

# TAILORING INSTRUCTION TO IMPROVE SKILLS IN PRESCHOOLS: EXPERIMENTAL EVIDENCE FROM PERU

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## Abstract

Changing pedagogy is a promising avenue for improving education in developing countries, especially when done without changing current inputs, such as teachers and instruction time. Previous research suggests that tailoring instruction to each student needs can produce significant learning gains. In this paper, we present the results of a randomized evaluation of a program that uses an individualized approach to tailor instruction to each student to teach Mathematics to preschoolers in Peru. Our results show an improvement of overall Mathematics outcomes, which persist even one year after the program ended for some areas. We find no evidence of differential effects by gender, language-spoken at home, and proxies for socioeconomic status, in contrast with results from previous research that suggest Mathematics programs are biased along gender and socioeconomic lines but we do find persistent stronger impacts on students whose teachers have university degrees.

**Keywords:** Education, Pedagogical Innovations, Tailored Instruction, Mathematics, Early Childhood Development.

**JEL Classification:** I21, I28, O15.

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## 1. Introduction

There is wide agreement on the importance of improving skills for subsequent economic and social performance, especially among poor children. However, it is less clear which specific pedagogical approaches and techniques can improve learning for students in different educational levels. This is especially relevant for preschool programs because of both the relevance of early childhood development and pre-school education for subsequent development of cognitive and non-cognitive (Cunha and Heckman, 2007) and because of the wide heterogeneity in terms of effectiveness of different preschool programs (e.g., Duncan and Magnuson, 2013; Dillon et al. 2017). A promising avenue is related to the development of cost-effective pedagogical innovations that change the way teachers teach holding expenditure, staffing, and instructional time constant (e.g., Kremer et al., 2013; Jackson and Makarin, 2017; Muralidharan, 2017). This paper explores the effects of one such intervention, the Mimate program, which provides tools to *regular* pre-school teachers to use a scaffolding approach to teach Math using normal school hours.<sup>2</sup> The program includes teacher training and support, tools to organize the classroom and the lessons, and additional educational materials.<sup>3</sup> The annual cost per student of scaling up the program is \$37, which represents about 2.5% of the public expenditure per pre-school student in the areas in which the program was implemented (ESCALE, MINEDU).

The conceptual motivation for this intervention is related to finding efficient ways of solving the problem of the organization of teaching in a context in which there are heterogeneous students, multitasking, economies of scale, and several binding constraints (Lazear, 2001; Barrow et al., 2009; Jackson and Makarin, 2017, Muralidharan, 2017). In the scaffolding approach activities are tailored to the individual child's ability level, so they are neither too hard nor too easy. This approach keeps the child in the "zone of proximal development", which is the level of difficulty at which the child can learn the most (Heckman and Mosso, 2014). This is closely related to recent research on the effects of the "teaching at the right

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<sup>2</sup> Scaffolding is an adaptive interactive strategy that recognizes the current capacities of children (trainees) and guides them to further learning without creating frustration. Several papers document that some of the most promising recent models of parent-child, teacher-child, and parent-teacher-child relationships involve attachment and scaffolding as major determinants of child learning (Heckman and Mosso, 2014).

<sup>3</sup> Mathematical thinking is cognitive foundational (Clements and Sarama, 2009, 2011). In fact, several papers document that poor mathematics performance throughout primary school can be traced to weaknesses in pre-primary number competencies (Gersten et al, 2005; Malofeeva et al. 2004; National Mathematics Advisory Panel, 2008). Moreover, several studies document that mathematics skills acquired in kindergarten predict academic performance in primary education better than early reading skills, verbal and spatial cognition, or even measures of attention span, memory, and social skills (Duncan et al., 2007, Romano et al., 2010, Jordan and Locuniak, 2009, Pianta et al., 2008a, Aunola et al., 2006). Still other studies find impacts of early mathematics learning on adult life outcomes (Geary et al., 2013).

level” approach, which also seeks to focus the instruction on each student needs (Banerjee et al., 2016, 2017).

The program seeks to change the traditional vertical teaching model of memorization and repetition into a horizontal, student-centered model in which students progress at their own rate.<sup>5</sup> The program includes sessions in which the teacher splits up the children into small groups or pairs for activities. The lesson plan proceeds with mathematics challenges, gradually progressing from very basic to advanced, in which each task prepares the student to tackle the next one. Mimate emphasizes the development of competencies in two main areas: numerical literacy and understanding shapes. Each student also receives a personal box with hands-on teaching materials to encourage exploration of mathematical ideas, shapes, measurements, numbers, and patterns. All items are suggested to be kept in the “Mimate corner” of the classroom so that children can play with these toys and tools at free hours during the day. The program also includes twice-a-month formative assessments with a simple 5-minute round of flash cards between the teacher and individual students. Based on the students’ answers, the teacher then knows which skills the students need to practice and can direct them to an appropriate activity. In addition, there is an initial training period for the teachers before the program starts, and in-class visits from teacher assistants during the school year to ensure the quality of teacher-student interactions.

We evaluate the impact of this program using a randomized controlled trial (RCT) implemented in schools located in and around three cities of Peru: Huancavelica, Angaraes, and Ayacucho. We implemented a stratified randomization with 54 treatment schools and 53 controls schools, stratifying by cities and urban/rural area. The baseline information we collected suggest that the randomization was successful, as most variables were balanced across treatment and control groups.

We find that, at the end of the program, the intervention increased mathematics outcomes for children that attended the treated schools by 0.10 standard deviations ( $\sigma$  hereafter) for items related to numeracy and by 0.12 $\sigma$  for items related to understanding shapes. In addition, when one looks at specific items, we find that the impacts are bigger for geometric shapes (impact of 0.20 $\sigma$ ), number selection (0.18 $\sigma$ ), additive composition (0.15 $\sigma$ ), shape recognition (0.14 $\sigma$ ), spatial ability (0.13 $\sigma$ ), and oral counting (impact of

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<sup>5</sup> Algan et al. (2013) document the presence and consequences for social capital of teaching practices that emphasize vertical teaching methods in contrast with group work and a more horizontal teaching practice in several countries of the world.

0.11 $\sigma$ ). The effects in these dimensions are statistically significant even when correcting the p-values for multiple hypotheses testing.<sup>7</sup>

We also study the potential existence of heterogeneous effects along several dimensions related to characteristics of the students and the schools. First, using quantile regressions, we find that the impact of the program is stronger for children in the lower quantiles of the learning distribution. This contrasts with previous evidence that finds stronger effects for students with good mathematics performance (Clements and Sarama, 2011; Duncan and Magnuson, 2013). This result suggests that the inquiry-based scaffolding approach may work better for students with lower abilities, who receive more attention than when taught using more traditional pedagogical approaches. Second, we study interaction effects considering several observable characteristics of the students and the schools, such as: the student's gender, language and socioeconomic status, location of the school, class size, and teacher education. We do not find that the treatment has statistically and persistent heterogeneous effects on these dimensions except for teacher education: our results indicate that when the teacher who implemented the program has a university degree, the average effect of the program increases to about 0.15 $\sigma$  (and the effect of the program for teachers without a university degree is not different from 0). This suggests that there is a complementarity between the teacher's human capital and the program, which probably indicates that pedagogical innovations like Mimate demand a certain minimum level of teacher human capital to successfully work.

Next, we study the medium-term treatment effects, using information on the same outcomes for the same students one year *after the program ended*. Our results imply that the effects decrease in magnitude after one year. The treatment effects for the overall mathematics test and for the numeracy section are not different from 0, and treatment effects for the understanding shapes section are equal to 0.06 $\sigma$ . These results resemble most of the findings from the literature on preschool interventions: significant, short-term effects on learning skills that decrease after the programs end (Duncan and Magnuson, 2013; Dillon et al., 2017). The only item for which we find a large and statistically significant medium-term effect is geometric shapes, with an impact of 0.16 $\sigma$  (correcting for multiple hypothesis testing). As we discuss below, the larger impacts we find in this curricular area may be a consequence of the intensity of implementation.

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<sup>7</sup> To correct p-values for multiple hypothesis testing we use the procedure developed by List et al. (2016).

In terms of medium-term heterogeneous effects, and mirroring our short-term results, we find that the only statistically significant and positive interaction effect is the one related to having a Mimate teacher with a university degree. Our quantile regressions suggest that, in the medium-term, the positive effects we estimate for understanding shapes seem to be concentrated in the students in the upper part of the learning outcomes distribution. This result may suggest that, once the program ends and students continue in first grade exposed to regular pedagogical approaches, those with higher learning outcomes are able to continue learning at a faster pace.

We study whether the program has an impact on other dimensions of the learning process and do not find evidence of indirect effects using results from the Raven test of general cognitive ability and from an early literacy test. This is an important result as, on one hand, there may be potential positive externalities of a program like Mimate if the new abilities that the students acquire also affect child development and learning in other areas, but there may also be negative effects if the effort to improve mathematics outcomes displaces resources (such as time, teacher effort or even student interest) from other activities and learning dimensions. We do not find that these effects are important in this context.

To facilitate the interpretation of the results, we also collected information on the program's actual implementation using administrative data, class observations, and surveys applied to teachers and parents. The process evaluation suggests that, on average, 66% of the 86 planned 45-minute lessons were implemented. This partial implementation was mainly due to a national teacher strike that suspended up to three months of class time in some schools. This may explain our findings, given that sessions on number sequence, quantities, and patterns came at the end of the program and were covered less intensively, in contrast to the sessions on shapes and figures that were covered at the beginning of the school year. In fact, our process evaluation finds that while 82% of the sessions planned to cover figures were implemented (equivalent to about 30 sessions), just 57% of the sessions related to numbers were implemented (equivalent to about 25 sessions).<sup>9</sup> This may explain both our short- and medium-term results.

In addition, results from class observations and a survey applied to teachers after the program was implemented suggest that the program affected students' and teachers' classroom behavior, the teachers'

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<sup>9</sup> This is a very coarse classification between numbers-related and shapes-related sessions, as the program seems to influence both dimensions in an interlinked way. However, we want to illustrate the differences between dimensions in sessions covered by the program.

beliefs about their students, and the teachers' ability to meet the objectives and to teach mathematics (all of this with respect to the teachers in the control group). Differences in treatment effects between teachers and with and without university education can help us to understand the mechanism to explain the impacts of the program. We find that differences in favor of treated teachers related to improvements in the perceptions of student behavior and abilities are stronger for teachers with university degrees (in particular, in dimensions such as ability to learn math and other concepts). We also observe that while treated teachers with university degrees are more like to state that they have enough time to cover the materials and have a more positive approach to the teaching of math than teachers with university education in the control group, the same result does not appear for teachers without university degrees. In contrast, results about teaching support, availability of materials, and other dimensions related to the program are not different for teachers with and without university education. These results suggest that the positive impacts of the intervention operated mainly through a change in beliefs and teaching practices more than through increases in resource availability and teacher support. These results also confirm that this program probably needs a minimum level of human capital in order to produce improvements in student learning.

Although there is a considerable literature exploring the causal impacts of preschool programs (see review in Almond and Currie, 2010) and exploring the effect of pedagogical innovations (see review in Kremer et al., 2013), only few studies have conducted randomized controlled trials to study the effects of implementing pedagogical innovations among preschoolers in the developing world (He et al., 2009; Naslund-Hadley et al., 2014; Dillon et al., 2017).<sup>10</sup> Thus, this paper makes several contributions to the existing literature. First, this study represents one of the few randomized evaluations of mathematics programs and the only randomized evaluation that combines a relatively large sample of schools and students and follows up the students after the program ends to identify medium-term effects. Dillon et al. (2017) test a Mathematics preschool program based on games in small groups of children in India but two key differences with respect to our paper is that we study an intervention implemented in schools by regular teachers in regular classrooms with about 30 students per class and we focus on an intervention base on tailoring instruction at the student level.

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<sup>10</sup> We do not discuss in detail the literature on the effects of early childhood interventions in developed and developing countries that track individuals from early childhood into adulthood and show that children brought up in a more favorable early environment are healthier and taller, have higher cognitive ability and educational attainment, and earn significantly higher wages (see Paxson and Schady 2010; Stith, Gorman and Choudhury 2003; Liddell and Rae 2001; Walker, et al. 2005; Gertler, et al. 2014; Havnes and Mogstad, 2011).

Second, this paper contributes to the research on inquiry-based and individualized instruction that allows students to solve problems, develop explanations, and communicate ideas, while adapting the teaching process to the learning pace of each student. This is related to both the “teaching at the right level” (Banerjee and Duflo, 2010; Banerjee et al., 2016) and the scaffolding (Heckman and Mosso, 2014) empirical literatures.<sup>11</sup> Regarding scaffolding, while several papers have studied the impact of these types of programs in different contexts (Lynch and Kim, 2017; Kim et al., 2017), to our knowledge this study represents the first randomized evaluation of a big scale intervention using the scaffolding approach for preschoolers in instruction in developing countries.

Third, this paper contributes to the literature on light-touch interventions that analyze the impact of classroom-based interventions that try to change the pedagogical practices without affecting the current stock of teachers (He et al., 2009; Banerjee et al., 2010, 2016; Barrow et al., 2009, Muralidharan et al., 2017). The fact that the cost per student of our intervention just represents a small increase of the current regular costs (2.5%) contrasts with other successful interventions involving individualized instruction and tutoring that are much more expensive (eg., Fryer, 2014 and Dobbie and Fryer, 2013). Fourth, our result that there is a complementarity between pedagogical innovations and teacher human capital is new in the literature for developing countries. While this result contrasts with Jackson and Makarin (2017), who show that a low cost intervention produce stronger effects for less educated teachers in the US, there is a big difference in human capital level of teachers in both studies. While in our sample 44% of the teachers do not have a college degree, 44% have college degrees, and just 12% have post-graduate, in their sample 40% of the teachers have MA/PhD degrees and all the others have college degrees. Thus, the sample of less educated teachers in that paper are equivalent to more educated teachers in our sample. Fifth, we use evidence from both a process and an impact evaluation to suggest that the part of the program that was implemented as planned—that related to instruction about geometric shapes—tends to have larger effects in the short-run and some persistent effects in the medium-run. Moreover, the information collected from teacher surveys suggest that the program effects are derived from changes in pedagogy rather than from increases in resources or the mathematics topics covered in class. This is an important contribution to the literature, which typically does not present detailed information about actual program implementation (with Muralidharan et al., 2017 being a recent exception).

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<sup>11</sup> Both approaches are related in the sense that they try to implement specific ways of teaching that adapt to each student level. However, a relevant difference among them is that in the scaffolding approach the specific way of adapting to each student is more focused in the relationship and interaction between the teacher and the student.

The remainder of the paper is structured as follows. Section 2 briefly presents Peru's educational context, and a description of the Mimate program and its relationship with the literature on mathematics preschool programs. Section 3 describes the research design and the data used in the paper. Section 4 describes the implementation of the program using administrative data, class observations, and answers to a teacher survey applied after the program was implemented. Section 5 discusses the main results, including estimates of both short- and medium-term effects. In order to understand the mechanisms that may explain the impact results, Section 6 we present comparisons between treatment and control in terms of class observations and teachers opinions about teaching practices, abilities of their students, and gender-bias. Finally, Section 7 provides a summary of our findings and draws some policy implications.

## 2. Context and the Mimate Program

### *a. Education in Peru*

Access to education in Peru is high, with net school enrollment rates in primary and secondary education above 95% and 75% in 2013, respectively.<sup>12</sup> Although learning outcomes have also improved considerably in the last decade, they are still low compared to countries with similar income levels and present steep socioeconomic gradients. At 15 years of age, according to the 2015 PISA report, Peruvian students ranked 62 in mathematics, 63 in reading, and 64 in science out of the 70 countries that participated. Moreover, Peru is a country that displays one of the largest performance gaps in PISA between low-income and high-income students (Bos et al., 2016). Similarly, results from Peru's 2<sup>nd</sup> grade national census evaluation show a difference of about one standard deviation between children in the richest and poorest quintiles (Berlinski and Schady, 2015). Schady et al. (2015) document similar differences for six-year olds in urban and rural contexts of Peru. Even at five years of age, Peruvian children score on average 15 percentage points lower on the Raven test of cognitive ability than five-year olds in the average of countries for which data is available (See Table 1). This difference is sizeable, as it is equivalent to about 60% of a standard deviation observed for five-year olds in the United Kingdom.

The Peruvian Ministry of Education (MINEDU) has recognized pre-primary school as a priority to improve educational outcomes. As a result, from 2007 to 2011, MINEDU increased pre-primary education spending per student by 70%, compared to increases of 60% and 46% in primary and secondary education

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<sup>12</sup> See IADB (2018), accessible on <https://www.iadb.org/es/cima>

respectively (ESCALE, MINEDU). In parallel, the rate of attendance to preschool for children ages 3 to 5 years increased from 53% to 75% in the 2001-2012 period, with increases for children living in both rural and urban areas (attendance increased from 53% to 75% in urban areas and from 44% to 66% in rural areas during the same period). Moreover, Berlinski and Schady (2015) report that the gap in enrollment between students from the richest and poorest quintiles dropped from 36% to 12% between 2000 and 2013.

This effort to expand access to pre-primary education, however, was not initially accompanied by programs aimed at changing the pedagogical practices as a vehicle to improve learning outcomes. Thus, the status-quo in terms of pedagogical practices in pre-primary education was one of memorization and repetition using a model of vertical pedagogy, in which all the students in the classroom received the same materials and tended to repeat, at the same time, what the instructor did—e.g., all students would sing at the same time or repeat the number the instructor mentioned in front of the class (APOYO, 2012).

### ***b. The Mimate Program***

Mimate was designed by pedagogical experts with the relevant literature on early education kept closely in mind. The program is delivered in 45-minute sessions to fit smoothly into the daily schedule of Peruvian preschools, and includes a workbook, formative assessments, and visits from teacher assistants to ensure the quality of teacher-student interactions.

The salient characteristic of Mimate is the use of inquiry with scaffolding techniques. Inquiry-based learning, or co-operative learning as Vygotsky (1978) called it, is based on the idea that social interaction is essential for learning. Inquiry-based learning tends to rely heavily on scaffolding to guide learners through complex tasks and keep the student engaged in what Vygotsky (1978) described as the “zone of proximal development,” the range of concepts between what learners can do on their own and what can be achieved in collaboration with instructors or peers (Ellis and Worthington, 1994). Scaffolding can be achieved using soft or hard approaches (Saye and Brush, 2002). Soft scaffolding is human support provided by a teachers or peers that helps students meaningfully participate in the performance of actions. Teachers who provide soft scaffolding must remain cognizant of students’ stages of learning in order to provide just the right amount of support at the right time to each student (de Grave et al. 1999; Hogan and Pressley 1997; Lepper et al. 1997). Hard scaffolds are computer or paper-based materials that anticipate the student’s needs during the unit by following a pedagogical flow that builds upon concepts

incrementally (Saye and Brush, 2002). Ideally, both soft and hard scaffolding measures can occur simultaneously to allow teachers to keep an entire classroom engaged with the material. Mimate uses both elements.

Individualized instruction requires teachers to know where each child stands in terms of her understanding of the material.<sup>13</sup> This is no simple task in classrooms of up to 30 students per teacher and without access to technology. Mimate developed a solution that makes accurate, formative assessments possible with a simple 5-minute round of flash cards between the teacher and each individual student.<sup>14</sup> Based on the student's answers, the teacher then knows which skills the student needs to practice and can direct her to an appropriate activity.

The nature of the program also needed teacher training, which included two different dimensions. Before the program started, teachers participating in the program received three training sessions in which they received information on the objectives of the program and training on the program's sessions and materials. The second component of training support was in-class training. For this, teacher coaches observed the sessions taught by the teachers and gave advice on how to improve the application of the program. These sessions took place during the school year (from March to November).<sup>15</sup>

In terms of mathematics contents, Mimate is motivated by research that suggests preschoolers can learn mathematics and, moreover, most children at the preschool age actually enjoy the basic mathematics challenges (Seo and Ginsberg, 2004; Clements and Sarama, 2008). Similarly, research also shows that preschool mathematics programs aimed at children from low socioeconomic status can have significant impacts on their mathematics outcomes (Ramani and Siegler, 2011).<sup>16</sup>

The Mimate program emphasizes the following four areas of mathematical development:

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<sup>13</sup> This is related to the literature that emphasizes the importance of the quality of the interactions between students and teachers in order to attain good learning outcomes (see Berlinski and Schady, 2015 and the references therein).

<sup>14</sup> Recently, sophisticated computer programs have become popular tools to test students and recommend further exercises based on their specific capabilities (Barrow et al., 2009; Muralidharan et al., 2017). However, these types of programs were not feasible to implement in the Peruvian context as only 7% of schools had internet access and computer skills among teachers were sparse.

<sup>15</sup> In addition, during the final part of the implementation of the program (between October and December), participating teachers were invited to attend lesson study sessions in which they could share their experiences with other teachers.

<sup>16</sup> It is well known that low-income children enter preschool with fewer number-related experiences—at home, in their communities, and in their early care centers—than their middle-income counterparts and that these early learning opportunities set middle-income children at an advantage (Clements and Sarama, 2008).

- a) *Numerical literacy: number sequence and number aspects.* Children learn the variety of purposes for numbers: to count one-by-one, to order objects, to measure size or time, etc. The two basic types of “number words” (i.e., one, two, three, etc. and first, second, third, etc.) are also practiced.
- b) *Numerical literacy: capturing structure.* Children practice the rule of cardinality, that the last number spoken when counting signifies the total number. When counting is understood, children are stretched to consider numbers in small groups and learn how to combine and separate groups mentally without relying on counting. This catalyzes quick and efficient mental calculus later on.
- c) *Understanding shape: variety of geometric shapes.* Children play with various shapes (circles, squares, rectangles, triangles and rhombuses), different types of lines (straight or curved, closed, or open). They are challenged to visualize points, planes, and three-dimensional spaces.
- d) *Understanding shape: training fine motor skills.* Children construct shapes with clay, draw shapes with pencils, and learn symmetry by folding or cutting paper. Neuroscience has demonstrated that knowledge of form comes through experiential learning with the hands in one channel and language in the other. The activities hone the coordination of fingers while reinforcing the lessons of earlier modules.

### **3. Research Design and Data**

A randomized controlled trial employing randomization at the school level forms the basis of the study design. We randomly selected 53 treatment schools and 54 control schools from Huancavelica, Angaraes, and Ayacucho. The treatment group would adopt the Mimate program in their preschool classrooms, while the control group would not receive the intervention and continue using traditional pedagogical practices (as we discussed above, generally this means teaching practices based on frontal instruction, memorization and repetition). The randomization considers the existence of six strata that come from the combination of the school location (urban/rural) and the city in which the school is located.

The primary data used in this paper were collected through the baseline and two follow-ups. Baseline data were collected in March 2012. A first follow-up was collected at the end of the school year in December 2012 (referred to as “short-term follow-up” in the paper). We collected a second follow-up in December 2013, one year after the treatment was completed and when the students were at the end of their first grade

of primary education (referred to as “medium-term follow-up” in the paper). In total, 2,400 children participated in the baseline and short-term data collections, while 2,416 participated in the baseline and medium-term data collections out of a total baseline sample of 2,926 students.

The general format of these data collection processes was very similar, consisting of the application of student tests in the baseline and two follow-ups and the application of parent and teacher surveys in the baseline and first follow-up. To measure the development of mathematics skills, we applied preschool-adapted versions of the “Early Grade Mathematical Assessment” (EGMA) originally developed by the Research Triangle Institute International. The tests measure various abilities related to mathematics with the following exercises: Comparing quantity, basic shape recognition, advanced shape recognition, basic object counting, advanced object counting, number selection, advanced number selection, fine motor skills, symmetry, shape sequence, number sequence (clock), number sequence (calendar), additive composition, geometric shapes, and addition and subtraction word problems. Appendix 1 provides a detailed description of these items. In the paper we present results of the items included in EGMA at three different levels of aggregation: (i) an overall index that includes all the items in EGMA, (ii) two indices by curricular area, one for items related to numerical abilities and the other for items related to shapes, and (iii) measures of the development of each ability included in EGMA. The preschool version of EGMA was originally developed for Paraguay and was validated to align the test with the Peru preschool curriculum and pretested for use in Ayacucho and Huancavelica (CPAL, 2012; IPA, 2012). The most important adjustment was the inclusion of additional items to assess fine motor skills based on Hammil et al. (1995). In addition to mathematics tests, we also applied instruments to assess the development of non-mathematics outcomes: the Raven test of general cognitive ability and a test of early literacy skills test.<sup>17</sup>

The questionnaires applied to teachers and parents collected information about the child’s classroom and home experience. We use the information from these surveys for two purposes. First, to study treatment heterogeneous effects (such as classroom size, access to educational materials, teacher’s education, mother’s education, dominant language at home, etc.). Second, the information from these surveys allow us to understand the mechanisms through which the program may have affected learning outcomes.

In addition, to help with the interpretation of the results, we collected process information about actual program implementation in all treatment schools. Lastly, between the months of October and December

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<sup>17</sup> Early literacy skills were measured through a preschool version of the Early Grade Reading Assessment (EGRA).

of 2012 an external team also visited 44 randomly selected schools (37 treatment and 7 control schools) to verify the intensity of treatment (teacher and student attendance records and level of implementation of different Mimate lessons). In addition, to observe teacher-student interactions and student-student interactions, a sample of 12 treatment and 4 control schools were randomly selected to videotape mathematics classes,<sup>18</sup> which were analyzed using the CLASS (Class Assessment Scoring System) rubric, which codes teaching practices in three areas: emotional support (i.e., generating a respectful environment and listening to children), classroom organization (i.e., managing time and keeping control of students), and teaching support (i.e., developing concepts thoughtfully and reinforcing student learning). With respect to this third category, the instrument provides a general indication of the teaching approach used but does not detail the precise pedagogical practices used.<sup>19</sup>

#### **4. Program Implementation**

This section presents information to characterize the implementation of the Mimate program. This will allow us to learn about the fidelity of treatment implementation and can provide us with useful insights to interpret the program's quantitative results.<sup>20</sup>

##### ***a. Process Information***

Concurrently to the experimental evaluation, we collected data to produce rough measures of the program's actual implementation both in terms of quantity and quality.

First, we collected administrative data on all the sessions implemented by each school. Table 2 presents a general description of how the program was planned and implemented from March to December. The program planned 86 sessions in total. The administrative data implies that, on average, 66% of the sessions were implemented. It is important to highlight that during the school year 2012, a teacher strike suspended

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<sup>18</sup> Financial restrictions did not allow us to expand the sample to more schools for the class observation and to have more treatment and control schools to videotape Math classes.

<sup>19</sup> See Pianta et al. (2008b) for a description and Araujo et al. (2016) and Cruz-Aguayo et al. (2015) for applications in Latin American countries. For cost reasons, we were not able to use other instruments (for example, the TIMSS video study) that would have allowed us to measure the precise pedagogical practices used by teachers.

<sup>20</sup> Section 6 presents a comparison with the pedagogical practices in control schools using both class observations and the answers of teachers to a follow-up questionnaire, which also allows us to understand the intensity of the different components that may be affected by the program with respect to the status-quo's pedagogical practices (those of the control group).

up to three months of classes in some schools. In total, 87% of teachers in the sample participated in the strike at some point in time. This rate was higher in rural areas (95%) than urban areas (83%).

The partial implementation of the program implied that the actual coverage of the topics planned to be taught in the last three months of the school year was smaller than that for topics planned for the beginning of the year. For instance, while all the topics planned for March to July were implemented by all schools, none of the topics planned for November and December were covered. Given the intended order of the sessions, this partial implementation means that actual coverage of the numerical literacy and the understanding shapes parts of the program was significantly different. In fact, while 82% of the sessions directly related to shapes were implemented, just 57% of the sessions directly related to numeracy were covered. This is an important fact to consider in our empirical analyses. In terms of attendance of teachers to the training sessions, 83% of the teachers attended the three sessions before the program started and teachers received in average six visits of in-class training.<sup>21</sup>

To analyze whether there are some systematic implementation patterns regarding both the sessions taught to the children and to the training received by teachers related to the schools' observable characteristics, in Table 3 we present regressions of the share of sessions actually covered in each treatment school (in Panel A) and the share of training and support sessions attended by the teachers in each treatment school (in Panel B). These are two of the two main margins in terms of the implementation of the program. We run regressions of each variable on students' (baseline mathematics scores, gender, language, and socioeconomic status) and schools' (location, average class size, and teacher education) observable characteristics.

Columns (1) to (7) in both Panels of Table 3 present the relation between the percentage of completed sessions (in Panel A) and completed training (in Panel B) and each variable individually, and column (8) includes all the variables. Our models do not successfully predict the number of implemented sessions, as all the variables combined can just explain about 22.5% of the variance in the number of sessions (column 8, Panel A) and 19.6% in the case of the share of completed training sessions (column 8, Panel B). In terms of individual significance to explain the share of completed sessions, we find that schools with higher test scores at the baseline, with more Spanish speaking students, with more students coming from high SES households, and located in urban areas implemented more sessions. However, in all the cases,

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<sup>21</sup> In addition, 63% of the teachers attended the sessions implemented at the final part of the program to share their experiences with other teachers.

the size of the impact, while statistically significant, is not economically relevant. Moreover, when including all the variables together (column 8), none of them has a correlation that is statistically different from 0—which could probably be a consequence of the high collinearity among the right-hand side variables. In all, these results suggest that while some variables seem to be correlated with the percentage of completed sessions, none of these variables seem to have a first order effect on the program’s actual implementation.

In turn, in terms of individual determinants of the share of training sessions completed by teachers in treatment schools, we find that teachers in schools with lower test scores at the baseline, with more Quechua speaking students, and located in rural areas completed more training sessions. Actually, as these variables are correlated among them, when added together (in column 8), the only one which is statistically significant is whether the school is located in an urban area. In this case, the size of the effect is -15.5 percentage points, which corresponds to about one additional session received by the teachers in rural schools.

#### ***b. Class observations***

Next, to study the quality of the program’s implementation, we use class observations from a sample of 37 treated schools. The idea was to identify a number of relevant pedagogical dimensions and see whether actual implementation was consistent with the program’s objectives.

We now report findings from the monitoring of the intensity of the treatment. All the schools in the sample have the “Mimate corner” in the classroom and in 78% of the cases the actual set-up of the corner was consistent with the design suggested by the program. The board games provided by Mimate were available to students in 92% of the schools. In 100% of the schools, teachers were using the Mimate materials as suggested by the program. These results suggest that implementation fidelity was very high and that teachers were using the Mimate program as designed.

### **5. Estimates of Impact on Test Scores**

We start the discussion of the empirical results by characterizing the population included in the study at baseline. The baseline tests completed by all study participants revealed a real academic disadvantage for Peruvian preschoolers compared to international standards (see Table 1). This implies that their basic

mathematics competence was of concern. For instance, fewer than four in ten children could write their age and only about half of the children could count to the number ten. As for the teachers, 12% had earned a Masters or Doctorate degree, 44% possessed a university degree, and the rest had earned a tertiary-level teaching certification. On average, teachers had 14 years of experience and were responsible for a class of 24 students.

Table 4 presents an analysis of heterogeneity in mathematics outcomes across different groups using the baseline data. We present standardized outcomes (i.e., with an average of zero and a standard deviation of one) for tests that measure mathematics, cognitive ability, and early literacy skills. We identify significant gaps in learning among most dimensions: urban vs. rural students; Spanish, Quechua, and bilingual speakers; and males vs. females. This is not surprising when one considers that, when looking at the infrastructure and resources of the schools, less than half of the participating rural schools were connected to the public water system, compared to 88% of urban schools, and one in five had a computer, compared to one in two for urban schools. In this setting, rural students scored on average 0.46 standard deviations below their urban peers in the baseline mathematics assessment.

Two in three of the participating rural students spoke exclusively Quechua at home, and the rest were split evenly between bilingual and Spanish speakers. Only 2% of participating urban students spoke exclusively Quechua at home, and the remainder spoke only Spanish. The Quechua speakers performed at baseline even lower than the rural group (0.61 standard deviations below Spanish-speaking students), and the bilingual students also had lower performance compared to Spanish speaking students (0.46 standard deviations below Spanish speaking students).

In the remainder of this section, we first present the econometric models and statistical tests we use. Then, we perform an initial check of internal validity and attrition in the three data collection processes. Lastly, we present the main results for both the short-term and medium-term follow-ups and considering both average and heterogeneous treatment effects.

#### *a. Econometric Models and Statistical Tests*

The empirical framework for the main analyses of this paper uses observations on children who attended schools that were randomly assigned to the treatment and control groups. We estimate the following regression model:

$$Y_{ij} = \theta + \alpha T_j + X'_{ij}\beta + \varepsilon_{ij}, \quad (1)$$

where  $Y$  represents an outcome for student  $i$  who attends school  $j$ ,  $T$  is a dummy variable that takes a value of 1 if the school is part of the treatment group,  $X$  is a vector of control variables, and  $\varepsilon$  is the error term that is clustered at the school level  $j$  in each regression. Then, estimates of  $\alpha$  quantify the differences in means between students attending schools that received the Mimate program over the 2012 school year and those that did not receive it.

We include the following variables in vector  $X$ : the value of  $Y$  for student  $i$  at baseline, strata dummies, and dummies for the different enumerators. If the randomization is successful, adding these variables should not change the estimate of  $\alpha$  and these controls should just provide more precise estimates. For instance, it is well established that tests scores at the student level present high variation levels. Therefore, controlling for baseline estimates reduces the idiosyncratic variation in the results and allows us to obtain more precise estimates (Duflo et al., 2008). We find that the differences in the estimates of  $\alpha$  when including and excluding  $X$  in equation (1) come from differences in the precision of the estimates of  $\alpha$ . Therefore, to save space, we only report estimates including  $X$  in the tables.

We extend this basic analysis in two dimensions. First, we present robustness exercises that deal with the fact that the number of students tested in the baseline and the two follow-up measurements is not constant due to attrition. Thus, we present estimates using inverse probability weighting and Lee bounds (Lee, 1999). As we discussed below, this is not likely to be a concern as we show that attrition is not correlated with observables and the sample is balanced. Second, we estimate the effect of the share of Mimate sessions implemented in each school (this is equal to 0 for all control schools) on the overall EGMA score. We estimate this both using OLS (which assume that the actual number of sessions is not endogenous to other unobserved school characteristic) and an IV procedure in which we use both the treatment indicator and the interaction between the treatment indicator and the duration of the teacher strike in each school as instruments for the share of implemented sessions.

In addition, we implement the following additional econometric exercises to analyze heterogeneous treatment effects. First, we run regressions considering interaction effects between the treatment dummy and students/schools observable characteristics of the following form:

$$Y_{ij} = \theta + \alpha T_j + \gamma T_j * W_{ij} + \eta W_{ij} + X'_{ij}\beta + \varepsilon_{ij}, \quad (2)$$

where  $W$  corresponds to a variable that varies at the school or student level. Then, if we estimate that  $\gamma$  is statistically different from 0, it implies that treatment effects are different for students having different  $W$ . Second, we use quantile regressions to estimate the effects of treatment for students in different quantiles of the outcomes distribution, following a structure similar to the one presented in equation (1). In this case, we obtain an estimator of  $\alpha$  that is different for individuals in different quantiles of the distribution, conditional on outcomes in the baseline (as we include them in the vector of covariates).

As we include different outcomes, we may face an inference problem related to multiple hypotheses testing. That is, significant coefficients may emerge simply by chance, even if there are no treatment effects (List et al., 2016), and we may be over rejecting the null-hypothesis of no treatment effect. Thus, in the case of tests for treatment effects on individual components of the test, we calculate adjusted p-values following the methodology suggested by List et al. (2016).

### ***b. Balance and Attrition***

Table 5 compares outcomes at baseline for variables collected for students, teachers, and parents in the treatment and control groups. We do not find differences in 23 out of the 24 variables we test. The only statistical difference we find is that the share of girls among treatment students (52%) is higher than in the control group (43%).<sup>25</sup> Other variables do not present statistically significant differences. In each panel, we also present the results of an F test of the joint significance of all the variables to predict treatment status. Results imply that we cannot reject the null hypotheses that the variables at baseline for each group are not correlated with treatment status.

In terms of attrition, at baseline the main sample includes 2,926 students attending the schools that participate in this study. We were able to collect information for 2,400 students in the first follow-up in December 2012, which implies an attrition rate of 17.9 percent. In the second follow-up (December 2013), we were able to collect information for 2,446 students, which implies an attrition rate of 16.4%. The main reasons for not finding a student at the follow-up measurements were that the student had withdrawn from the school or she was absent from school the day the instruments were applied. The attrition rate in both

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<sup>25</sup> It is worth noting that in Table 8 we present regressions in which we show that controlling for gender does not change the results in a meaningful way.

follow ups is not statistically different between treatment and control groups and is not correlated with observable characteristics.<sup>27</sup>

### *c. Short-term Results*

We start discussing results of the follow-up collected in December 2012, at the end of the 2012 school year. This corresponds to the end of the implementation of the Mimate program for the cohort of students for which we applied the baseline in March 2012.

First, we present impact estimates of the Mimate program on the overall EGMA test scores, considering all the dimensions, in column 1 of Table 6. The estimate is statistically significant and implies an impact of the Mimate program of  $0.10\sigma$  in favor of students in the treatment group. As a benchmark, . As a benchmark, Araujo et al. (2016) document that well identified “teacher effects” (i.e., the effect of increasing the quality of the teacher by one standard deviation) for a sample of kindergarten classrooms in Ecuador is  $0.09\sigma$ . Thus, this suggests that this low-cost intervention is comparable in terms of impacts to big increases in teacher quality.

Next, we study the potentially different effects of the program in the numeracy and shapes abilities that the Mimate program aims to develop. This is important as our implementation analysis showed that a higher proportion of the sessions focused on shapes were implemented compared to sessions focusing on numeracy skills. We present the results in columns 2 and 3 of Table 6. Results imply a slightly bigger impact ( $0.12\sigma$ ) on an index that considers just the abilities related to shapes in EGMA than on an index considering just the abilities related to numeracy in EGMA (an impact of  $0.10\sigma$ ). These results are consistent with the fact that the sessions related to shapes had a higher degree of implementation than the sessions related to numbers. In addition, the estimate for numeracy was closer to the overall program estimate than the estimate for shapes, which may imply stronger effects for numeracy.

To formally test for the effect of the share of implemented sessions on learning outcomes, we run regressions of the share of Mimate sessions implemented in each school (this is equal to 0 for all control schools) on the overall EGMA score. This is presented in column 4 of Table 6. We find that the coefficient

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<sup>27</sup> Results not shown here but available from the authors upon request.

of the share of sessions implemented is equal to 0.15 (significant at the 1% level). Next, to deal with the potential endogeneity of the share of sessions, column (5) uses the IV approach we discussed before.<sup>28</sup> The point estimate is 0.14, which is statistically indistinguishable from the OLS estimate.<sup>29</sup> These results imply that an increase in the number of sessions from what we observed on average (about 57 sessions) to the planned number of sessions (86) would increase the effect of the program by 0.05. These results also imply that differences in the share of sessions related to numeracy and shapes (25%, accordingly to our process data) would translate into a difference of 0.035 standard deviations in terms of the effects in both dimensions, which is above what we observe in columns 2 and 3 of Table 6 (0.02 standard deviations). Thus, we interpret these results as suggesting that the number of implemented sessions may explain the slightly larger program effect on skills related to shapes.

Table 7 presents two different robustness exercises to deal with the potential effects of attrition on our estimates. Estimates using inverse-probability weighting are almost equal to the ones we find using an OLS approach, we just find an increase in the overall effect from 0.10 to 0.11. Regarding Lee bounds, we find that in the three cases the lower bounds are statistically different from 0 and in a range of effects between 0.08 and 0.09 $\sigma$ . The upper Lee bounds reach values between 0.10 and 0.13. In all, these results suggest the potential effects of selective attrition of students in the first follow up does not affect the estimates in a significant way.

Next, we present estimates for the different items included in the EGMA test. We do this to learn which dimensions of mathematics learning are affected the most by the Mimate program. We present both unadjusted (without considering the potential existence of a multiple hypothesis testing problem) and adjusted (considering multiple hypothesis testing) p-values in Table 8. First, in terms of numeracy skills, we find statistically significant effects for number selection (effect of 0.18 $\sigma$ , significant at the 1% level), additive composition (effect of 0.15 $\sigma$ , significant at the 1% level), and oral counting (effect of 0.11 $\sigma$ , significant at the 5% level). Second, in terms of abilities related to shapes, we find a significant effect for geometric shapes (with an effect of 0.20 $\sigma$  that is significant at the 1% level), shape recognition (with an effect of 0.14 $\sigma$  that is significant at the 5% level), and spatial ability (with an effect of 0.23 $\sigma$  that is

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<sup>28</sup> In the first stage we find that the coefficient of the treatment status is 1.01 (with a standard error of 0.05) and for the interaction is -0.0041 (with a standard error of 0.006). This implies that 20 additional days of the teacher strike decrease the share of sessions by 8.2%. Notice also that the average duration of the strike was 49 days for treatment schools.

<sup>29</sup> We also run an additional exercise in which we control for all the school variables included in Table 3 as correlates of the share of implemented sessions. Results in both the first- and second-stages do not change in a significant way (e.g., the second stage estimate is now 0.138).

significant at the 5% level). The fact that we find effects on several different dimensions suggest that the overall treatment effects we estimate are not driven by increases in just one specific dimension of knowledge of Mathematics.

We next present in Table 9 estimates to test for heterogeneous treatment effects.<sup>30</sup> First, we study whether Mimate has a differential effect by gender. This is important because: (i) there are gender gaps in learning outcomes at baseline (see Table 4), (ii) gender was not balanced across treatment and control students at baseline, and (iii) several papers document large differences in terms of mathematics teaching across genders, with a bias in favor of boys. Our results show no statistically significant treatment differences between boys and girls. This implies, on the negative side, that Mimate was unable to close the existing gender gap but, on the positive side, that it is a gender-neutral program.<sup>31</sup> Mimate inherently addresses the gender bias generally found when teaching Mathematics by requiring regular attention to each student, regardless of sex, and thus preventing the monopoly of attention that fidgety and high-energy boys can sometimes demand from their teachers at the expense of better-behaved girls. In fact, as we discussed before, results in both panels of Table 3 suggest that the implementation of the program was similar in classes with more girls and classes with more boys.

Second, we study whether there are heterogeneous effects by the language of the student. This is a dimension that poses challenges, given the difficulty of adapting the materials to different languages. Moreover, we found significant gaps in test scores at the baseline in favor of Spanish speaking kids. Results in column 2 of Table 9 show that there are no statistical differences between students who are bilingual and Spanish speakers. The effects for Quechua speaking boys is marginally different from Spanish speakers in statistical terms (at the 10% level) and the size of the difference is important (equivalent to 0.10 standard deviations).<sup>32</sup>

Next, we study whether results are different for students from high and low SES households (column 3 of Table 9). We know that the exposure to different levels of mathematical reasoning for students from different SES families seems to have strong effects in terms of mathematics learning. Yet the Mimate

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<sup>30</sup> We only present heterogeneous effects for the overall EGMA test to save space and because we do not find systematic differences in the pattern of heterogeneous effects when analyzing effects for the numeracy and shapes dimensions of the test. All heterogeneity analyses presented here are based in the original evaluation plan.

<sup>31</sup> The existence of boys-biased programs in schools is not unfamiliar to Peru. Results from a science program showed that the program widened the achievement gap between boys and girls (Beuermann et al., 2013).

<sup>32</sup> This is very remarkable as our results in Table 3 (Panel A) found that schools with more Quechua-speaking students implemented fewer sessions of the program.

program did not favor the higher SES sectors. Results imply that there are no statistical differences and that, if anything, children from low SES improved at a faster rate than children from high SES. The same result emerges when comparing students from rural and urban areas (column 4 of Table 9). These results echo the findings of Ramani and Siegler (2011), providing another example that fun, interactive mathematical games are also beneficial for low SES students.

We also study whether the effects of the Mimate program vary by different school characteristics. First, we consider potential differences between schools located in urban and rural areas (column 4 in Table 9). We do not find statistical differences among students attending urban and rural schools and, if anything, the effects for students attending rural schools are larger than for students attending urban schools. This can also be a consequence of the fact that teachers of rural schools received more training (Panel B, Table 3) in spite of the fact that rural schools implemented fewer sessions (Panel A, Table 3). In any case, the result of bigger impacts for rural schools is striking given the above documented challenges faced by rural schools. We then consider the effect of class size (column 5 in Table 9). Teachers face the difficulty of keeping a large classroom focused on learning, but by emphasizing collaborative work in small groups, Mimate appeared to have neutralized the effect of class size as well. Students in large classrooms improved equally, on average, compared to students in smaller classrooms.

Finally, we study whether the teacher's educational level generates differential program effects. Results in column 6 of Table 9 suggest that this is the case. Teachers with university degrees have stronger effects than teachers with a tertiary degree. In fact, the effect of the Mimate treatment is  $0.15\sigma$  for schools in which the treatment was implemented by teachers with university degrees in contrast to an effect of just  $0.04\sigma$  (and not statistically different from 0) for schools in which the program was implemented by teachers with a tertiary, non-university degree. The inherent classroom difficulties in Peru, along with a completely new pedagogical model, can explain why teachers who have university-level teaching degrees saw their students improve significantly more with Mimate in the short-term than teachers with a tertiary, non-university degree.<sup>33</sup>

In all, the results in Table 9 suggest that the Mimate program did not have many heterogeneous effects for students with different characteristics, a positive finding given the status quo of big gaps in several dimensions, such as gender, language, income, and geographic location. The most important difference

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<sup>33</sup> It is interesting to notice that we also find that years of teaching experience did not have a significant impact on the effects of the program.

we found was related to the fact that Mimate program seems to have a larger impact when the teachers have more years of education. We study in detail this point in section 6 using results from the teacher follow up survey.

Next, we present the results of treatment effects using quantile regressions. This exercise allows us to estimate the impact of the treatment on the distribution of test scores (Table 10). In mathematics, teachers often find it especially difficult to find a balanced lesson plan that stimulates the curiosity of the high-achieving students without confusing the low-achieving ones.<sup>34</sup> Mimate’s scaffolding model, which adapts to meet the individual needs of students, may help to mitigate this problem. Results in Table 10 imply that the treatment effects are significantly stronger for students in the bottom part of the test score distribution than for students in the top part of the distribution. For instance, while the impact for students in the bottom 10% and 25% of scores improved by between  $0.12\sigma$  and  $0.16\sigma$  (depending on the test considered), treatment effects for students in the top 10% and 25% of the score distribution were just between  $0.04\sigma$  and  $0.08\sigma$ . This shows an equitable impact of the program, and it suggests that Mimate may even narrow the achievement gap between the highest- and lowest-achieving students.

Finally, Table 11 presents treatment effects of the Mimate program on non-mathematics dimensions of the learning process using the Raven cognitive development test and a test of early literacy skills. Results show that the program did not have statistically significant effects on these dimensions. This suggests that neither the additional learning of mathematics skills created positive externalities on other areas nor that the new focus on mathematics skills and teaching distracted resources from learning in other dimensions.

In sum, the short-term results imply that the Mimate program had a statistically significant effect on general mathematics learning outcomes, with slightly stronger effects on abilities related to understanding shapes. In terms of heterogeneous effects, the program did not produce statistical differences against girls, students from low socioeconomic status, or students who live in rural areas. Also, we do not find differentiated effects for classrooms of different sizes, but we do find stronger effects when teachers with university degrees implemented the program—in comparison to teachers without tertiary level degrees.

#### *d. Medium-term Results*

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<sup>34</sup> There is a general literature on the effects of several innovations to try to deal with class heterogeneity, such as tracking (see Duflo et al., 2011 and the references therein) and the use of software that allows students to advance at a different pace (see Barrow et al., 2009 and Muralidharan et al, 2017 and the references therein).

We now move to the discussion of the results of the follow-up implemented in December 2013 at the end of the school year. This corresponds to a follow-up after the students attended school for one year after the program ended and *without* receiving the program and allows us to study the medium-term effects of the intervention. We present results for the same estimations used in the short-term follow-up.

In terms of the effects of Mimate on the overall EGMA test, we do not find statistically significant effects (Table 6, Panel B and Table 7). This implies that the effect of the program that we found in the short-term does not persist in the medium-term. This result is like what has been previously found in the literature on the effects of pre-school programs in primary education (see Duncan and Magnuson, 2013). However, as we discussed above, given the large difference in terms of program implementation in the areas related to shapes and numeracy and the consequent differences we find in their EGMA scores, we also expect to find a differential effect of the Mimate program in these areas. Results in Panel B of Table 6 and Table 7 confirm this, as we find that Mimate has an effect that is not statistically significant for the numeracy score but a statistically significant impact for shapes geometric shapes with an effect of  $0.06\sigma$ . Moreover, results in Panel B of Table 8 show a big and statistically significant effect on geometric shapes of  $0.15\sigma$  (significant at the 1% level using the p-values adjusted for multiple hypotheses testing). This result is interesting as we find that the strongest program effect in the short-term is also the one that has an effect in the medium-run. It is important to stress that we are very conservative in reaching this conclusion, as we are correcting our p-values for multiple hypotheses testing and, therefore, it is highly unlikely that this result is an outcome obtained by chance.

In terms of heterogeneous effects of the intervention, we do not find significant effects, with the exception again of a positive and statistically significant interaction between the Mimate treatment and teachers with university degrees. This interaction has almost the same effect in both follow-ups ( $0.11\sigma$  in the short-term follow-up and  $0.12\sigma$  in the medium-term) and might suggest a potential complementarity between Mimate and the educational level of the teachers. In fact, this result is consistent with the argument in Yoshikawa et al. (2013) that "structural quality" is a necessary condition for "process quality" in preschool education. We will come back to this point in Section 6.

For students located at different points in the outcome distribution (Panel B of Table 10), we find that the significant effects for shapes are concentrated among the students located in the top of the distribution. This result suggests the existence of a specific type of complementarity in which after the program ended higher-achieving students benefit more in the medium-term than lower-achieving students. In the short-

run, (when the program is being implemented) the opposite is true. More research is needed to have a clear explanation for this finding.

## 6. Mechanisms

Our previous results suggest a statistically significant effect of the program in the short term that decreases in the medium term (after the program ended) and just stays significant for shapes. We also find persistent stronger effects of the program in treatment schools with more educated teachers. In this section we use class observations and answers from the teacher's survey in the first follow up survey to understand in a better way the mechanisms behind the effects of the program both in levels and in terms of bigger impacts for students with teachers with university education.

### *a. Class observations*

In addition to the information for treatment schools reported in section 4 for 37 treatment schools, we also implemented class observations for seven control schools (chosen in a random way). This allows us to compare same practices between treatment and control schools (in an exploratory way given the small sample of control schools). Using this information, we identify several interesting results when comparing treatment and control schools. First, in the area of classroom organization, the Mimate classes were 38% more likely to be “prepared and structured with a clear objective” than control classes. Teachers in the control group, on the other hand, were many times observed improvising with activities during the lesson.

Second, in the area of emotional support, teachers in the treatment group explained mathematics patiently more often than their colleagues in the control group (95 vs. 71%). Moreover, when students committed mistakes, Mimate teachers more consistently encouraged, in a friendly manner, their students to try activities multiple times (in 95% of the cases), compared to the control group (with 71% of cases).

Third, consistent with the program's inquiry-based approach, in most cases teachers in treatment schools were always or often allowing their students to discover by themselves the objectives of the activities (an average of 3.5 in a metric that goes from 0 to 4, with 1=never, 4=always). In 100% of the treated schools, boys and girls were equally included in classroom activities. Furthermore, Mimate teachers were observed to be “paying attention to those students who do not understand well and explaining with patience” at a higher rate (95%) than the control group (63%). Thus, consistent with the scaffolding approach, the

Mimate program seems to have helped teachers use class time more efficiently to reach to students that lag behind and adopt a more patient attitude.

Then we use the CLASS rubric to compare outcomes between 12 treatment schools and four control schools along the three areas described above (again the small sample makes these results just suggestive):<sup>35</sup> (i) the average rate of emotional support was higher in treatment schools (5.32 compared with 4.78 in control schools, and the difference is equivalent to about  $0.72\sigma$ ), (ii) the level of classroom organization was higher in the treatment schools (4.47 in versus 4.30 in control schools, equivalent to  $0.16\sigma$ ), and (iii) the teaching support was also higher in the treatment schools (3.93 versus 3.79 in control schools, equivalent to about  $0.15\sigma$ ).<sup>36</sup> In sum, we find some differences in favor of treatment schools that are consistent with the impact results we report above—with the caveat that it is difficult to make statistical inferences from these observations given the small sample size.

#### *b. Teachers' follow-up surveys*

We use answers to surveys applied to 119 teachers in 95 schools in Table 12, as a source of additional information on the program's actual implementation. Given that we also include control schools in this sample, we are able not only to understand the changes created by the program. We report results for the complete sample and also we split the results for teachers with and without university education (we have 60 teachers with university education) to understand in a better way factors driving the results in terms of levels and also in terms of bigger impacts for children receiving the program from more educated teachers.

We find several significant differences between the treatment and control groups. Regarding teaching practices and resources,<sup>37</sup> treatment teachers are more likely to agree that they have had enough time to teach all the material they were supposed to cover and to address all the dimensions of the curriculum. Interestingly, the overall differences in these two dimensions are driven exclusively by big treatment effects for university educated teachers. This may suggest a mechanism to explain the stronger effects of the Mimate program for university educated teachers, who may have the human capital needed to apply the program in a way that allows them to optimize the instruction time. This may not be possible for

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<sup>35</sup> The rating scale for CLASS goes from 1 to 7, with 7 being the highest score.

<sup>36</sup> As a reference, Cruz-Aguayo et al. (2015) report results of the application of the CLASS instrument in classrooms in grades K-2 in Brazil, Chile, and Ecuador. Their results are similar to what we observe in our study, with relatively lower performance in the area of teaching support and similar results for emotional support and classroom organization.

<sup>37</sup> The questions have answers in five categories from strong disagreement to strong agreement, we code the answers from 0 to 4.

teachers without enough human capital. Then, it is not surprising that we also find treatment effects for teachers with university education in their opinions in favor of teaching math in preschool and in their beliefs that students have fun learning math. In contrast, we do not find the same treatment effects for teachers without university degrees.<sup>38</sup> We also find treatment effects for using games to teach math and agreement with the statement that they receive enough advice and pedagogical supervision. While both effects are slightly bigger for university education, they are not statistically different from the effects for teachers without university degrees.

We also find improvements in the perceptions of the teachers in treatment schools with respect to teachers in control schools regarding their students' behavior, general abilities to learn and abilities to learn any concept, and performance in Math. Interestingly, these results are stronger for teachers with university degrees, confirming our previous results. The only dimension in which teachers without university degrees in treatment schools express an improvement is in terms of an improvement in attendance of students to schools. In this case it worth noting that we do find that teachers with university degrees have worse expectations about their students in terms of math performance, teamwork, ability to learn, and behavior. Thus, the program may have been especially helpful for them in terms of increasing their beliefs about their students' abilities. As we discussed before, a challenge that all mathematics programs face is related to the potential gender-bias that can be present when teaching the subject. Interestingly, teachers in the Mimate program have more egalitarian beliefs about what happens in the classroom and about their students. However, as noticeable from Panel C of Table 12, treatment effects are concentrated in teachers without university degrees (and we do not find significant differences in these beliefs among teachers with and without university degrees).

Finally, we have access to surveys for 1,780 parents in 99 schools after the treatment was implemented. We asked questions to understand whether the program changed the beliefs, attitudes, homework, and involvement of parents in their children's education. We do not observe significant differences among parents in treatment and control schools in any of these dimensions. The only exception is that treatment parents are more likely to strongly agree that their children will do well on mathematics in school (41%

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<sup>38</sup> It is worth noting that we do not observe many systematic differences among teachers with and without university degrees in terms of the variables included in Panel A in Table 12. We only find the following statistical differences: university teachers are (i) less likely to agree with the statement that is not necessary to do math assessments, (ii) more likely to agree that children have fun learning math, (iii) more to likely to agree with the statement that to teach math is not enough to know the content, and (iv) more to likely to agree that they include games.

versus 33% in the control group). This suggests that the program does not seem to have affected parenting beliefs about mathematics in a significant way and, therefore, this may not be a mechanism to explain the results we find.

In sum, the information analyzed in this section helps us to understand the overall impacts and also the mechanisms behind the impacts we find. First, results suggest that the Mimate program helped to improve the management of several dimensions in the classroom which allowed teachers to cover more materials and use their time in a more efficient way. We also find improvements in teacher support and supervision, improvement in beliefs about the student's abilities, and a more gender-neutral approach for treatment schools. However, our results for teachers with university education (who produced stronger impacts in terms of test scores) suggest that it is likely that the impacts of the program are more related to improvements in the ability to manage the classroom than to improvements in other dimensions affected by the program. Thus, our results suggest that pedagogical innovations need a minimum level of human capital of teachers to produce big effects in students learning outcomes.

## **7. Discussion and Conclusions**

There is no silver bullet that solves all education problems, but tested pedagogical strategies backed by theory are a promising avenue for delivering returns to investments in education (Duncan and Magnuson, 2013; Kremer et al., 2013; Jackson and Makarin, 2017, Muralidharan, 2017). Moreover, these types of interventions are particularly important when they allow improvements in outcomes without changing current inputs, such as teachers and instruction time. We study the impacts a program implemented in Peru which provides preschoolers with age-appropriate materials that can bolster their foundations in mathematics and trains teachers to become listeners and facilitators of each child's development. The importance of mathematics skills at the preschool level has become increasingly apparent but it is less clear the specific programs that produce big impacts in this level (Duncan and Magnuson, 2013, Dillon et al., 2017). In Peru, as in many developing countries, where underachievement in mathematics persists from preschool all the way into secondary schools, a well-designed program could produce significant effect sizes.

The results in this paper suggest that Mimate has statistically significant impacts after one-year of implementation and some persistent effects one year later. The effects seem to be slightly stronger in

outcomes related to forms and shapes than to numeracy in the short-term and the effects are only persistent in the medium term for items related to shapes. This is consistent with the process information we present in this paper, which suggests that the implementation of the program was higher exactly in sessions related to this area. We do not find evidence that the implementation was significantly different for schools and teachers with different characteristics, suggesting that the variation in the implementation was closely related to the interruption of the program due to teacher strikes. Thus, our results suggest that the heterogeneous implementation of the program is probably driving the different effects in the numeracy and the shapes outcomes. It remains to be seen whether a complete implementation of the program can improve the impacts of the numeracy items both in the short- and in the medium-term.

We also find that while the effects of the program are not significantly different for students with different socioeconomic backgrounds, school types, or achievement levels (and if anything, stronger for weaker students), the effects are much stronger and persistent for teachers with university education (versus teachers without college degrees). This suggests that teachers human capital is a complement with a program that helps teachers to manage the classroom using an approach that seeks to personalize the instruction in an efficient way. This is consistent with information coming from surveys to teachers after the program was implemented, which suggest that the program has bigger impacts on the practices and beliefs of these teachers. This information also suggests that a key mechanism to explain the results is the impact of the program on the ability of teachers to manage the classroom in a more efficient way.

In terms of external validity, it is important to stress that (i) most schools in Peru and other developing countries use the same teaching methods that the Mimate program replaces (e.g., APOYO, 2012; Banerjee et al., 2016), (ii) the surveys and class observations we collected suggest that teachers, parents, and students liked the program, (iii) the process information we collected suggest important changes in practices among teachers, and (iv) the implementation of the program was done using a light-touch approach during regular hours and holding constant expenditure and staffing. These factors suggest that the program can be implemented as studied. The only main limitation is related to the human capital of teachers, where our results suggest that the effects are stronger for teachers with university degrees and, therefore, that this type of pedagogical innovation needs teachers with university education to produce big impacts.

Moreover, in terms of cost-effectiveness, the complete program has an annual average cost of about \$37 per student per year (which, as previously discussed, is equivalent to an increase about of 2.5% on top of

the regular expenditures). Thus, our results imply that \$100 increases about 0.27 standard deviations.<sup>39</sup> If we compare this to some of the results reported by Kremer et al. (2013) for innovations for primary education in developing countries, we find that the program is less cost-effective than the most efficient innovations these authors review, but that it is more cost-effective than most of the interventions involving teachers.

There are several implications and questions for future research and experimentation that can be derived from our results. Dramatic changes, like asking experienced teachers to step down from the pulpit and provide inquiry-based and tailored instruction based on each student's learning needs, can take some time to take hold. The results that better qualified, but not more experienced, teachers taught the program more effectively suggest that teaching flexibility, or tools of teaching learned later in school, are critical to the program's success. In this dimension, one could think of teacher training visits or directed special attention to teachers with lower levels of education as interventions to help close this gap. However, further research would be needed to establish this connection. Another dimension that may be relevant is extending Mimate into the home with simple take-home games (e.g. dice, puzzles). This could increase the intensity of the treatment, especially in the case of teacher strikes. Parents would then have tangible resources to engage in mathematics and mathematics talk with their children.

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<sup>39</sup> Notice that this is a conservative computation, if we consider that just about two-thirds of the program was implemented, an \$100 increase in expenditure in our program would imply a 0.41 standard deviation increase in test scores.

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## Appendix 1: Exercises included in the “Early grade Mathematical assessment” (EGMA)

The quantitative tests were preschool adapted versions of the “Early Grade Mathematical Assessment” (EGMA) originally developed by the Research Triangle Institute International. The test measures various abilities related to mathematics with the following exercises:

- a) *Comparing quantity*: Children are tested for their understanding of “more,” “less,” and “equal” with an image exercise comparing rows of kittens, chickens, and bunnies. The tester challenges the child to indicate in each row which box had more, less, or equal numbers of animals.
- b) *Basic shape recognition*: Children are presented with a circle, triangle, square, and rectangle and asked to correctly name each shape.
- c) *Advanced shape recognition*: The same shapes are dispersed in a matrix of shapes, and the children are asked to match four plastic tiles (a circle, square, triangle, and rectangle) with their corresponding shapes.
- d) *Basic object counting*: Children are asked to point with their finger and count balloons in a picture of balloons numbered 1, 2, 3, 4.
- e) *Advanced object counting*: The same exercise is repeated with a picture of twelve balloons numbered 1 through 12.
- f) *Number selection*: Children view a grid of twelve boxes, each one containing a different number of stars rising from 1 to 12. Then, they are asked to point out which box has three stars, six stars, nine stars, and twelve stars.
- g) *Advanced number selection*: Children view three boxes containing clusters of four hearts, five hearts, and eleven hearts respectively. Below the boxes are the numbers 5, 11, and 4 placed out of order. The children are asked to match each symbolic number with the appropriate box of hearts.
- h) *Fine motor skills*: Children copy to the best of their ability images of basic shapes, symbolic numbers and letters. Scores were later calculated by a team of digitation specialists.
- i) *Symmetry*: Children are shown an image of a butterfly and asked to draw a line over the butterfly that divides it into two equal parts.
- j) *Advanced symmetry*: Children try to match one side of a house with one of three options to complete the picture.

- k) *Shape sequence*: Unfinished patterns of shapes (triangle, square, circle, triangle, square...etc.) are presented to the children. Children indicate which shapes on the right side of the page would complete the pattern for each row. Patterns with color were also tested and color blindness did not affect performance.
- l) *Number sequence (clock)*: Confronted with an image of a clock face, children respond to the questions “Which number comes after 4?” and “Which number comes before 9?”
- m) *Number sequence (calendar)*: The tester shows children a calendar page of April and asks the children to help reschedule a party by answering the question “What day is two days after April 5<sup>th</sup>?”
- n) *Additive composition*: On the left side of the page is a box displaying three kittens and on the right side are pairs of similar boxes showing another numbers of kittens. Children are asked to identify the correct pair of boxes (one kitten and two kittens) that together are the same as the box on the left. The exercise is repeated three more times with flowers, apples, and hearts.
- o) *Geometric shapes*: Children are given four plastic triangle tiles and a plastic rhombus tile and asked to arrange them to cover up a large hexagon shape depicted on the page. Then, the tester takes away two triangles and gives the child a rhombus and asks them to complete the task again.
- p) *Addition and subtraction word problems*: “Daniel has one dog. María has one dog. How many dogs do they have in total?” and “There are four children walking to school. Two of them are boys and the rest are girls. How many girls are walking to school?”

Table 1  
Global Raven cognitive test scores

Country	Score	Standard deviation	Average Age	Source
Peru	12.3	5.5	5.2	This study
United Kingdom	15.1	3.7	5.3	Gathercole, 1994
Denmark	18.5	2.4	5	Olsen 1992
India	12	4.5	5	Bhogle 1992
Poland	15.1	4.5	5	Szustrowa 1992
Slovakia	14.4	3.8	5.7	Ferjencik 1992
Argentina	14	3	5	Leibovich de Figueroa 1992
Canada	14.2	-	5.3	Wright 1995
Global Average	14.5	3.8	5.1	

*Notes: Raven test comparison between countries.*

Table 2  
Process Information: Planned and Implemented Sessions

Module (by date)	Number of sessions	Average of sessions completed (%)
<i>March</i>		
Basic shapes	2	100.00%
Spatial relationships	7	100.00%
<i>April</i>		
Bend and cut	4	100.00%
Cover figures I	3	100.00%
<i>May</i>		
Construct with cubes	3	100.00%
Number sequence I	3	100.00%
Dice images	4	100.00%
<i>June</i>		
Define quantities I	6	100.00%
Assemble quantities	2	100.00%
Order numbers I	4	100.00%
<i>July</i>		
Quantity representations	3	100.00%
<i>August</i>		
Draw figures and patterns	3	99.39%
Symmetry	5	95.27%
<i>September</i>		
Cover figures II	2	83.64%
Pre-writing I	2	69.09%
Recognize shapes and space	4	50.91%
Pre-writing II	1	43.64%
Cognitive game	2	39.09%
<i>October</i>		
Pre-writing III	1	32.73%
Bend	5	17.45%
Number sequence II	2	14.55%
Define quantities II	2	6.36%
Pre-writing IV	1	5.45%
<i>November</i>		
Order numbers II	3	0.00%
Pre-writing V	1	0.00%
Number patterns	7	0.00%
<i>December</i>		
Numbers for measuring	2	0.00%
Number representations	2	0.00%
Total number of sessions	86	
Total avg. % of completed sessions	65.96%	

*Notes: Comparison between planned and actually completed number of sessions by module. The order of the modules in this table follows the MIMATE timeline. Data comes from the Mimate program.*

Table 3  
Panel A: Determinants of the Percentage of Completed MIMATE Sessions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baseline overall Math score	0.087 (0.042)							-0.032 (0.056)
% women per (treated) school		0.062 (0.077)						0.141 (0.086)
% of quechua speaking households per (treated) school			-0.067 (0.029)					-0.031 (0.045)
% of bilingual speaking households per (treated) school			-0.081 (0.036)					-0.083 (0.051)
% of high income families per (treated) school				0.067 (0.034)				0.006 (0.050)
Urban schools					0.057 (0.022)			0.044 (0.040)
Average class size per school						0.003 (0.002)		-0.000 (0.003)
% of teachers with university degree per (treated) school							0.020 (0.026)	0.038 (0.027)
Observations	43	43	43	43	43	43	40	40
R-squared	0.121	0.012	0.142	0.070	0.122	0.096	0.014	0.225

Panel B: Determinants of the Percentage of Completed Training Sessions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baseline overall Math score	-0.139 (0.055)							-0.070 (0.084)
% women per (treated) school		-0.074 (0.141)						-0.011 (0.171)
% of quechua speaking households per (treated) school			0.128 (0.060)					-0.089 (0.108)
% of bilingual speaking households per (treated) school			0.004 (0.064)					-0.153 (0.096)
% of high income families per (treated) school				-0.087 (0.086)				-0.036 (0.114)
Urban schools					-0.122 (0.040)			-0.155 (0.078)
Average class size per school						-0.004 (0.003)		0.003 (0.004)
% of teachers with university degree per (treated) school							-0.035 (0.048)	0.038 (0.027)
Observations	52	52	52	43	52	52	48	40
R-squared	0.087	0.004	0.095	0.161	0.176	0.037	0.013	0.196

*Notes: Dependent variable in Panel A is the percentage of completed sessions per (treated) school, which is an average of the percentage of completed sessions of all the (treated) classes in each school. Dependent variable in Panel B is the percentage of completed training sessions for teachers per (treated) school, which is an average of the percentage of completed training sessions attended by teachers of all the (treated) schools. Each column shows the correlation between the dependent variable and some potential determinants. Robust standard errors in parentheses.*

Table 4  
Educational outcomes by groups (standardized effects)

	Boys	Girls	Rural	Urban	Spanish	Quechua	Bilingual
Mathematics	0.02	-0.04	-0.37	0.09	0.15	-0.46	-0.31
Cognitive ability	0.04	-0.05	-0.28	0.08	0.15	-0.36	-0.28
Writing	0.01	-0.01	-0.59	0.16	0.22	-0.64	-0.42
Oral comprehension	0	-0.01	-0.4	0.11	0.17	-0.44	-0.36
N	1529	1397	623	2303	1809	393	243

*Notes: Baseline average deviation from the sample mean of each subgroup for different outcomes. Standardized effects for the complete sample. Data comes from the Mimate program.*

Table 5  
Sample Balance, Baseline Survey

	Treatment	Control	Difference	t-stats
<b>Panel A: Students sample</b>				
Score on baseline math	-0.04	0.03	-0.07	-0.83
Score on baseline cognitive	-0.08	0.08	-0.16	-1.31
Score on baseline writing	-0.07	0.08	-0.15	-1.24
Female	0.52	0.43	0.09	3.00
Attended preschool age 3 and 4	0.86	0.84	0.02	0.66
Speaks Quechua at home	0.19	0.18	0.01	0.08
Attends a rural school	0.21	0.21	0.00	-0.04
Age	5.00	5.03	-0.03	-0.44
SES index	2.92	2.94	-0.02	0.12
Has help at home to do homework	0.73	0.71	0.02	0.55
F test (p-value)	0.20			
<b>Panel B: Teachers sample</b>				
Age	41.02	38.61	2.41	1.49
Female	1.00	1.00	0.00	0.00
College Degree	0.61	0.58	0.03	0.30
Tenured	0.63	0.57	0.06	0.61
Union Member	0.22	0.28	-0.06	-0.56
Teaches mostly using Quechua	0.16	0.23	-0.07	-0.79
Rural	0.39	0.43	-0.04	0.35
F test (p-value)	0.41			
<b>Panel C: Parents sample</b>				
Father lives with kid	0.75	0.73	0.00	0.11
Mother education	0.21	0.25	-0.04	-1.30
Father Unemployed	0.10	0.11	-0.01	0.76
Has educational books at home	0.73	0.75	-0.02	-0.52
Parenting (index)	3.96	4.01	0.02	0.66
Child expected education (index)	4.08	4.12	-0.04	-0.24
Family income	697	682	14	0.15
F test (p-value)	0.68			

Table 6  
Effects on Mathematics Outcomes

<b>Panel A: Short-term effect</b>					
Dependent Variable	Overall Test	Shapes Items	Numeracy Items	Overall Test	Overall Test
	(1)	(2)	(3)	(4)	(5)
Treatment	0.10 (0.03)	0.12 (0.04)	0.10 (0.03)		
Share of Completed Sessions				0.15 (0.05)	0.14 (0.05)
Controls	Yes	Yes	Yes	Yes	Yes
Estimation Method	OLS	OLS	OLS	OLS	IV
Observations	2400	2400	2400	2152	2152
<b>Panel B: Medium-term effect</b>					
	Overall Test	Shapes Items	Numeracy Items	Overall Test	Overall Test
	(1)	(2)	(3)		
Treatment	0.00 (0.03)	0.06 (0.03)	-0.03 (0.05)		
Share of Completed Sessions				0.00 (0.02)	0.00 (0.02)
Controls	Yes	Yes	Yes	Yes	Yes
Estimation Method	OLS	OLS	OLS	OLS	IV
Observations	2416	2416	2416	1895	1895

*Notes: Standard errors corrected for heteroskedasticity and intra-cluster correlation at school level in parenthesis. Data comes from the Mimate program.*

Table 7  
Effects on Mathematics Outcomes: Robustness Checks

<b>Panel A: Short-term effect</b>			
Dependent Variable	Overall Test	Shapes Items	Numeracy Items
	(1)	(2)	(3)
Treatment, IPW	0.11 (0.04)	0.12 (0.05)	0.10 (0.04)
Upper and Lower Lee bounds	0.09;0.13	0.08;0.12	0.08;0.10
Confidence Interval	[0.06,015]	[0.05,016]	[0.05,014]
Controls	Yes	Yes	Yes
Observations	2399	2399	2399
<b>Panel B: Medium-term effect</b>			
	Overall Test	Shapes Items	Numeracy Items
	(1)	(2)	(3)
Treatment, IPW	-0.01 (0.01)	0.05 (0.04)	-0.05 (0.05)
Upper and Lower Lee bounds	0.00; 0.00	0.03; 0.06	-0.02;0.00
Confidence Interval	[-0.01;0.01]	[0.01;0.09 ]	[-0.06,0.04]
Controls	Yes	Yes	Yes
Observations	2416	2416	2416

*Notes: Standard errors computed using block bootstrapping at school level in parenthesis. Data comes from the Mimate program.*

Table 8  
Effects by items of the EGMA test

Panel A: Short-term effect				Panel B: Medium-term effect			
Dependent variable	Coefs.	Significance level		Dependent variable	Coefs.	Significance level	
		Unadjusted	List et al			Naïve	List et al
<b>Understanding shapes</b>							
Geometric shapes	0.20	***	***	Geometric shapes	0.16	***	***
Shape recognition	0.14	**	**	Shape recognition	0.07		
Spatial ability	0.13	**	*	Spatial ability	-0.08		
Symmetry	0.10			Symmetry	0.09	*	
Figure sequence	0.07						
Reproduce figures	0.07			Reproduce complex figures	0.07		
<b>Numerical Literacy</b>							
Number selection	0.18	***	***	Number selection	0.01		
Additive composition	0.15	***	***	Additive decomposition	-0.02		
Oral counting	0.11	***	**	Oral counting	-0.02		
Addition and subtraction word problems	0.12	*		Addition and subtraction problems	0.00		
Comparing quantity	0.10	*		Comparing quantity	-0.08		
Naming numbers	0.09	*		Naming numbers	-0.07		
Advanced numeration	0.08			Advanced numeration	0.02		
Number sequence	0.07			Ordering numbers	-0.05		
Comparing numbers	0.05			Comparing numbers	-0.06		
Basic numeration	0.02			Number sequence	0.03		
				Previous and subsequent	-0.01		
				Measurement units	-0.07		
				Writing numbers	-0.03		

Notes: Unadjusted corresponds to standard significance levels of the individual regressions, List et al. corresponds to the List et al. (2016) correction for multiple hypothesis testing. Data comes from Mimate program. Significance levels: \*10%, \*\*5%, \*\*\*1%

Table 9  
Heterogeneous effects: Overall index

Subgroup(s):	Female	1- Quechua 2-Both	High socio- economic level	Urban	Section size	Teacher w/ university title
	(1)	(2)	(3)	(4)	(5)	(6)
<b>Panel A: Short-term effect</b>						
	Mathematics					
Treatment	0.11 (0.04)	0.08 (0.04)	0.11 (0.04)	0.15 (0.07)	0.16 (0.11)	0.04 (0.05)
Subgroup 1 x Treatment	-0.00 (0.03)	0.05 (0.08)	-0.02 (0.02)	-0.06 (0.08)	-0.00 (0.00)	0.11 (0.06)
Subgroup 2 x Treatment		0.10 (0.06)				
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2399	2216	2361	2399	2234	1901
<b>Panel B: Medium-term effect</b>						
	Mathematics					
Treatment	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.01 (0.03)	0.01 (0.03)	-0.05 (0.05)
Subgroup 1 x Treatment	0.01 (0.01)	0.01 (0.03)	0.01 (0.01)	-0.01 (0.03)	-0.00 (0.00)	0.12 (0.06)
Subgroup 2 x Treatment		0.02 (0.03)				
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2416	2202	2256	2416	2293	1808

*Notes: All columns control for baseline score, school locality, test giver. Only column (2) considers two subgroups and two interactions: Quechua speaking household and household that speak Quechua and Spanish equally. Section size in column (5) is a continuous variable. Standard errors corrected for heteroskedasticity and intra-cluster correlation at school level in parenthesis. Data comes from the Mimate program.*

Table 10  
Effects according to baseline mathematics quantiles

<b>Panel A: Short-term effect</b>			
	<i>Overall</i>	<i>Shapes</i>	<i>Numbers</i>
	(1)	(2)	(3)
q10 Treatment	0.12 (0.04)	0.15 (0.04)	0.16 (0.04)
q25 Treatment	0.14 (0.03)	0.15 (0.02)	0.13 (0.03)
q50 Treatment	0.09 (0.01)	0.13 (0.02)	0.09 (0.02)
q75 Treatment	0.08 (0.02)	0.08 (0.03)	0.05 (0.02)
q90 Treatment	0.04 (0.02)	0.05 (0.03)	0.05 (0.02)
Controls	Yes	Yes	Yes
Observations	2399	2399	2399
<b>Panel B: Medium-term effect</b>			
	<i>Overall</i>	<i>Shapes</i>	<i>Numbers</i>
	(1)	(2)	(3)
q10 Treatment	-0.03 (0.04)	0.02 (0.03)	-0.04 (0.05)
q25 Treatment	-0.01 (0.04)	0.02 (0.03)	-0.03 (0.02)
q50 Treatment	-0.02 (0.02)	0.03 (0.03)	-0.01 (0.03)
q75 Treatment	0.03 (0.02)	0.07 (0.03)	0.00 (0.02)
q90 Treatment	0.03 (0.03)	0.10 (0.06)	-0.01 (0.02)
Controls	Yes	Yes	Yes
Observations	2416	2416	2416

*Notes: Standard errors corrected for heteroskedasticity and intra-cluster correlation at school level in parenthesis. Data comes from the Mimate program.*

Table 11  
Effects on Other Learning Outcomes

	Cognitive abilities	Writing
	(1)	(2)
<b>Panel A: Short-term effect</b>		
Treatment	0.06 (0.08)	-0.02 (0.05)
Controls	Yes	Yes
Observations	2387	2365
<b>Panel B: Medium-term effect</b>		
Treatment	0.030 (0.059)	0.031 (0.060)
Controls	Yes	Yes
Observations	2,111	2,068

*Notes: Standard errors corrected for heteroskedasticity and intra-cluster correlation at school level in parenthesis. Data comes from the Mimate program.*

Table 12: Teacher Survey: Differences in Averages

	Complete sample	Teachers with university degrees	Teachers without university degrees
Panel A: Teaching Practices and Resources			
I think the way I teach math is the best	0.06	0.08	0.03
You must teach reading and writing before learning math in Initial	0.00	0.04	-0.08
Mathematics is too abstract for children from Initial	0.03	0.06	-0.04
It is enough to teach the numbers and the forms in Initial	-0.03	-0.02	-0.03
Free play is the best way for children to learn math	0.05	0.03	-0.01
It is not necessary to do math assessments in children in Initial	0.01	0.03	0.00
Children of initial age have very basic mathematical skills	0.00	-0.03	0.10
Children have fun learning math	0.05	0.11 **	-0.01
Mathematics tires children	0.04	0.06	-0.01
Mathematics must be taught in initial	0.04	0.08 *	-0.06
The learning of mathematics is very important for citizenship training	0.05	0.05	0.00
I dedicate enough time to teaching mathematics, I cover the objectives	0.11 **	0.15 **	0.03
I feel properly trained to teach math	0.07	0.06	0.06
To teach mathematics is not enough to know the content	-0.08	-0.05	-0.14
For me it is easier to teach language than mathematics	-0.01	0.06	-0.15
I have enough time to address all the dimensions of the curriculum	0.11 *	0.20 **	0.01
I have no difficulties when it comes to structuring math classes	0.05	0.06	0.06
I find it difficult to teach math in Initial	0.01	0.04	-0.04
I would like to learn new ways to teach math	-0.03	0.00	-0.10 *
Teaching math bores me	-0.01	0.01	-0.04
I have the necessary teaching resources	0.07	0.10	0.08
I have adequate advice and pedagogical supervision	0.10 **	0.14 *	0.11
In my classes I include games, activities that involve all students	0.05 *	0.08 ***	0.05
Panel B: Perceptions about Students			
The students have good behavior	0.08 **	0.11 *	0.09
They have abilities to learn	0.10 **	0.15 **	0.10
They know how to work in a team	0.04	0.02	0.06

They are very interested in learning	0.04	0.05	0.03
They have very good assistance	0.03	-0.01	0.12 *
They have problems of concentration in the assigned work	-0.09	-0.05	-0.16
They can learn any concept that they are taught	0.10 **	0.15 **	0.03
They have good performance in mathematics	0.11 ***	0.15 **	0.03
Panel C: Perception on Gender Differences			
No gender differences in discipline problems	0.17 **	0.13	0.23
No gender differences in need of help from teacher	0.22 **	0.15	0.24
No gender differences in ability to pay attention in class	0.11	-0.04	0.28 *
No gender differences in ability to follow instructions	0.28 ***	0.16	0.42 ***
No gender differences in performance in mathematics	0.26 ***	0.21 *	0.41 ***

Notes: Estimates corresponds to a test of differences in average for the treatment and control group in each sample. Significance levels: \*10%, \*\*5%, \*\*\*1%