NUMERACY AT SCALE FINDINGS BRIEF

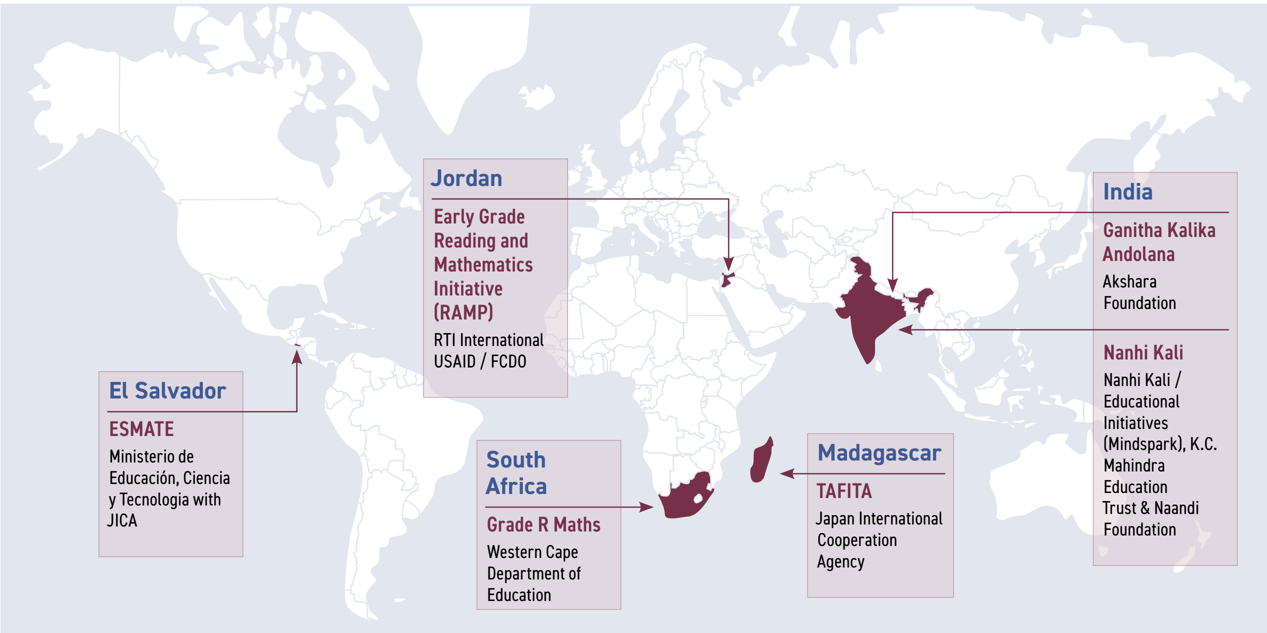
ESMATE Program in El Salvador

Introduction to Numeracy at Scale

The Learning at Scale study was designed to explore programs that have a demonstrated impact on foundational learning outcomes at scale. The goal of this research is to identify and examine successful aspects of these programs to provide policy makers and development practitioners with evidence-based strategies for improving instruction and learning outcomes across contexts. The research is being led by RTI International and is part of the Center for Global Development education research consortium, funded by the Bill and Melinda Gates Foundation.

While the first phase of Learning at Scale focused on literacy, the second phase, Numeracy at Scale, is focused on (1) identifying instructional strategies that are essential for improving numeracy outcomes at scale in low- and middle-income countries; and (2) learning about the characteristics of the education systems within which successful scaled-up numeracy programs operate. To this end, the study team identified and analyzed six programs across five countries that had rigorous evidence of impact on numeracy learning outcomes and which were operating at scale or which showed the potential for scale in an entire region or country (see Figure 1).

Figure 1. Numeracy at Scale partners



The six Numeracy at Scale programs represent a variety of designs, from providing instruction to at-risk girls via interactive software to a national-scale numeracy initiative integrated into all public primary schools. Despite their differences, these programs share a large number of common elements (see Figure 2).

Figure 2. Common elements across successful large-scale numeracy programs

Instructional Practice

- Targeted / differentiated instruction
- Procedural and conceptual knowledge
- Student discussion of math concepts
- Continuous assessment
- Use of manipulatives
- Group / pair work
- Time for students to practice skills

Materials and Teacher Support

- Local-language materials
- Teaching aids for students
- Teacher's guide / lesson plans
- External coaches
- Teacher communities of practice

System and Structural Support

- Coaches meet in groups
- Training for head teachers
- Face-to-face teacher training
- Structured training materials
- Trainings focused on modeling and practice
- Government monitoring
- Dashboard for results/data sharing
- Monitoring data used for decision-making

Even with these common elements, these programs provide evidence of multiple pathways to success. For example:

- All programs provided teachers with training and/or other instructional supports, but the forms that teachers found most impactful for student learning varied.
- In all programs, teachers incorporated independent and group work and focused on building both procedural and conceptual understanding, but their use of materials and student discussion varied.
- Head teachers were trained and relied on the use of data for decision-making in five of the programs, but they differed across programs in how they provided (or sought) support for struggling teachers.
- Coaches or mentors were engaged across programs, but their roles, expectations, and level of support varied greatly.

The remainder of this brief provides an overview of the Numeracy at Scale research methodology generally and explores the findings from one of the programs studied—the ESMATE program in El Salvador.

Numeracy at Scale Research Methodology

The Numeracy at Scale study investigated three main research questions:

1. What classroom ingredients (such as teaching practices and classroom environment) lead to learning in programs that are effective at scale?
2. What methods of training and support lead to teachers adopting effective classroom practices?
3. What system-level support is required to deliver effective training and support to teachers and to promote effective classroom practices?

In addition, cross-cutting questions, based on previous research on mathematics teaching and learning, focused on whether and how teachers emphasized conceptual understanding, the role of representations or conceptual models, and the use of manipulatives or other hands-on activities.

In each country, the study teams carried out a mixed-methods study. See Figure [1] for an overview of the study design.

The data collection in El Salvador was unique in that data were collected from (1) one of the departments that was originally included in the pilot and (2) two departments where the program was recently scaled up. The team collected quantitative and qualitative data from both groups. Figure 4 shows the respondents from the data collection in El Salvador.

Figure 3. Numeracy at Scale study design

Quantitative:

- 80–130 schools per country
- In each school:
  - Math lessons observed
  - Interviews of teachers, head teachers, trainers, teacher meeting facilitators, and/or coaches
  - Mathematical Knowledge for Teaching survey[1]

Qualitative:

- 10 schools (subsample)
- In each school:
  - Math lessons observed for 3 days
  - Open-ended interviews of teachers
  - Cognitive interviews with students
- Semi-structured interviews with program staff and Ministry of Education officials, including those responsible for teacher training, school supervision, and curriculum and materials

Figure 4. El Salvador study respondents

Respondent		Pilot department: *San Miguel*	Scaled-up departments: *La Libertad & Santa Ana*	Total
Quantitative				
	Schools	29	60	89
	Teachers	48	108	156
	Head teachers	29	60	89
Qualitative				
	Schools	4	6	10
	Teachers	4	6	10
	Students	19	29	48
	District/local officials	N/A	2	N/A
	Region/central officials	N/A	3	N/A
	Program/partner staff	N/A	1	N/A

1 The Mathematics Knowledge for Teaching survey is a short survey (23 items) that measures primary-grade teachers' knowledge of mathematical concepts and their pedagogical content knowledge. For more information, see Wendi Ralaingita, Aizada Mamytova, and Yasmin Sitabkhan, "Capturing Teachers' Mathematical Knowledge for Teaching" (2023), https://shared.rti.org/content/mathematical-knowledge-teaching-survey-cies-2023-presentation.

ESMATE Program Overview

The ESMATE program is being implemented by El Salvador's Ministry of Education. The program supports mathematics teaching and learning in grades 1–11 for all schools in the country, with technical support provided by the Japan International Cooperation Agency (JICA). ESMATE's theory of change is centered around three elements: (1) the provision of high-quality textbooks for every student, provided every year; (2) active time on task, with students working with students working independently both in the classroom and at home; and (3) teacher support for student learning, including including teachers meeting with other teachers, one annual planning day, three annual teacher reflection days, and pedagogical support from school directors.

The first phase of ESMATE consisted of a randomized controlled trial conducted in 2018–2019 in 125 public schools in four departments (Cabañas, La Union, San Miguel, and San Vicente). After successful pilot results, ESMATE was scaled up to all of the country's public schools—namely, 4,666 primary schools, 2,726 junior high schools, and 705 senior high schools—beginning in 2019.

This study looked primarily at the instructional portion of ESMATE—that is, the classroom practices that make the program successful. Key design elements of this program, according to a document review and interviews, are shown in Figure 5.

Figure 5. ESMATE's problem-solving approach: Core elements

Structured materials

▶ All lessons promote student engagement and mathematical thinking using a consistent structure:

- **Analiza (Analyze)**: Problems for students to solve independently
- **Soluciona (Solution)**: The solution to the problem(s) presented in Analiza
- **Comprende (Understand)**: Explanation and model of the key concept of the lesson
- **Resuelve (Solve)**: Problems to solve in class
- **Resuelve en casa (Homework):** Problems to solve at home

Time on task

▶ Classroom materials are structured to provide ample opportunities for students to practice problems and gain an understanding of the content, both during class and at home.

Pedagogical reflection meetings

▶ Teachers meet three times a year to review the results of student assessments, review math content in upcoming units, and plan for instruction for the next trimester.

Findings from the ESMATE Program

Findings from the study's qualitative and quantitative interviews in El Salvador reflect similarly positive results as those from the ESMATE impact study. [2] Improvements cited in the interviews with head teachers include better student and teacher attendance, more active involvement of students, and improved teaching. Classroom observations revealed that teachers consistently engaged students

2 See Takao Maruyama & Takashi Kurosaki, "Developing Textbooks to Improve Math Learning in Primary Education: Empirical Evidence from El Salvador," *Economic Development and Cultural Change* (2022).

in the math lessons, and students actively solved problems in every lesson.

The following subsections discuss the findings from ESMATE in relation to the Numeracy at Scale research questions.

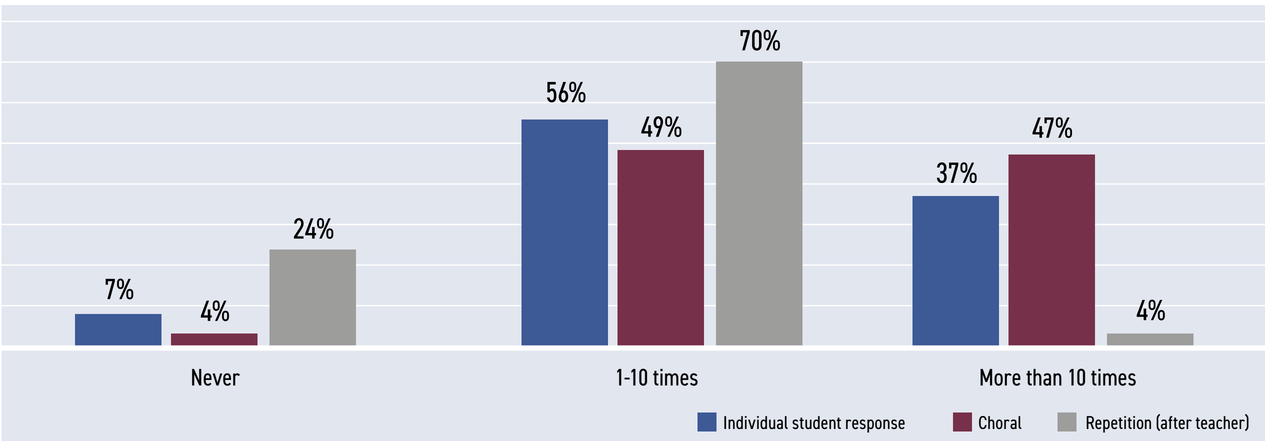
Research Question 1

What classroom ingredients (such as teaching practices and classroom environment) lead to learning in programs that are effective at scale?

To understand what instructional practices may be leading to improvements in learning outcomes, the study team analyzed both quantitative and qualitative classroom data, as well as teacher interviews, to identify common themes and to draw comparisons with the comparison schools. Qualitative data were analyzed using Dedoose, with inter-rater reliability at 90% or above. Overall, the team found that ESMATE schools demonstrated key behaviors associated with successful math instruction, such as clear presentations of developmentally appropriate and sequenced content and ample opportunities for students to practice new skills. The team also noted differences between schools in the original pilot department (San Miguel) and schools in the scaled-up departments (Santa Ana and La Libertad), as discussed below.

THEME 1 **Student engagement and opportunities to practice.** Across all observations, teachers engaged students in the content and used a variety of strategies to ensure the participation of all students, as seen in Figure 6. Teachers solicited answers from different students as a way of ensuring that students were paying attention and engaged in the lesson, asking individual students at least one question in almost all observations (93%). Teachers also relied on choral responses to keep children engaged with the content, with 47% of observed lessons including choral responses more than ten times in a lesson. Repetition, which is not a strategy that encourages student thinking, was present but occurred with less frequency in lessons than the other types of engagement (e.g., only 4% of lessons included more than ten instances of repetition).

Figure 6. Types of student engagement (% of observed lessons)



In the qualitative observations, there were 12 instances (from five classrooms) where teachers asked questions aimed at encouraging students' explanation and justification, a higher-order skill that ESMATE has built into its lesson plans (see Figure 7).

An average of 19 minutes per lesson was dedicated to independent work time, out of an average lesson time of 45 minutes. This provided ample opportunities for students to practice new math content. Teachers frequently monitored learning by observing students during independent work time (in 96% of observations). When teachers stopped to work with individual students, the majority of that time (94%) was spent on helping students with the math content.

Quantitative observations showed that there were at least a few incorrect student responses in a majority of lessons. When this happened, teachers responded in different ways, depending on whether they were part of the original pilot group or the recently scaled-up groups, as seen in Figure 8. Teachers in the pilot were more likely to discuss why the answer was correct, ask students to solve a problem again, and help students solve the problem. In the scaled-up schools, teachers tended to either ask another student to answer or to provide the correct response themselves. It could be that teachers who were part of the pilot were provided more support on what to do in these situations or that they are more familiar with the materials and thus better able to anticipate student responses.

Figure 7. Teacher support of student explanation and justification

During the whole-class part of the lesson, the teacher and students were solving the problem 48 + 75 in column form:

C	D	U
	4	8
+	7	5

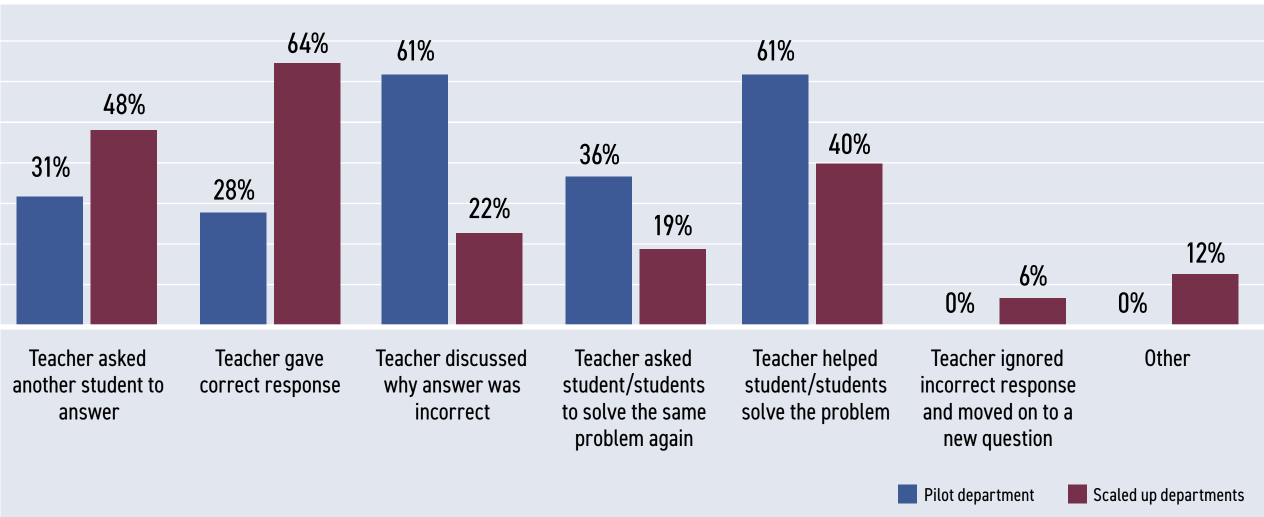
The teacher asked the students to use their counters to add 8 + 5, as seen in the photo.

She then asked a student:

Why did you put the 3 below and the 1 on top when you got the answer 13?

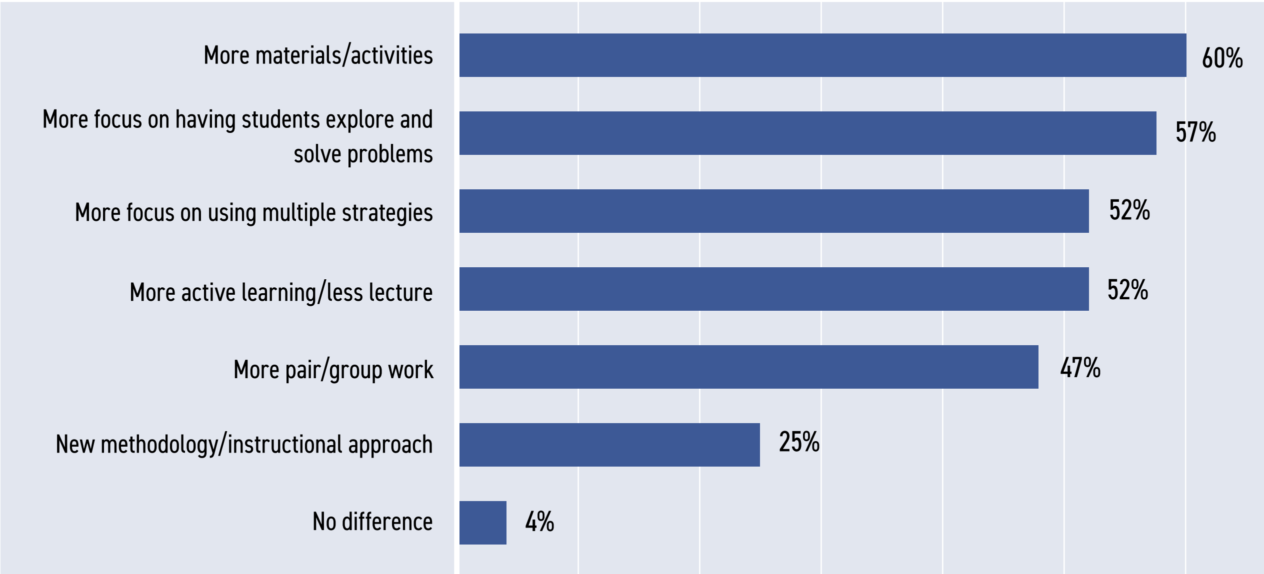
The open-ended "why" question probed students' understanding of place value and operations.

Figure 8. How did the teacher respond to the incorrect answer or no response?



When asked "How has your instruction changed since you started working with ESMATE?," teachers often cited more active learning, more pair or group work, and more focus on having students explore and solve problems (Figure 9).

Figure 9. How has your instruction changed since you started working with ESMATE?



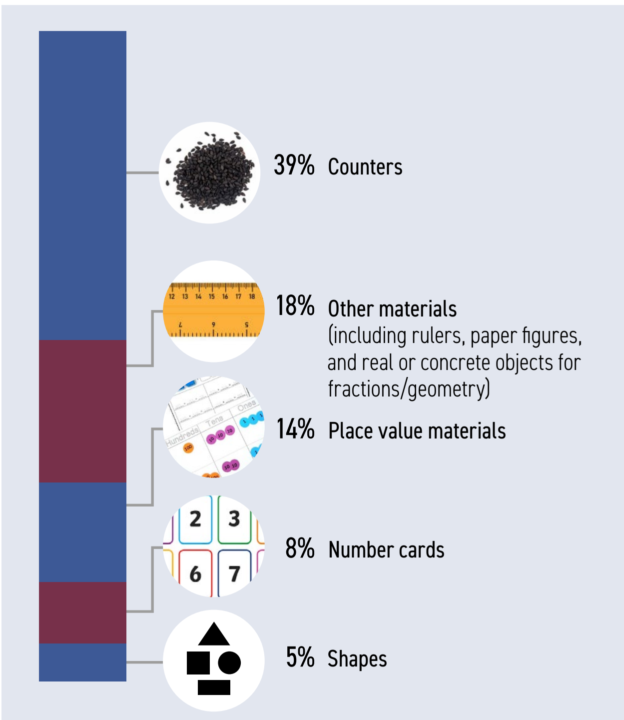
"How to ensure that learning is active in the student, that the student is involved in what he is doing. And for that, it is not only a matter of encouraging him, but that the methodology is oriented so that he is the main actor"–Ministry of Education Official, El Salvador

THEME 2 Use of multiple representations and models to support conceptual understanding.

Guided by the ESMATE materials, teachers used different models in their instruction and encouraged students to use additional manipulatives to support learning. During whole-class instruction, teachers used some kind of manipulative to model a concept in 64% of lessons. Figure 10 presents the frequency of different manipulatives used during instruction.

During independent work, students were observed using manipulatives in 57% of lessons. When employing materials for independent work, the majority of classrooms (72%) saw all students using the materials. Interestingly, in the pilot region (San Miguel), 100% of all observations with manipulatives used during independent work included all students (1:1 ratio in all instances). In scaled-up regions (Santa Ana and La Libertad), only 59% of instances of manipulative use involved all students. The rest of the time, manipulatives

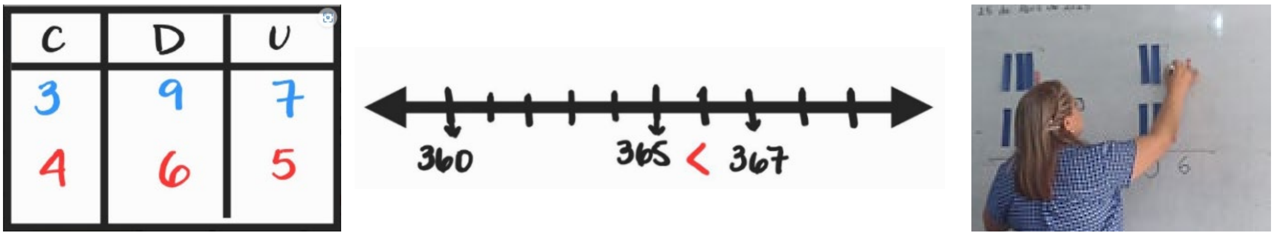
Figure 10. What materials, if any, were used during the teacher model or discussion?



were used by only a subset of learners or by the teacher. This difference could be due to the extra time that pilot teachers had to become familiar with and gather the materials, or training/support they received on how to gather materials.

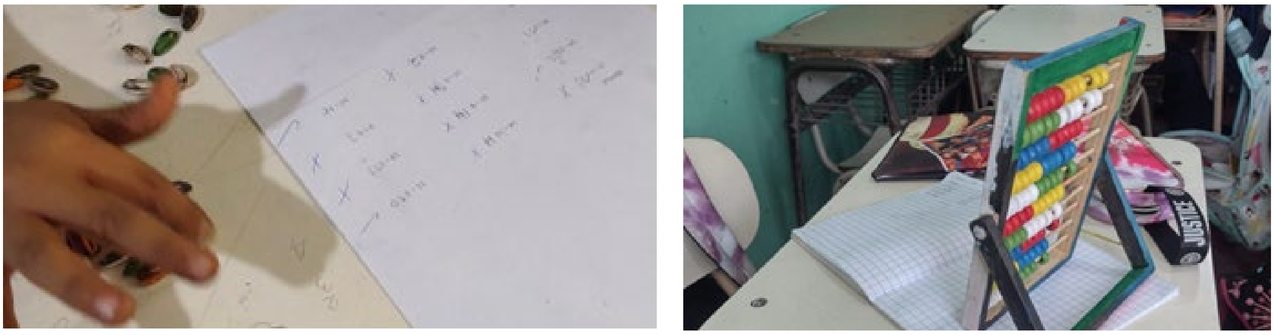
In qualitative observations, a majority of teachers (seven out of nine) used multiple models to explain complex topics. For example, for double-digit addition, teachers used the tabla de valores (place value chart), drawings on the board, number lines, and cutouts that represented place value to scaffold the content, as seen in Figure 11.

Figure 11. Different representations used in ESMATE lessons



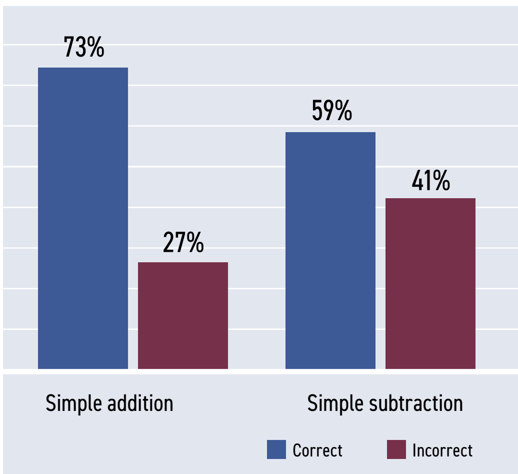
When students appeared to struggle, teachers reminded students to draw on additional manipulatives and representations that were not provided in the books, such as fingers, seeds, lines drawn on paper, and abacuses. Some students independently drew on these manipulatives, as seen in Figure 12.

Figure 12. Students using seeds and an abacus to solve problems



Data from cognitive interviews with students, in which students were provided with grade-level problems, asked to solve the problems, and then asked to give explanations for their answers, provided confirmation that students are able to use manipulatives and other representations to solve problems. Figure 13 shows students' strategy use (via their explanation for solving the problem) by correct answers for two problems involving simple operations. Students who used representations for the addition problem (13 + 6) and subtraction problem (16 – 4) solved the problems correctly a majority of the time (73% and 59%, respectively), showing that students who drew upon counters or drawings to solve the problems were more likely to be correct.

Figure 13. Students' use of manipulatives and representations (e.g., counters, drawings, and fingers)



THEME 3 **Using the curriculum to enhance instruction.** In qualitative and quantitative observations, teachers used the curriculum to create connections to real life that were aligned with the concept being taught and to create their own problems to supplement the lessons. Often, these connections and problems were not included in the textbook.

In 42% of the quantitative observations, teachers connected the content to an example from real life. Similarly, in the qualitative observations, there were 19 instances of a real-life connection in seven out of nine classrooms. Some of these examples were word problems taken directly from the curriculum, while others were instances in which the teacher supplemented problems by adding a brief real-world example to heighten students' understanding. This connection to real life helped students connect an abstract rule (e.g., you can't subtract a larger number from a smaller number) to a real situation in order to give it meaning.

Qualitative observations revealed that teachers frequently created their own problems to supplement the lessons. These problems were aligned to the lesson to enhance content and provide extra practice for students. Sometimes the problems were given on the board and copied into exercise books; other times teachers provided worksheets or created games for the students. For example, quantitative observations showed that 86% of lessons involved students solving problems from the board or textbook, which were problems provided by the ESMATE program. 23% of all lessons involved other activities that included extra practice not provided by the ESMATE program, such as the activity seen in Figure 14.

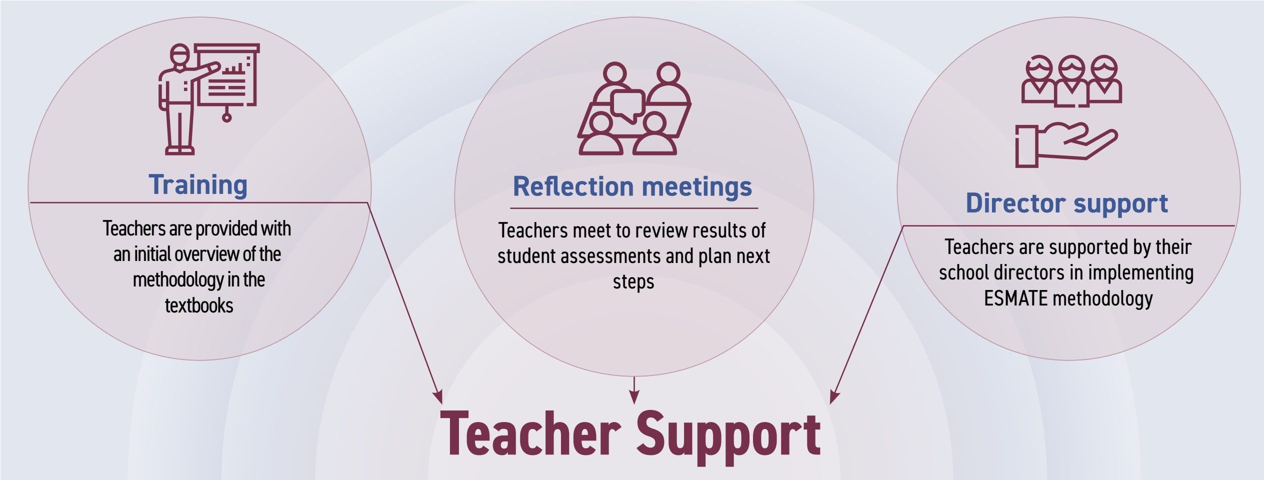
Figure 14. Students playing a number comparison game

Research Question 2

What methods of training and support lead to teachers adopting effective classroom practices?

The ESMATE program model for supporting teachers includes structured materials, initial training, and teacher reflection meetings (see Figure 15).

Figure 15. ESMATE teacher support model

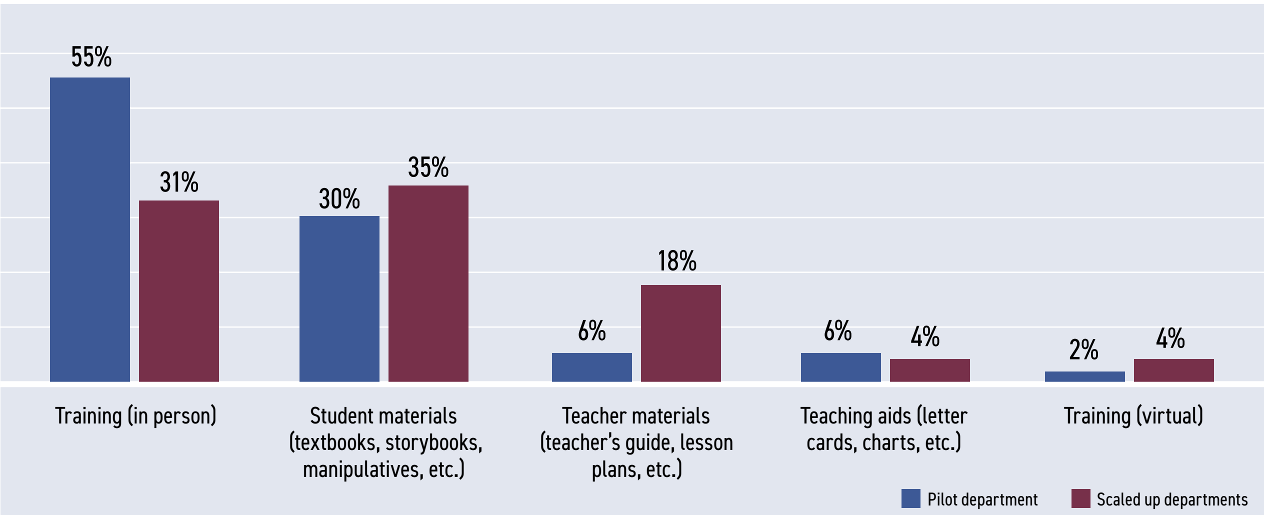


Data from interviews with teachers, head teachers, and other ministry officials reveal how this teacher training and support model has led to successful implementation of the ESMATE program.

THEME 1 **Teacher's guide and student textbooks provide explicit guidance for teachers.** The main supportive elements for teachers' instruction are the teacher's guide and textbooks. The guide provides detailed guidance on the problem-solving approach embedded in each lesson. The student textbooks mirror this approach, creating a consistent approach across lessons and topics that is easily recognized by students. The guide also includes details on how to model and teach core concepts.

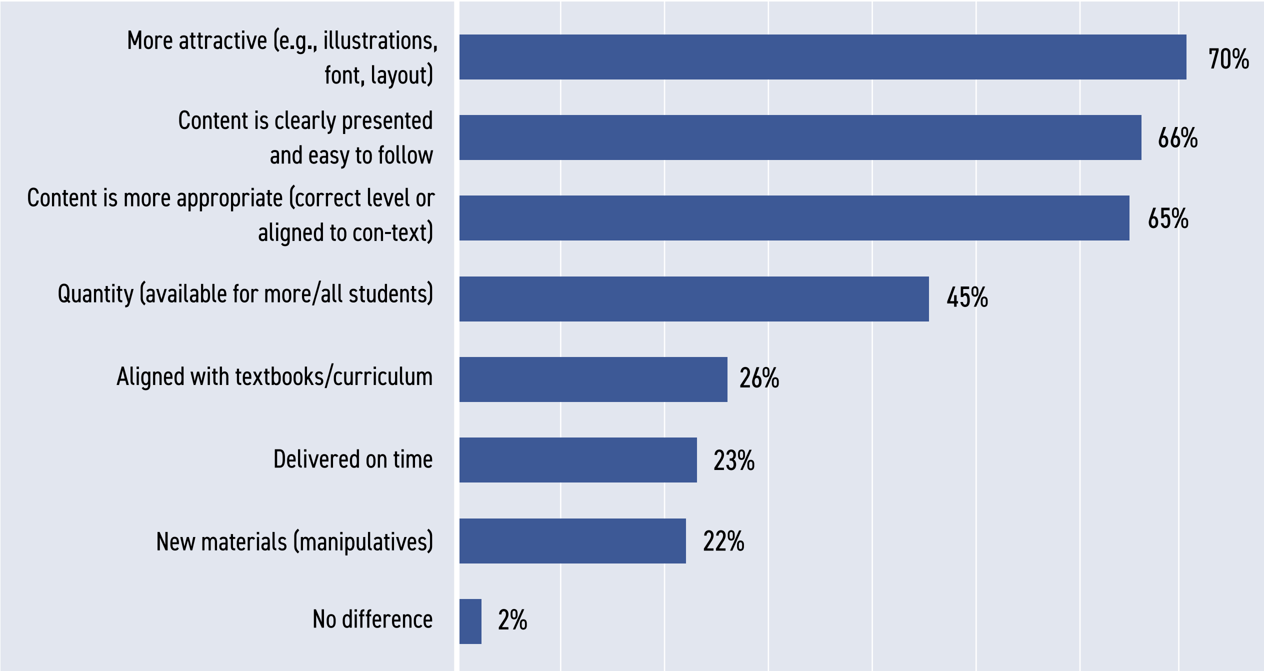
When asked to identify which supports they find most useful, nearly one-half (47%) of teachers interviewed cited the student or teacher materials. Teachers in schools where the program was later scaled up (Santa Ana and La Libertad) cited teacher and student materials as most helpful more frequently, while more teachers in the pilot schools saw training as most helpful—likely because the trainings were more intensive and deliberate under the initial pilot.

Figure 16. Grade 2 & 3 teachers: Which one of these supports do you feel is the most useful?



When asked to identify which teaching materials they find most useful, 77% of all teachers cited either the teacher's guide, the tablet, or the teacher's version of the textbook. When asked about student materials, 74% of teachers said that student textbooks are the most useful to them. As Figure 17 shows, teachers most frequently noted that the ESMATE student materials are more attractive, better aligned to the curriculum (i.e., appropriate), and more clearly presented than materials they have received in the past.

Figure 17. Grade 2 & 3 teachers: How do these student materials differ from what you were using before ESMATE?

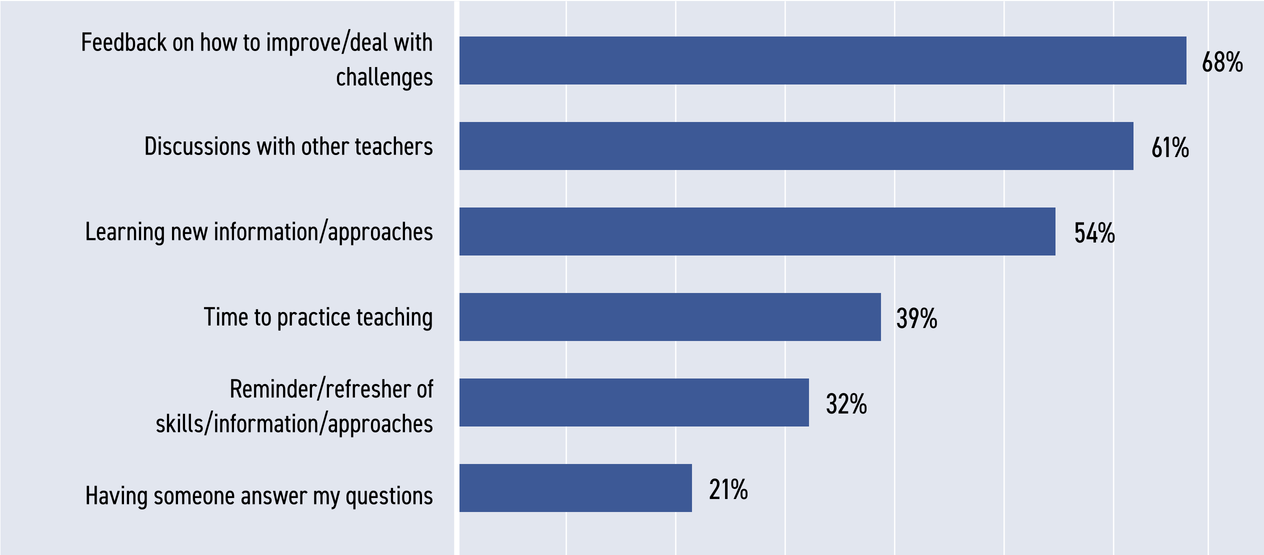


THEME 2 **Ongoing support emphasizes content and instruction.** Teachers reported receiving support from the ESMATE program through various mechanisms, including in-person and virtual trainings, teacher reflection meetings, and visits from the department coach (gestor pedagógico) and the school director. Regardless of these varied mechanisms for teacher support, they share a common element: all support is focused on content and instruction.

For teacher reflection meetings, teachers reported that meeting time is spent on topics relevant to the delivery of math instruction, including how to teach lessons, current challenges they are facing, areas in which to improve, and lesson planning. Very little time is spent on administrative topics.

Figure 18 shows teachers' answers regarding what they feel is useful from the teacher reflection meetings. Teachers cited several elements as being useful, with many teachers choosing feedback on how to deal with challenges (68%) and discussions with other teachers (61%). Learning new information and approaches was chosen by 54% of teachers. In the pilot department (San Miguel), only 40% of teachers included this response, whereas in the scaled-up regions 69% of teachers included this item, reflecting teachers' greater familiarity with the ESMATE approach in the pilot region.

Figure 18. What do you find useful from the teacher meetings?



For trainings, 57% of teachers found lesson planning using the ESMATE guide as the most useful element of training. In addition, teachers reported receiving support on other elements related to instruction including strategies for mathematics instruction, remediation, and conducting student assessments.

Research Question 3

What system support is required to deliver effective training and support to teachers and to promote effective classroom practices?

Coupled with the quantitative data, qualitative interviews with program staff and government officials allowed the study team to develop a portrait of essential systems support elements that have helped promote effective teaching and learning under ESMATE.

THEME 1 **High-level political will, supported by evidence.** In 2015, the Ministry of Education in El Salvador determined that its current math materials were not achieving the desired outcomes and made the decision to develop something new. Having worked successfully with JICA in the past, the ministry reached out to JICA for support in developing and piloting new materials.

In addition to helping the ministry develop and test such materials, JICA also supported ESMATE to provide intensive training and support to all teachers in pilot schools. While it was political will that catalyzed the ESMATE pilot, it was evidence of the pilot's effectiveness that informed the decision to take ESMATE to a national scale.

THEME 2 **Strategic investment in high-impact supports.** Under ESMATE, the Ministry of Education has prioritized printing new textbooks annually, ensuring that every child gets a new book at the start of each school year. According to the country's education policy, each child receives a paquete escolar—an allowance for school supplies—each year. To cover the cost of these books, the ministry withholds one to two dollars from each paquete to pay for printing (which is done en masse to ensure cost efficiency).

Because the textbooks are comprehensive and easy to follow, teachers are expected to be able to use them on their own to guide instruction, with few additional supports. This justification was used to rationalize other adaptations to the pilot design, which were necessary for ESMATE to achieve national reach. These adaptations included replacing centralized, intensive trainings dedicated to ESMATE with more generalized trainings and meetings held at the departmental level. For example, mandatory teacher reflection meetings are held in every department but cover multiple subjects and curricula.

THEME 3 **Communicating a spirit of progress from the central office, through all levels of the system.** Throughout the study team's interviews with officials at different levels of the education system, there was a palpable sense of pride in what ESMATE has achieved. In addition, there was a significant amount of direct communication noted between actors at different levels of the system.

During the pilot, The Ministry of Education hired a cadre of math specialists and trained them in pedagogy and teacher professional development. Despite their initial lack of experience supporting teachers, this group brought energy to their work and found ways to improve efficiency. For example, the team identified that one bottleneck in the production of materials was having to jump between the Microsoft Word version of materials that they were using and the Microsoft InDesign version that the graphics team used to design the textbooks. To resolve this, the team trained themselves to use InDesign so that they could make changes directly to the design documents. Because their roles and time were dedicated to ESMATE, they had the space and agency to make these kinds of improvements.

Today, the ESMATE team still sits at the Ministry of Education's central office, overseeing the national scaling of the program. Each team member visits at least one school every 2 months to observe and provide support to department-level coaches. Additionally, there is an email address that teachers can use to ask questions about ESMATE—these emails go directly to the central team for a response.

"So, during the pedagogical reflections [ESMATE] was emphasized, as well as during the visits to the schools. So…this process is injected from the very local actors, so that they appropriate it. And in this way, once they already feel or have been convinced of the process, that there is some evidence of improvement in children's learning, then they begin to do the same" – ESMATE Official

Future Considerations

As discussed above, the analysis undertaken by the study team includes evidence that echoes the positive findings of ESMATE's earlier impact study and identifies some of the key ingredients that appear to be contributing to that success. As the government of El Salvador seeks to learn from and expand the program's impact, there are some key areas for consideration to further strengthen ESMATE's success in improving learning outcomes.

Scaling Up

Interviews and observations showed that teachers are adopting high-impact, effective strategies such as using multiple representations, presenting clear models of mathematical content, and encouraging mathematical discussion. In some of these areas, there are differences between the original pilot schools and the scaled-up departments. For example, manipulatives are more often seen in the hands of students in San Miguel than in the other departments. Teachers in the pilot schools also tend to support students in arriving at correct answers and discussing incorrect answers instead of simply providing the answer. This difference perhaps suggests that the intensive support that teachers received during the pilot leads to more sustained, high-quality implementation of the program and that all teachers need an initial period of intensive support. Alternatively, it could be that teachers in San Miguel have had more time to implement the program and therefore show behavior more aligned with ESMATE's goals. Teachers in the newer scaled-up departments might need more time to become familiar with the materials. More research is needed to better understand this difference between the two groups and how to continue to support teachers in the scaled-up departments.

Teacher and Student Knowledge

While teachers are demonstrating a variety of effective teaching strategies, their grasp of mathematical pedagogical knowledge is still in a nascent stage, particularly as it relates to developmental progressions in the learning of mathematical concepts. Future efforts by the ESMATE program could consider including the targeted development of teacher knowledge, based on demonstrated weaknesses, through trainings or educative curricula (e.g., textbooks and teacher's guides that build teacher knowledge while providing instructional content).

Cognitive interviews with students revealed that students are able to solve simple problems using concrete strategies. However, they tend to struggle with problems that require new, more abstract strategies. For example, students are successful in solving addition and subtraction problems within 20 using drawings and concrete objects. However, when presented with operations problems within 100, many attempt to use these same strategies but are ineffective at arriving at the correct answer. Qualitative observations also revealed that teachers tend to emphasize concrete strategies (e.g., when solving the problem 23 + 56, encouraging students to use counters to solve 3 + 6). The ESMATE program materials, which cover more abstract strategies, may need to better support teachers in understanding when to move children from concrete to abstract strategies so they can better develop higher-level skills.

Interestingly, a somewhat infrequent but insightful pattern emerged from the cognitive interviews with students, whereby students used personal reasoning to explain their solution to a problem (see

Figure 16). While not widespread, this practice may stem in part from the connections to real life that teachers are often making in class. The reasoning displayed by students was not mathematically correct and shows that teachers may need to be more explicit about the mathematical content of word problems and place less emphasis on the context of the problem.

Figure 16. Students' use of personal reasoning to answer math problems

Problem	Students' Response
Felix has 12 candies. Sandra has 18 candies. How many more candies does Sandra have than Felix?	**(Student ID 23)** Sandra should not have any more candies.
Francisco's mother has 15 mangoes. She wants to share them equally among her 5 children. How many mangoes does each child get?	**(Student ID 5)** Only 1 each. She [the mother] can't give them because they will get sick. **(Student ID 36)** 2 each. They should save the rest for later.

Balancing Dedicated and Shared System Resources

The passionate, driven core ESMATE team, sitting in the Ministry of Education, has served as a catalyst for this program, fostering a sense of pride and commitment throughout the education system. Because their roles are dedicated entirely to ESMATE, members of this team have the bandwidth and agency to adapt and improve certain elements. Multiple actors also expressed a great deal of pride in ensuring that each student receives a new math textbook each year. These are the two areas—a dedicated team and new annual textbooks—where the ministry has invested significant resources. To balance this investment, other elements of the program, such as teacher professional development and support, have been incorporated into preexisting trainings and meetings conducted at the department level, diluting the intensity of the intervention as compared to its pilot phase. Understanding the decisions and conversations that drove this balancing of resources is important as other countries attempt to scale their own foundational literacy and numeracy interventions.

Authored by: Yasmin Sitabkhan, Rachel Jordan, and Jessica Mejia

AUGUST 2023