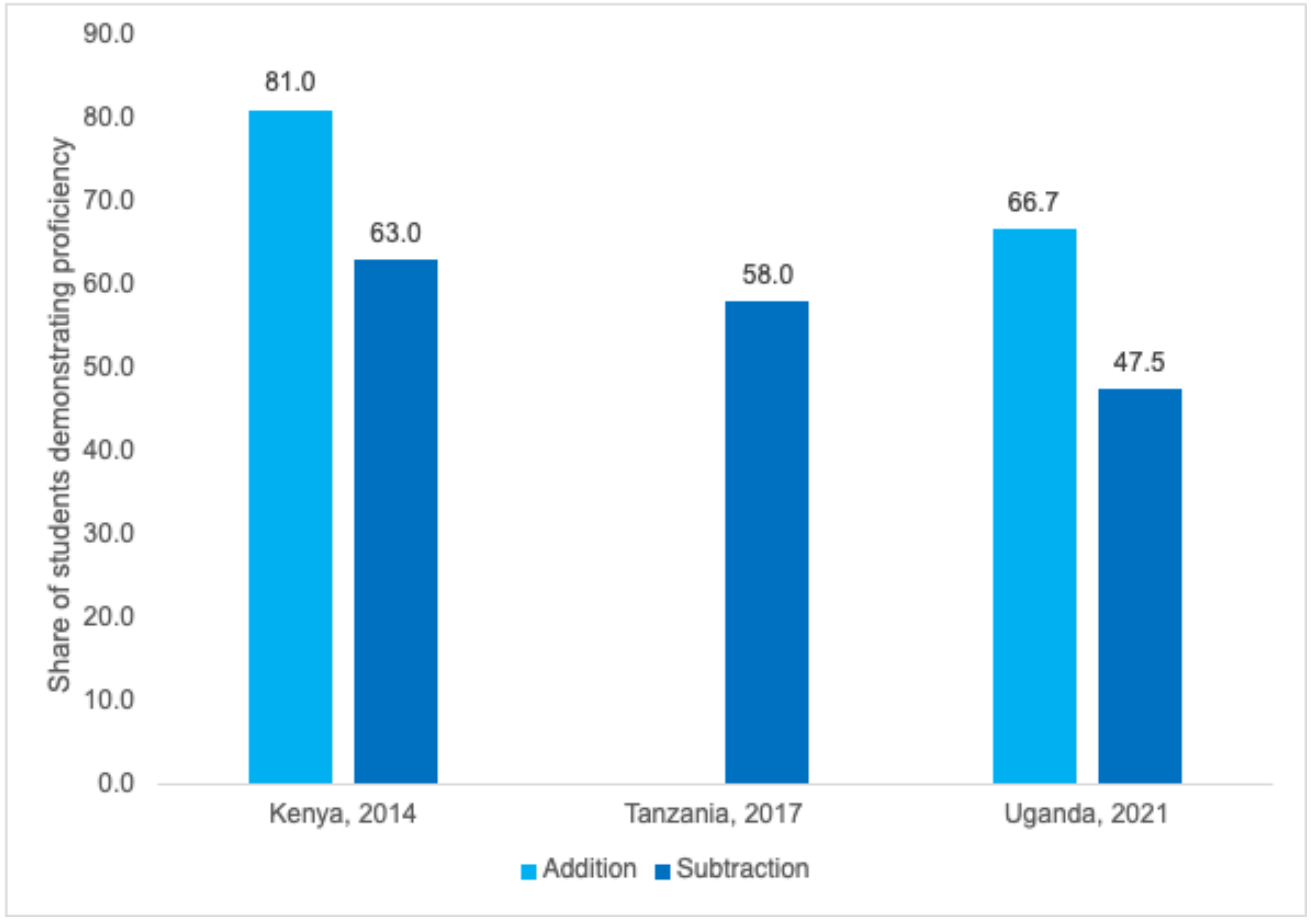
Share of students receiving zero-scores on ASER and Uwezo mathematic assessments



Single- and double-digit addition and subtraction

- A majority of students are able to reliably calculate single-digit addition and subtraction problems by Grade 3
- Grade 1 students, on average, can perform about 5 addition and 3 subtraction calculations correctly per minute, increasing to 10 and 7 by Grade 3
- Procedural fluency decreases substantially when borrowing is introduced with double-digit operations

Share of Grade 3 learners demonstrating proficiency with single digit addition and subtraction on Uwezo assessments



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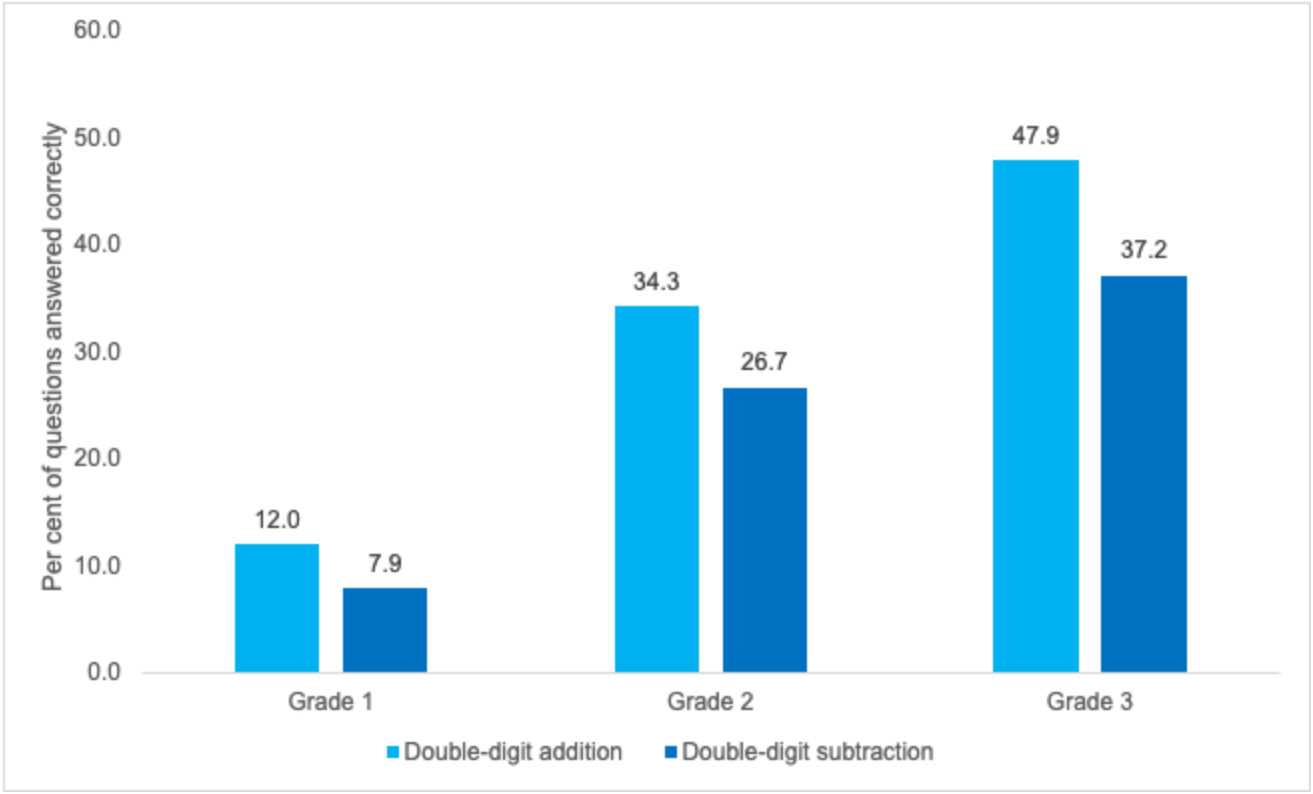
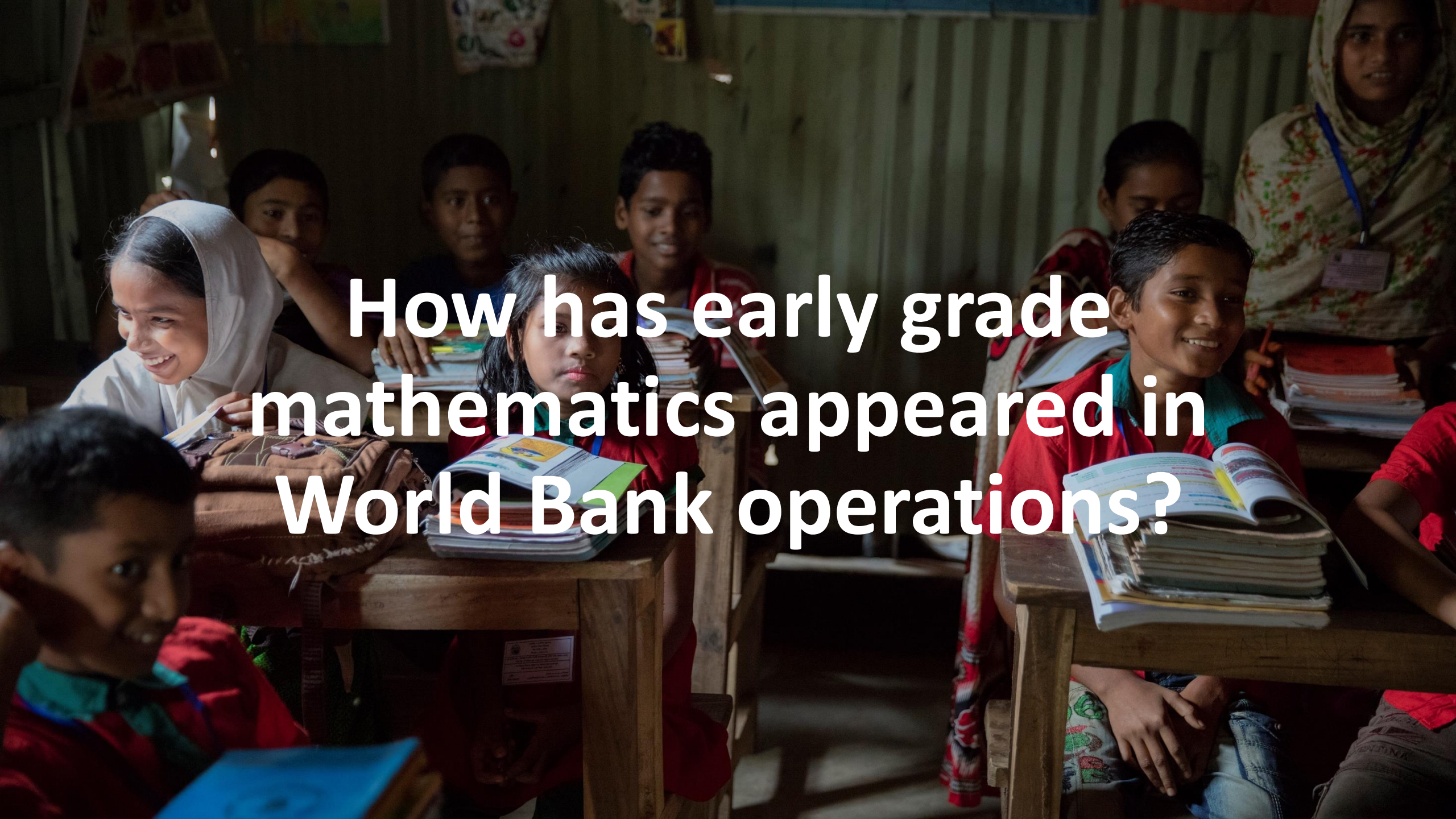
Average score on double-digit addition and subtraction (with borrowing) EGMA sub-tasks



Multiplication, division, and word problems

- Most students are **not demonstrating grade-appropriate proficiency** in multiplication and division after five years of primary schooling
    - According to the most recent ASER conducted in India and Pakistan, only **25.6 per cent** and **46.3 per cent** of students can perform division calculations consistently by the end of primary
- Performance with mathematical word problems **varies substantially by context.**
    - While Grade 2 students in Lebanon answered only **20 per cent** of word problems correctly, Grade 2 students in Sierra Leone answered **50 per cent** correctly.



How has early grade mathematics appeared in World Bank operations?

A two-pronged approach to exploring early grade mathematics in World Bank operations

- A **portfolio review** of early grade mathematic activities
  - To better understand (i) what the Bank is currently doing to improve early math education and (ii) how the implementation of these efforts is progressing
- **Surveys** and **semi-structured interviews** with World Bank Task Team Leads
  - To identify opportunities for and obstacles to success in early grade mathematics activities in World Bank operations

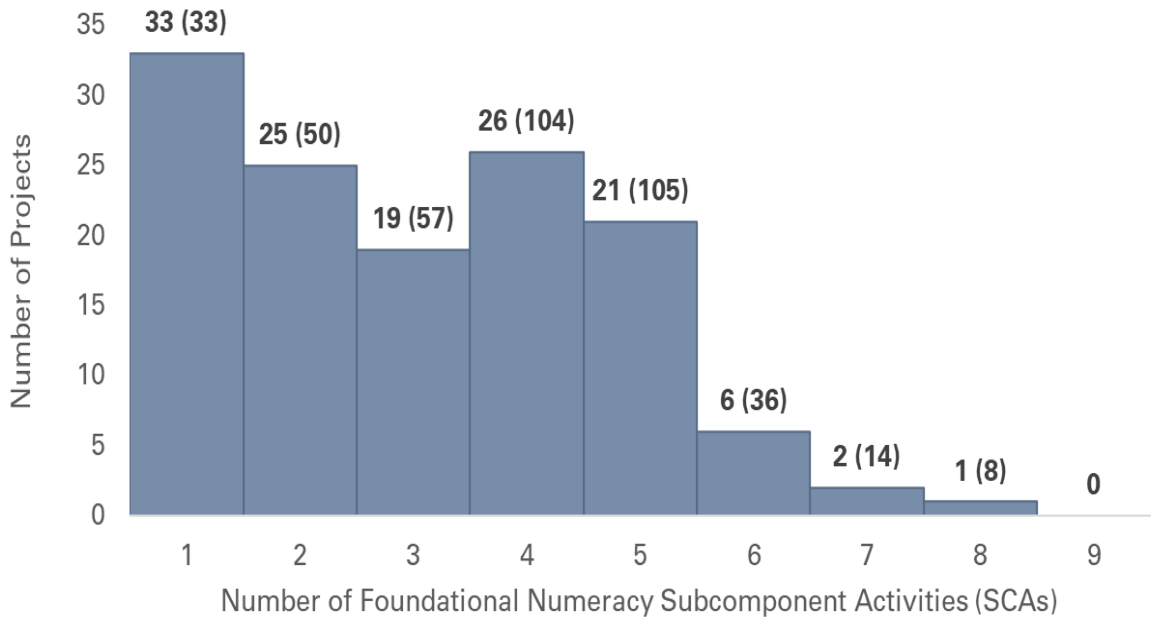
Analysis built on a Foundational Learning Framework

	Foundational Literacy SCAs	Foundational Numeracy SCAs
Pillar 1: Political will	1a: Political will	1a: Political will
	1b: Baseline measures & diagnoses	1b: Baseline measures & diagnoses
	1c: Age-appropriate milestones for literacy development	1c: Age-appropriate milestones for numeracy development
Pillar 2: Supported teachers	2a: Coherent curricula and clear pedagogical guidance	2a: Coherent curricula and clear pedagogical guidance
	2b: Practical professional development and coaching	2b: Practical professional development and coaching
Pillar 3: Teaching & learning materials	3a: Each child has a textbook for reading instruction	3a: Each child has a textbook for math instruction
Pillar 4: Language of Instruction	4a: Literacy instruction in the mother tongue	4a: Numeracy instruction in the mother tongue
Pillar 5: Home environment	5a: Oral language development	5a: Early numeracy activities
	5b: Home environment for reading	5b: Home environment for math

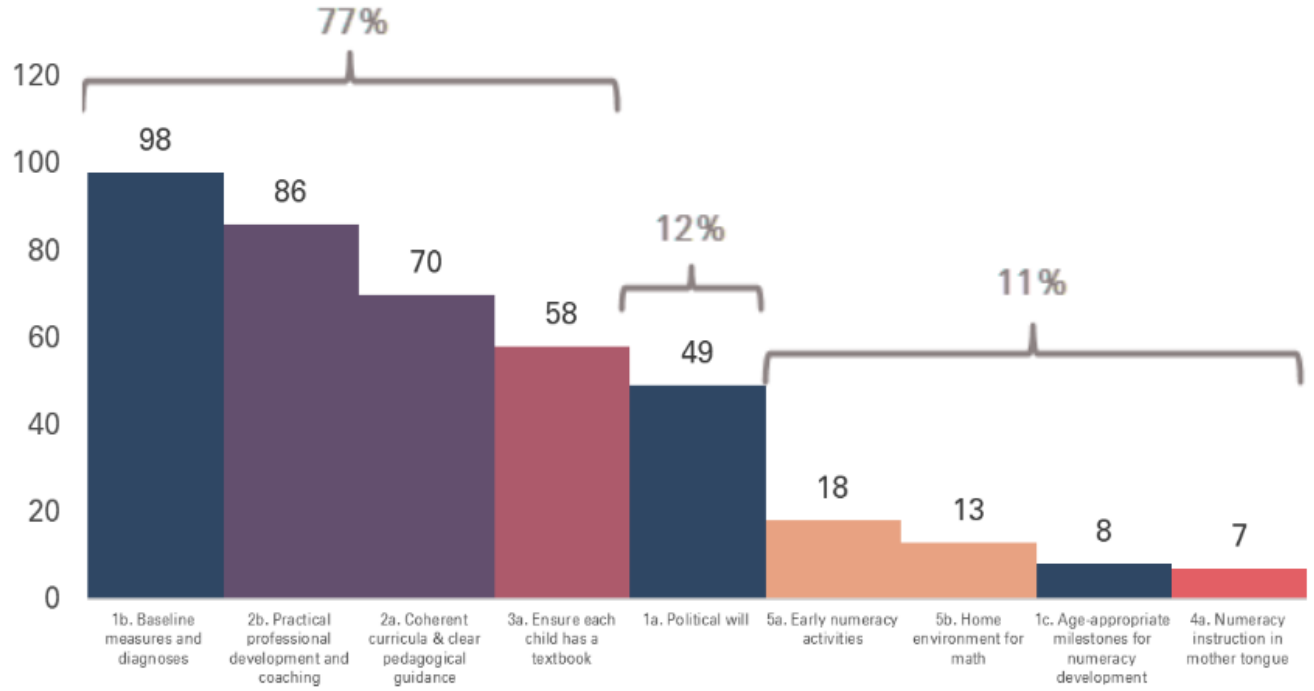
Of the 263 assessed, only 75 projects can be classified as early grade mathematics projects

- World Bank financing is supporting 407 subcomponent activities in 133 projects.
- Projects supporting early grade mathematics, on average, had 3.1 SCAs.
- More than three-fourths of the SCAs involve baseline measurement, teacher training, curricular revision/pedagogical guidance, or providing books.

Early grade mathematics SCAs per project



Distribution of early mathematics SCAs

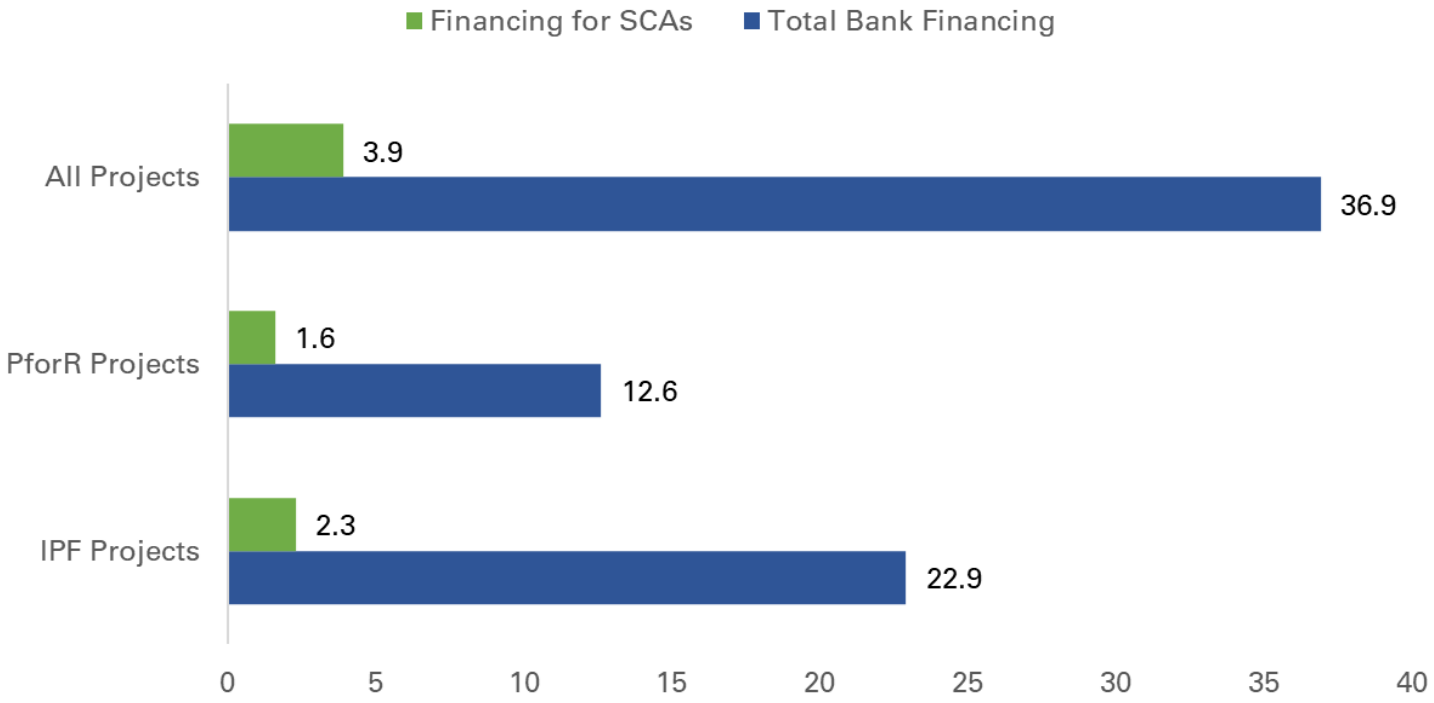


The World Bank is spending, at most, 21 per cent of financing resources on early grade mathematics.

Financing of early grade mathematics

	No. of Projects	Total Bank Financing (USD)	SCA Financing (USD)	SCA Share of Education Lending
All Projects	263	36.9 billion	3.9 billion	11%
Projects with at least one SCA	133	18.9 billion	3.9 billion	21%
Projects with at least three SCAs	75	12.3 billion	2.5 billion	20%

Distribution of World Bank financing



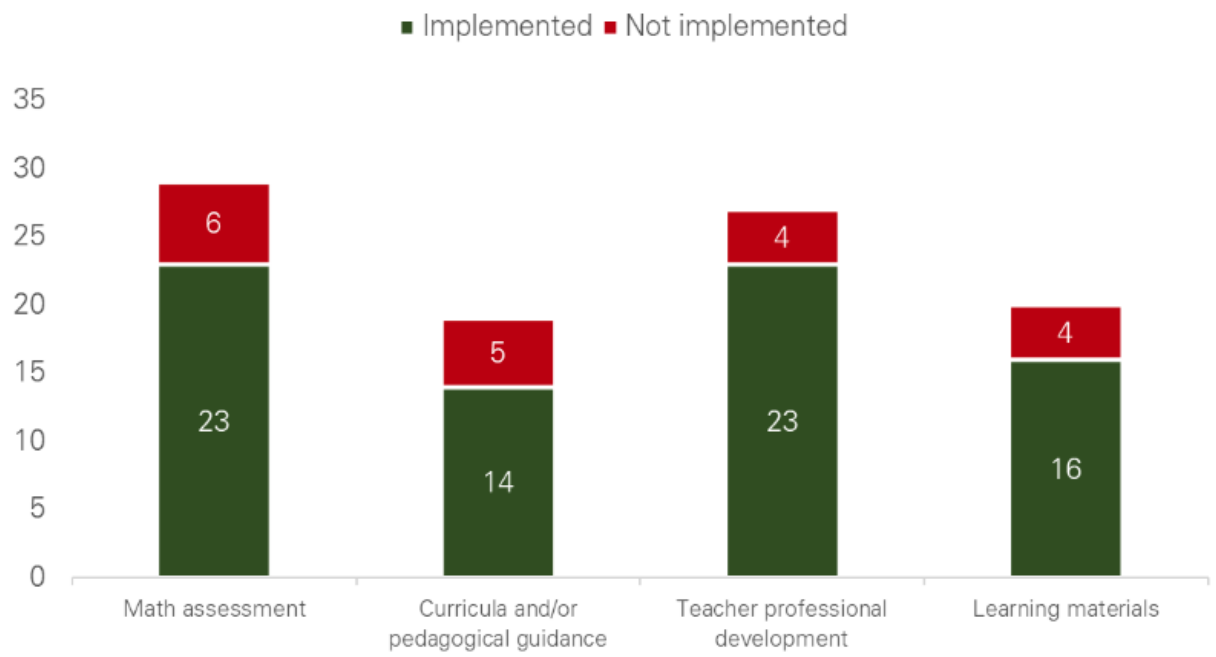
Implementation of early grade mathematics activities varies

- A subsample of projects with early grade mathematics activities were analyzed to better understand implementation progress
- 27 of the 75 early grade mathematics projects have completed the four major numeracy SCAs.
- Two-thirds of projects had successfully completed all planned early grade mathematics activities.

Implementation status for across education projects

	SCA 1b (math assessment)	SCA 2a (curricula and/or pedagogical guidance)	SCA 2b (teacher professional development)	SCA 3a (learning materials)
1. All analyzed projects (133)				
Implemented	60	42	60	31
Under implementation	32	23	22	23
Not implemented	6	5	4	4
Total	98	68	86	58
2. Early grade mathematics projects (75)				
Implemented	41	34	27	27
Under implementation	22	20	38	18
Not implemented	4	5	3	3
Total	67	59	68	48

Status of implementation of SCAs by project close

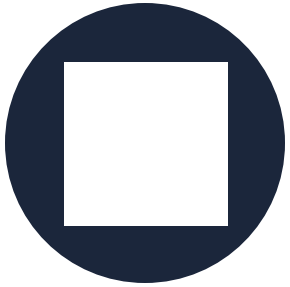


TTLs feel somewhat prepared to engage in early grade mathematics policy dialogue and project design

TTLs recognize the importance of including early grade mathematic activities

Comfort with engaging country clients on matters of numeracy varies.

TTL experience with numeracy operations is low

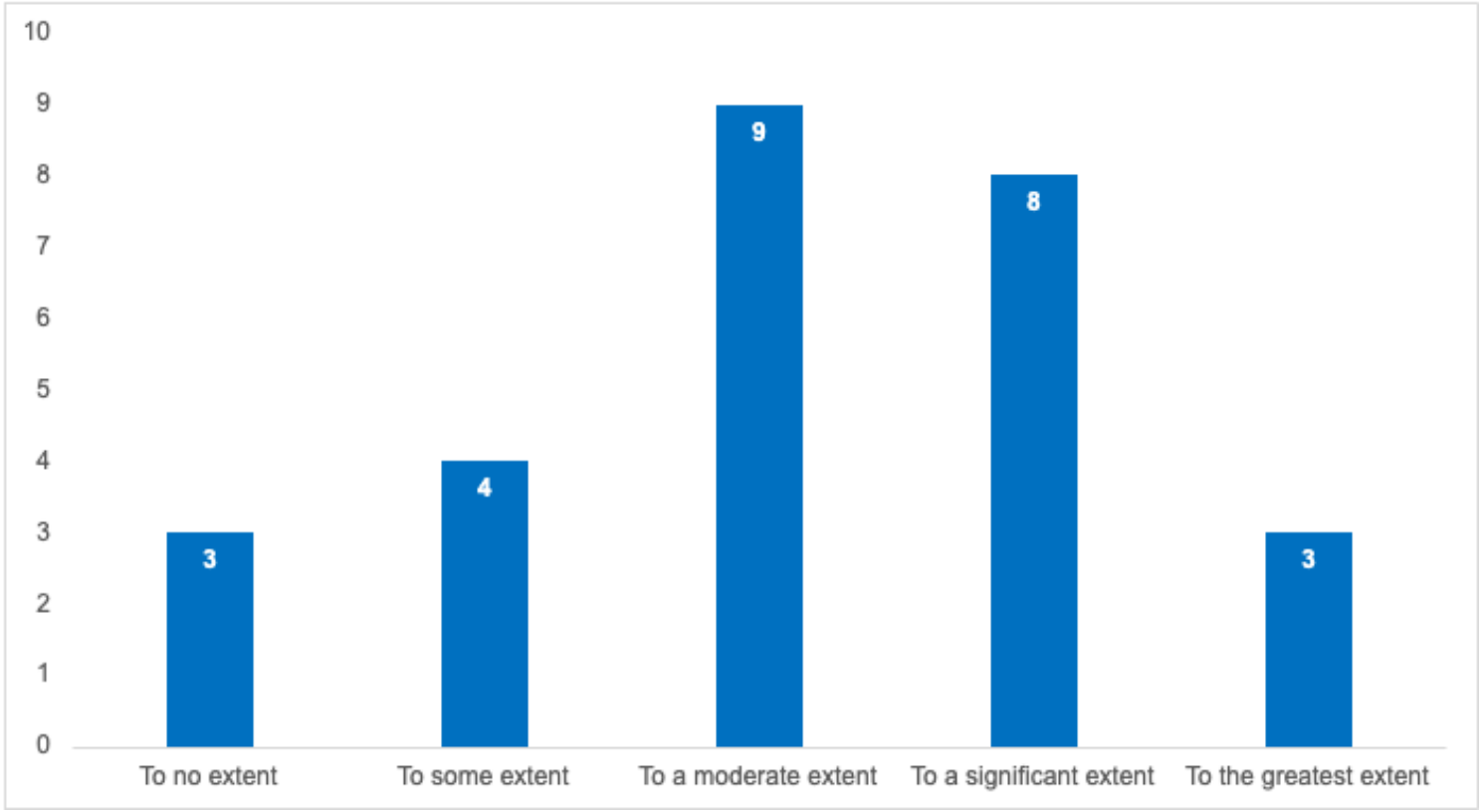


Most lack comfort with project design, linked to knowledge gaps and the lack of an organizational strategy

A growing demand for early grade mathematics support

- Client awareness of mathematics teaching and learning stands to be strengthened
- Demand for the inclusion of numeracy operations is believed to be moderate.
- Demand is, in part, driven by:
  - Greater access to learning data.
  - Linkages to performance in other subject areas and skills.

Extent TTLs have been successful in advocating for a greater focus on early grade mathematics in policy dialogue with country clients



The contexts of country clients significantly impact the World Bank's ability to advance work on early grade mathematics.

Enabling factors for the inclusion of effective numeracy-related projects

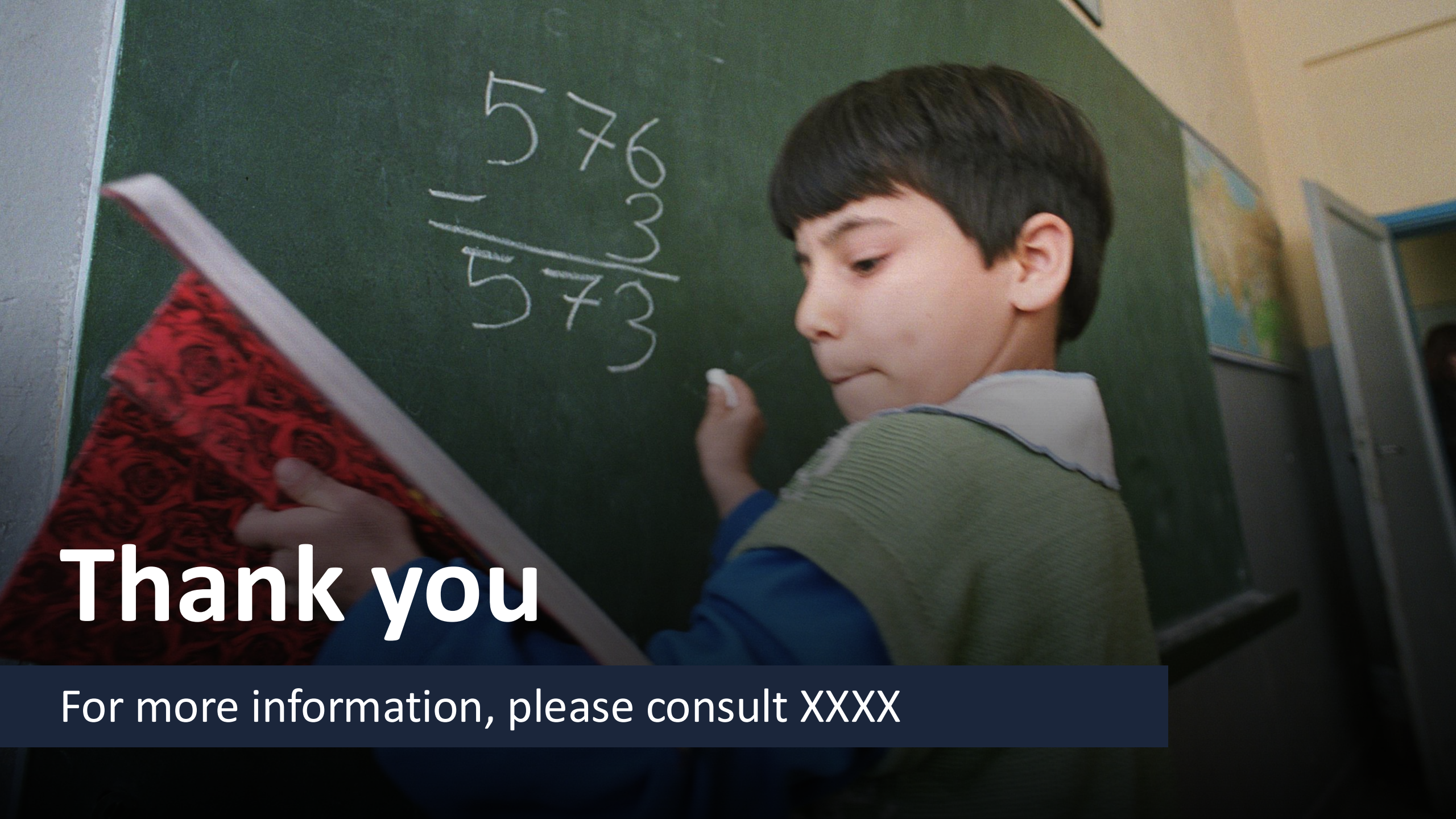
- A growing availability of learning assessment data at early grades
- Commitment to a clear foundational learning agenda, thereby recognizing the foundational learning crisis and seeing mathematics as a foundational skill for all children.
- Openness to learning from best practices and operational insights from other contexts

Prohibitive factors for the inclusion of effective numeracy-related projects

- Limited and overburdened ministerial capacity, such as minimal staff specialized in early grade mathematics
- Funding constraints, especially due to minimal evidence on low-cost interventions and client demands for 'quick wins'
- Development partners not aligned on a common numeracy agenda, pulling country client focus elsewhere

The World Bank has yet to define its unique value-add for supporting early grade mathematics

- TTLs report not knowing how to position the World Bank's comparative advantage when engaging in early grade mathematics
- The lack of an organizational approach to improving numeracy outcomes limits opportunities for engagement.
- A particularly challenging issue for countries in which more numeracy-oriented development partners are present.



Thank you

For more information, please consult XXXX