THE IMPACT OF AKSHARA GANITHA
A LONGITUDINAL STUDY
2012–13 TO 2014–15

RESEARCH AND EVALUATION
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Executive Summary

The position paper on Teaching of School Mathematics in India envisages the mathematics curriculum as appropriate when children learn to enjoy mathematics, use the techniques of mathematics, consider mathematics as a medium to communicate and work together, relate the curriculum to their life experiences, and use abstractions to perceive relationships and structure. However, the field reality depicted by several surveys and reports shows that despite a significant increase in the resources spent on primary schooling in India, improvements in mathematics learning have been difficult to achieve. Most of the learning outcome surveys have revealed low student scores year after year, with the majority failing to achieve the expected competencies.

It was against this paradoxical context that "Akshara Ganitha," an elementary school mathematics program, was developed by Akshara Foundation, an education NGO based in Bangalore, in the South Indian state of Karnataka. The crux of the program was to provide hands-on experience in mathematics teaching and learning with the aid of tactile and concrete teaching-learning materials to empower mathematics teachers of Grades 1–5 with resourceful strategies and to make children mathematically literate. The program follows a pedagogical strategy involving three stages, viz., concrete, representational, and abstract learning in mathematics. The TLMs designed are expected to help the teacher cover all the concepts specified in teaching mathematics up to Grade 5. The program is aligned to the text books prescribed by the Government of Karnataka.

Akshara Ganitha also aimed to ensure that the key objectives of teaching mathematics laid down by the National Curriculum Framework-2005 (NCF 2005) and the Karnataka State Curriculum Framework where achieved. The program has been implemented for four consecutive years targeting Grades 1 to 5 in all the government primary schools of three educational blocks, Hoskote, Kustagi, and Mundargi, in Karnataka.

This report outlines the findings of a longitudinal study conducted by Akshara Foundation in Hoskote Block of Bangalore Rural district. The study employed a controlled before-and-after design to compare the effectiveness of the program on the learning outcomes of the children, the classroom practices, and teacher behavior. The sample of two clusters was drawn from two educational blocks, Hoskote (treatment block) and Devanahalli (control block). All the schools of the two clusters were considered as the sample for the study. Nine assessments across three academic years were conducted for data collection on the learning outcomes and classroom behaviors.

The findings showed that the program led to gradual positive improvements in the students' scores from marginal to high levels during the study period. The percentage score ranged from 8–46 percentage points in 2012–13, 14–46 percentage points in 2013–14, and 7–35 percentage points in 2014–15 across all grades. The cohort analysis showed that greater the exposure to the program, the larger was the benefit in terms of scores on the learning outcomes. With reference to classroom behaviors, the study found a transition from low to effective usage of teaching learning materials by the teachers and children owing to the support of Akshara's field staff and repeated orientations across the three years. Finally, the findings suggested that classroom based pedagogical support can be a viable tool in enhancing teachers' abilities for teaching and for supporting students' learning.

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Section I
Introduction

Akshara Ganitha, Akshara Foundation's mathematics program, is a multi-year initiative aimed at improving the mathematics competencies of primary school students through the use of new pedagogy and classroom resources. The program was initiated in the summer of 2011 in all 257 government primary schools in 20 clusters in the Hoskote block, Bangalore Rural District.

This report examines the effectiveness of the program by employing a controlled before-and-after research design[1] (similar to a randomized controlled trial). One cluster each, from two neighboring educational blocks of Hoskote (treatment block) and Devanhalli (control block), were drawn for the stratification. A cluster is an educational administrative unit that caters to a set of 10–12 schools with time to time academic inputs. A Cluster Resource Centre, headed by a Cluster Resource Person, plays a major role in providing academic inputs to the schools under its jurisdiction. Therefore, the present study included all the schools from these two selected clusters in the sample. Based on the secondary data (District Information System for Education(DISE) the schools of the selected clusters were compared, and compatibility in terms of number of schools, number of teachers, and basic infrastructure was examined and found compatible before finalizing the clusters.

The two selected clusters for the study were the Sulibele cluster of Hoskote block and the Boodigere cluster of Devanahalli block, as treatment and control groups, respectively. The Akshara Ganitha program was implemented in the treatment schools and was not implemented in the control schools. The controlled before-and-after design allowed the study to compare the effectiveness of the program in terms of the learning outcomes of the children, the classroom practices, and some aspects of teacher behavior.

The main hypothesis that guided the present study was that of examining the Akshara Ganitha program's philosophy of fostering a constructivist environment centered on pedagogy, and provision of supportive Teaching-Learning Material (TLM) coupled with capacity building. The study examined whether the program could achieve its objective of impacting the mathematics learning of children. Factors affecting mathematics learning, such as children's exposure to tactile, concrete TLMs for hands-on experience, co-operative learning strategies, and teacher's facilitation capacity were expected to yield improvements in the learning outcomes of children.

To verify the above hypothesis, the study designed nine tools across three academic years, to test the learning outcomes and classroom behavior of the children. The tools were applied to both treatment and control groups. The students in the treatment and control schools were tested for three years and the mathematics classrooms were observed in both the groups. The data was collected by Akshara's staff and hired field investigators, across three cycles each, in each academic year from 2012-13 to 2014-15.

Before examining the empirical findings of the study in later part of the report, Section 1 lays out the context, background and philosophy, and implementation strategy of the Akshara Ganitha program, followed by Section 2 that unfolds some of the hard facts/realities inside the schools

[1] In this design, observations are made before and after the implementation of the intervention, both of a treatment group that receives the intervention, and of a control group that does not.

and classrooms to form an important backdrop for analyzing the impact of the Akshara Ganitha program. This is followed by an analysis of the learning outcomes of the children in Section 3, and a case study in Section 4. The findings from all the data points are expected to provide a comprehensive understanding of the program implementation, leading to concluding observations. The final section concludes with a summary of the findings, a brief look at the limitations of the study, and a post-script on the scaling up of the program.

1.1 Intervention Methodology

The position paper (2005)[2] on Teaching of School Mathematics in India considers a mathematics curriculum appropriate when children learn to enjoy mathematics, learn to use the techniques of mathematics, view mathematics as a medium to communicate and work together, relates to their life experiences, and uses abstractions to perceive relationships and structure.

However, the field reality depicted by several surveys and reports like the Annual Status of Education Report-2014 (ASER, 2014) shows that children of primary schools in rural India, including Karnataka, lag behind in terms of basic arithmetic abilities. The data reveals, 83 per cent of the children in Grade V could not solve division problem and 64 per cent of the grade IV children could not solve subtraction problem. Despite the significant increase in the resources spent on primary schooling in India, improvements in mathematics learning have been difficult to achieve.

The National Curriculum Framework (NCF) 2005 identifies the main goal of teaching mathematics as the 'mathematization of the child's thinking.' Mathematization refers to a child's ability to solve real world problems using mathematical concepts. This needs a shift from the rote method of learning to one that emphasizes on facts and procedures for achieving conceptual clarity and an ability to apply mathematics to solve real world problems. This requires building capacities not only in content areas such as arithmetic, geometry, etc., but also in mathematical processes such as formal problem solving, use of heuristics, estimation and approximation, optimization, use of patterns, visualization, representation, reasoning and proof, making connections, and mathematical communication. The NCF's vision for mathematics teaching is one that is fun, meaningful, and connected to real life, where every child learns effectively. This calls for a change in the mathematics pedagogy, teacher capacity building, and change in the modes of assessment.

Karnataka has adopted this vision of the NCF 2005. For Lower Primary Classes (Grades 1–5) it suggests a progression from concrete to abstract concepts. It is important that activities with concrete objects form the first step in the classroom to enable the child to understand the connections between the logical functioning of their everyday life to that of mathematical thinking. This is especially true for the lowest classes. While addressing number and number operations, due place must be given to the non-number areas of mathematics. These include shapes, spatial understanding, patterns, measurement, and data handling.

It was against this context that Akshara Ganitha, an elementary school mathematics program, was developed by Akshara Foundation, a NGO working in the field of education, based in

[2] Author Name, *Position Paper, NCF 2005*, National Focus Group: Teaching of Mathematics.

Bangalore, in the South Indian state of Karnataka. The program was designed across four verticals: the pedagogy, tactile teaching-learning aids aligned to the state curricula (Annexure 1), capacity building, and field support. The crux of the program was to provide hands-on experience in mathematics teaching and learning with the aid of tactile and concrete TLMs to empower mathematics teachers of grades 1–5 with resourceful strategies and to make children mathematically literate.

The vision of Akshara Ganitha is aligned with that of NCF 2005 regarding the teaching of mathematics and with the mathematics syllabus of the Karnataka state board. Additionally, the program's methodology aligns with the *Nali-Kali* philosophy of child-centric activity learning.

1.2 The pedagogical strategy

Akshara Ganitha is an attempt to achieve a fundamental shift in the mathematics teaching and learning methods while maintaining links with the government's syllabus and its priorities. To facilitate this, the intervention uses a combination of training teachers in new pedagogical methods and the provision of new learning materials to schools. The program covers all the topics that are in the current government-recommended syllabus of grades 1 to 5. Additionally, the TLMs designed for the program were expected to help the teacher to cover all the concepts related to mathematics that are taught up to Grade 5 in government primary schools in Karnataka. Furthermore, the pedagogy is aligned to the recommendations of the Karnataka State Curriculum Framework 2005 and the text books prescribed by the government.

The program followed a pedagogical strategy addressing the three stages in learning mathematics, viz. concrete, representational, and abstract learning. The pedagogy propagates constructivist practice based on Brunner's principle of Concrete-Representational and Abstract (CRA) steps. In the concrete stage, the teacher facilitates the understanding of concepts through the extensive usage of Teaching-Learning Materials, in this case, the Akshara Ganitha Kit and the activities designed to be conducted using the manipulators provided in the kit. This stage is followed by the representational stage, which is accomplished by using square-ruled books. Here, the focus moves from conceptual clarity to procedural fluency. The abstract stage involves the effective use of the prescribed textbook. Here, the children progress using mathematical symbols and notations successfully, and apply their learning to real life situations through word problems and real-life problem solving, finding patterns, mental mathematics, and understanding of approximations and estimates.

The teaching-learning process facilitated through the Akshara Ganitha program can also be divided into three overlapping categories based on the elements of the teaching-learning process: understanding by doing, co-operative learning, and continuous evaluation. While understanding by doing is achieved by the hands-on teaching-learning strategies used in the program, in co-operative learning, the teacher introduces a concept to the class and the students explore it and self-reinforce the lesson by participating in activities using the concrete materials, conducted in groups of 4–6 children. Co-operative learning shifts the emphasis of teaching mathematics away from rote learning onto the students' exploration and discovery of concepts by themselves, under the guidance of the teacher. Thus, the focus is to help more students learn mathematics in a team by giving importance to peer learning.

Continuous evaluation is designed to act both as a test of the students' progress and as a mechanism for reinforcing the concepts covered. After the introduction of a set of linked concepts, the students' understanding is assessed through hands-on group exercises and inter-

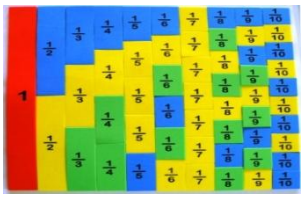
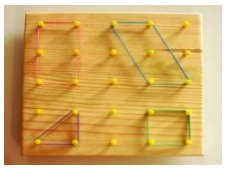
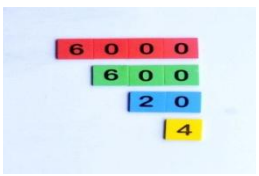
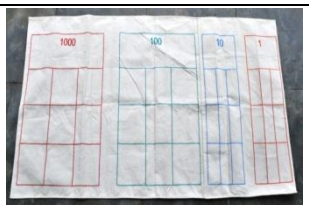
group quizzes during chapter-end evaluations. Additionally, workbooks are designed for the individual practice of the concepts and for conducting representational exercises in the classroom.

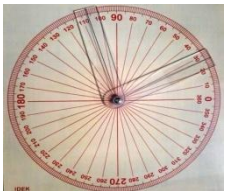
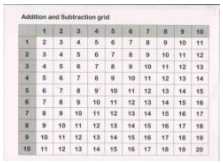
Akshara Ganitha's Teaching-Learning Materials

Teacher's Manual: This contains instructions for teachers to facilitate learning using the concrete materials, for each grade. It also encompasses the main framework of teacher training with a focus on refreshing mathematical concepts and imparting remedial education.

Mathematics Kit: This comprises concrete materials to introduce all the concepts in the lower primary mathematics syllabus and to reinforce them through co-operative learning activities. As shown in Section 1.3, the kit includes an abacus, replica currency, a series of 2D and 3D shapes, plastic counters, scales, a cardboard clock, a protractor, a number line with division blocks, a measuring kit, and slates with grids for sums. The concepts covered in this program, with reference to the TLMs have been described in Section 1.4.

1.3 The Akshara Ganitha mathematics kit

 Abacus	 Fraction strips	 Base 10 Blocks	 Geo Board
 Clock	 Counters		 Flash Counter Board
 Dice	 Measuring tape	 Number line	 Elementary pattern blocks
 Place value strips	 Place value mat	 Tangrams	 Play Money(currency)

 Compass and protractor	 Addition/ Subtraction and Multiplication Grid	

1.4 The mathematics kit: Concepts covered

		Counters	Number Line	Number Cards	Base 10 Blocks	Currency	Abacus	Place V. Grid	Boards	Procedure Grid	Dice	Rope & Clips	Fraction Strips	Decimal Strips	2D Shapes	3D Shapes	Tan gram	Elem. Ptn.	Geo Board	Measure Tape	Protractor	Volume Meas.	Clock	Weigh Scale	Work Cards	Manuals
Grade 1	Numbers (1 digit)	X	x	x	x	x																			x	x
	Numbers (up to 20)	X	x	x	x	x																			x	x
	Numbers (2 digit)		x	x	x	x	x	X	x																x	x
	Add/subtract up to 20				x	x			x		x														x	x
	Mental add/subtract																									x
	Linear and block patterns														x		x	x							x	x
	Money denominations					x																			x	x
	Comparing length											x								x					x	x
	Non-standard length measurement											x								x					x	x
	Comparing weight																							x	x	x
	Time sense																								x	x
Grade 2	Add/subtract till 100				x	x	x		x		x														x	x
	Geometric properties														x	x									x	x
	Line properties																								x	x
	Shadows														x			x							x	x
	Comparing volume																					x			x	x
	Collecting data	x			x																				x	x
Grade 3	Numbers (till 1000)				x	x	x		x																x	x
	Add/subtract procedure				x	x			x	x	x														x	x
	Multiply/divide concept				x	x			x																x	x
	Multiplication procedure				x	x			x	x															x	x
	Add/subtract mentally																									x
	Estimate add/subtract																								x	x
	2D shapes properties														x				x						x	x
	Maps																								x	x
	Money calculations					x																			x	x
	Standard length measurement and calculation																			x					x	x
	Non-standard weight measurement																							x	x	x
	Non-standard volume																					x			x	x
	Clock and calendar																						x		x	x
	Tally marks and pictographs	x																							x	x
Grade 4	Mental multiplication by splitting																									x
	Estimated multiplication/division																								x	x
	Circle properties														x										x	x
	3D shape properties															x									x	x
	Views															x									x	x
	Reflections														x			x	x						x	x
	Area/perimeter Concept																		x						x	x
	Standard weight measurement and calculation																							x	x	x

	Table Contd..	Counters	Number Line	Number Cards	Base 10 Blocks	Currency	Abacus	Place V. Grid	Boards	Procedure Grid	Dice	Rope & Clips	Fraction Strips	Decimal Strips	2D Shapes	3D Shapes	Tan gram	Elem. Pm.	Geo Board	Measure Tape	Protractor	Volume Meas.	Clock	Weigh Scale	Work Cards	Manuals
	Standard volume measurement and calculation																					x			x	x
	Elapsed time and calculation																						x		x	x
	Bar graphs	x																							x	x
Grade 5	Numbers beyond 1000			x	x	x	x	X																	x	x
	Column division				x	x																			x	x
	Factors/multiples																								x	x
	Fractions/decimals											x	x	x			x	x	x	x		x			x	x
	Angles																				x				x	x
	Symmetry														x	x		x		x					x	x
	Perspectives																								x	x
	Rotations														x			x							x	x
	2 dimension tables																								x	x
	Menstruation																		x						x	x

1.5 Capacity building

Akshara's training aims to enhance teachers' skills and knowledge, aid their professional development, and make them competent and efficient instructors. Its goal is to improve teachers' capability and output. Akshara Ganitha's training incorporates these features as well as classroom simulation techniques that provide "as close to the real thing" kind of experiences and memorable learning.

Capacity building of mathematics teachers as a part of the Akshara Ganitha program was designed as introductory 3-day training for primary mathematics teachers in the Hoskote block, using the cascade model. This is a multi-layered training pyramid in which the apex comprises Resource Persons identified by the government from among a pool of expert teachers whom Akshara personnel trained. These Resource Persons in turn trained the mathematics teachers at the cluster level. Using the cascading model was beneficial because it lowered the costs for Akshara in terms of direct training time, and because it facilitated the embedding of the new methodology and the necessary teacher training practices directly into the existing systems of the Education Department, Karnataka.

The training structure focused less on theory, and was hands-on and interactive. The teachers were made to work in groups and make presentations on how to use TLMs, create activities around the TLMs, and practice the Akshara Ganitha pedagogic strategy. The training covered all the lower primary school mathematics concepts, introducing teachers to the philosophy, methodology, and use of TLM in the first year (2012–13). This training was activity based, focusing on conceptual understanding.

In the subsequent years, the training component was incorporated in the routine in-service trainings designed by the Directorate of State Education and the Research Training wing of the Education Department as a part of the Sarva Shiksha Abhiyan training sessions. Additionally, during all the three years, the field co-ordinators of Akshara supported the implementation at the school level. These inputs were provided to all the schools of the Hoskote block (including the schools of the Sulibele cluster, which comprised the sample of the present study).

Thus, to aid their professional development, teachers were trained for three days in 2012, with a day's refresher training in the middle of the academic year. However, in 2013 and 2014, Akshara's teams trained teachers for half a day. Akshara's field staff extended follow-up support when the teachers asked for it during the course of the three years. Overall, the training concentrated on refreshing the teachers' knowledge of mathematics concepts and pedagogy, and introduced the program's teaching materials. It empowered the teachers to identify and utilize ways in which they could capitalize on co-operative learning in their classrooms.

1.6 Field support mechanism

The Akshara Ganitha program has an in-built field support mechanism. A "Field Co-ordinator" (FC) with professional qualification in education, sourced from the local community, is appointed by Akshara Foundation. At the block level, a Block Co-ordinator is appointed to manage the field staff and co-ordinate with the Block Education Officer and the Block Resource Co-ordinator of the Education Department. The FCs support the teachers at the school level during his/her visits and oversee the implementation of the program. Typically an FC supports an average of 20–25 schools and visits the schools under his/her jurisdiction twice a month as per the visit schedule prepared with the help of the Block Co-ordinator. During the field visits, the FC provides support to the teachers by clearing their doubts regarding the pedagogy, usage of the TLMs, etc. He/she also transfers unresolved issues to the program strategy team/resource team and conveys solutions to the teacher/s. The Block Coordinator of Akshara finally compiles the outcome details of the program and shares with the Block Education Officer of the government.

1.7 Expected outcomes of the program

The Akshara Ganitha was designed to help primary school teachers and children to get acclimatized to a constructivist pedagogy that utilizes activity based learning. The program was implemented in around 258 schools of Hoskote, 220 schools of Kustagi, and around 97 schools of Mundargi, in Karnataka. These schools were considered as test beds prior to proposing the State Government to scale up the program across all 45000 schools. Therefore, the effectiveness of the program was tested in the present study, the findings of which have been presented in the following sections.

Section II
The Study: Evaluating the Effectiveness of the Akshara Ganitha Program

2.1 Review of literature

The review of the literature showed that very few systematic studies exist in the area[3] of impact of innovative mathematics programs. It is evident from past research that children in government schools, particularly those in rural areas, are struggling to catch up with basic mathematics concepts. Most of the studies and surveys (NCERT Surveys, ASER Surveys, a study by Govind Pal[4]) focus on the learning achievement of children in mathematics, and not many studies have examined the impact of innovative mathematics programs on the learning achievements of children. Some studies (e.g., Heyneman and Loxley[5], Wu et al[6]) have concluded that student performance is determined by teacher quality, teacher training in the subject matter, and pedagogy.

There is a lack of consensus on what ensures better learning. The scale of the problem is often understated. Studies have shown that additional inputs like incentives, resources, and infrastructure can influence learning outcomes[7.] However, most long-term studies on learning outcomes provide little evidence on the classroom processes that ensure an understanding of the differential levels of children's learning skills. A study conducted in OECD[8] countries explicitly concluded that the learning outcomes in any setting are solely dependent on teacher efficiency and how teachers deliver the best possible instruction to each child[9.] Subramaniam (2003) explained that the poor state of mathematics education in India reflects the quality of the content of elementary mathematics taught in school and its pedagogy[10]. His study testified and suggested that "as long as instruction focuses on narrow learning outcomes and treats topics in a fragmentary manner, students will not have sufficient opportunities to achieve coordination of concepts." A study conducted by Lai *et al.* (2012) in the Chinese context showed that children who played computer mathematics games for 40 minutes, twice a week, to supplement their regular mathematics lessons exhibited an improvement in their mathematics scores by 0.14 standard deviations in just one term, with greatest improvements in children with the lowest initial scores or in those with less- educated parents.

A working paper published by 3ie in 2012, which examined the evidence from multiple studies, concluded that interventions providing additional teaching resources had a high impact on the full range of education outcomes. Additionally, teacher- and computer-assisted learning proved to be the most effective techniques.

However, Kremer et al. (2013) found that "providing additional inputs [to education] without changing pedagogy or governance has limited impact, whereas adapting teaching methods to reach the varied learning levels in developing countries is highly effective."

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[3] Rakhi Banerjee, Innovations and initiatives in mathematics education in India, *Dr. B . R. Ambedkar University, Delhi*
[4] Govind Pal, Teaching and Learning Mathematics in Primary School.
[5] Stephen Heyneman and William Loxley, "The Effect of Primary-School Quality on Academic Achievement Across Twenty-nine High- and Low-Income Countries," *The American Journal of Sociology* Volume (1983): 1174.
[6] Kin Bing Wu, Pete Goldschmidt, Christy Kim Boscardin and Deepa Sankar, "International benchmarking and determinants of mathematics achievement in two Indian states," *Education Economics,* 17: 3 (2009): 395- 411.
[7] Abhijit V Banerjee, Cole Shawn, Esther Duflo, and Leigh Linden. "Remedying Education: Evidence from Two Randomized Experiments in India" *Quarterly Journal of Economics* 122 (2007): 1235–64.
Paul Glewwe, Ilias Nauman and Michael Kremer, "Teacher Incentives," *American Economic Journal: Applied Economics 2 (July 2010): 205–227.*
[8] Organisation for Economic Cooperation and Development.
[9] http://www.oecd.org/edu/school/34990905.pdf
[10] First Name Subramaniam, "Elementary Mathematics: A Teaching-Learning Perspective." *Economic and Political Weekly*, Vol (2003): *3694-3702.*

To be implemented on a larger scale, any program needs to be supported by evidence; the present study was conducted to fulfill this need. Specifically, Akshara's research team designed a three year longitudinal study using the controlled before-and-after design, to compare the effectiveness of the new Akshara Ganitha pedagogy. This study involved quantitative and qualitative research methods at three different levels—the child, the classroom, and the teacher. This section discusses the research design, including the sampling methods, and the research tools employed in the present study. It ends with the limitations of this study and caveats encountered while collecting the data.

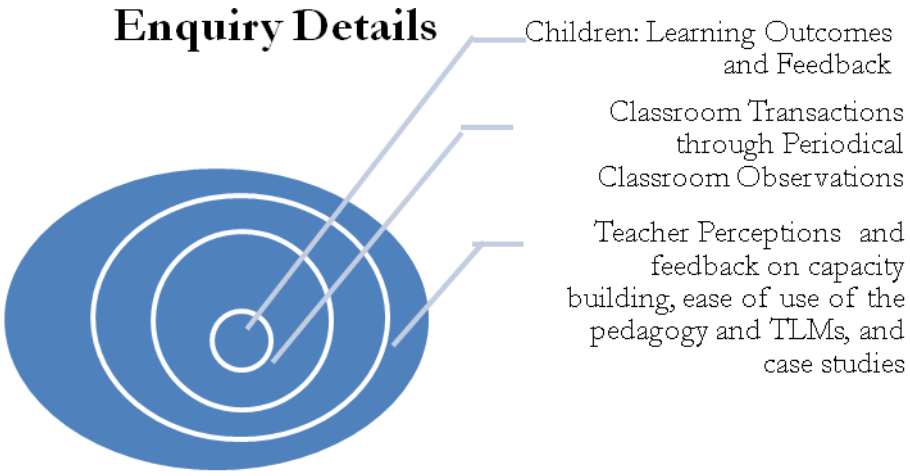
2.2 Study objective and research questions

The study was designed to test the hypothesis that Akshara Ganitha will impact the learning outcomes related to mathematics in the children of the schools where it was implemented. Therefore, the following research questions were framed to help investigate and collect evidence on the effectiveness of the program:

a. Did the teachers adapt to the pedagogical strategy of the Akshara Ganitha program and the usage of the Akshara Ganitha Kit?
b. Did Akshara Ganitha contribute to improvements in the mathematics learning outcomes of children?

2.3 Research methodology: The controlled before-and-after design

The methodology employed was a combination of both qualitative and quantitative methods. The framework followed was the Controlled Before-and-After Design, in which beneficiaries of Akshara Ganitha were compared with non-beneficiaries. Outcome variables were measured at the baseline, midline, and endline, in both treatment and control groups, to record the change before and after the intervention period. This research design can also be considered an experimental design since Akshara had control over the introduction of the intervention. Data on the schools, teachers, classroom processes, and learning outcomes was collected from the sample schools. The case study method was employed to facilitate an in-depth understanding of the complexities involved in implementing the program.



2.4 Data collection tools

The following data collection tools were used in accordance to the study objectives and research design:

1. **School and teacher information tool:** This tool was designed to collect data on school characteristics, such as the status of physical infrastructure of the school and classroom factors, as well as on teacher characteristics, such as the personal and professional details of teachers teaching mathematics.
2. **Classroom observation guidelines:** The classroom observation tools were developed to observe mathematics teaching in grades 1 to 5. Separate tools were developed for grades 1 to 3, the *Nali-Kali* classes[11] and for Grade 4 and 5. The observation guidelines were used to note characteristics of teaching, like teacher preparedness, the teaching-learning process, teacher-student relationships, teacher's competency, and ability to integrate the pedagogical strategies recommended by Akshara Ganitha.
3. **Competency-based student assessment tools:** Competency-based pen and paper tests were administered to all the students from grades 1 to 5. The test items included the mathematics competencies followed by the school curriculum in the course of an academic year. The questions were drawn from large, grade-appropriate question banks created and designed by primary and secondary school mathematics teachers. The tests were piloted before using them in the present study. The test competencies were unchanged across the nine cycles of testing.

2.5 Scope of the study

Akshara Ganitha was introduced in all the 258 schools of the Hoskote Educational Block of Bengaluru Rural District, located about 30 km from the district headquarters. The Hoskote block has around 20 clusters. and the present study was conducted in all the 10 schools of a cluster called "Sulibele." This was considered as the treatment cluster[12]. To measure the impact of the program, we selected all the schools (11) from a cluster called Boodigere, located in the adjacent block of Devanhalli, of the same district, to be included in the present study as the control group. Akshara Ganitha was not implemented in any of the schools of the control group.

2.6 Establishing the comparability of the control and treatment groups

In 2011–12, Akshara Ganitha was implemented for the students of Grade 4 and 5 in the Hoskote block. Teachers demanded that it be extended to the lower grades. Therefore, from 2012–13, the program covered all grades from 1 to 5.

Based on the data collected in 2011–12 for Grade 4 and 5, an analysis was carried out to determine if the treatment and control schools were comparable in terms of socio-economic, school, teacher, and student characteristics. While the comparisons on socio-economic characteristics were made across the blocks, for the rest of the parameters, the comparing units were the schools themselves, data for which was also collected in 2011–12.

[11] *Nali-Kali* is a a multi-grade, multi-level teaching-learning pedagogical environment implemented in all government primary schools in Karnataka.

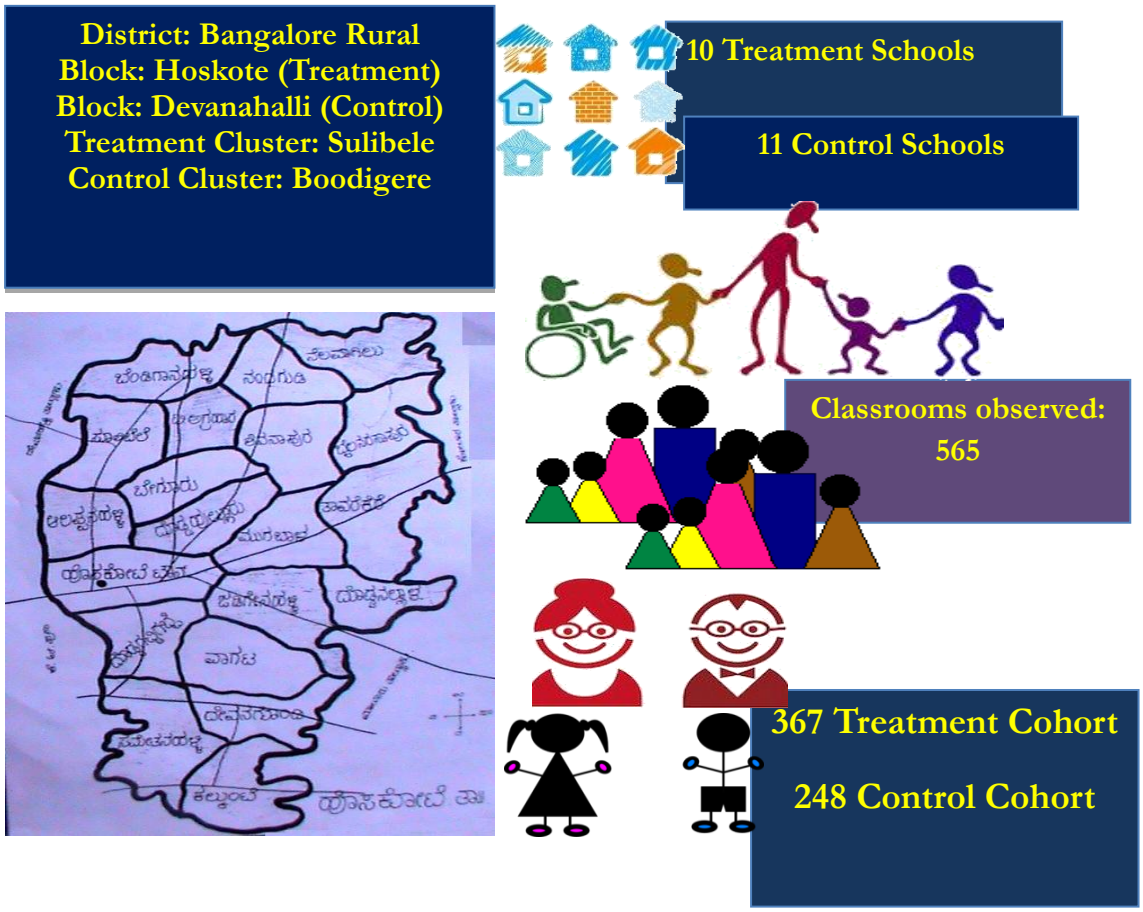
[12] In education administration, a cluster represents a set of schools that are overseen by a Cluster Resource Person.

Annexure 2 shows comparability of the treatment and control groups on a range of demographic and socio-economic variables. It was found that the only major difference was that the Hoskote block (treatment block) was a slightly more rural and more populous region as compared to the Devanahalli block (control block), where a higher proportion of the population belonged to scheduled tribes. In terms of household size, employment levels, and occupation, the two areas seemed well matched. Crucially, literacy rates in the two clusters were almost identical, thus reducing the concern regarding the confounding effects of differences in pre-existing educational levels participants from the two groups.

Annexure 3 shows the details of schools that were surveyed for the present study. Despite the re-organization of cluster boundaries in mid-2011, the data collection was restricted to the original 21 schools. An analysis was also carried out to compare the treatment and control schools using the baseline data collected on school facilities. Statistically significant differences were found between the treatment and control schools only in terms of the 47 school characteristics with reference to the Grade 4 data, and seven in the case of the Grade 5 data. Furthermore, for Grade 4, only 18 variables exhibited p-values of below 0.25, and the same was observed only in terms of 12 variables with reference to Grade 5. This suggests a strong probability that these samples were statistically identical along most vectors (Annexure 4).

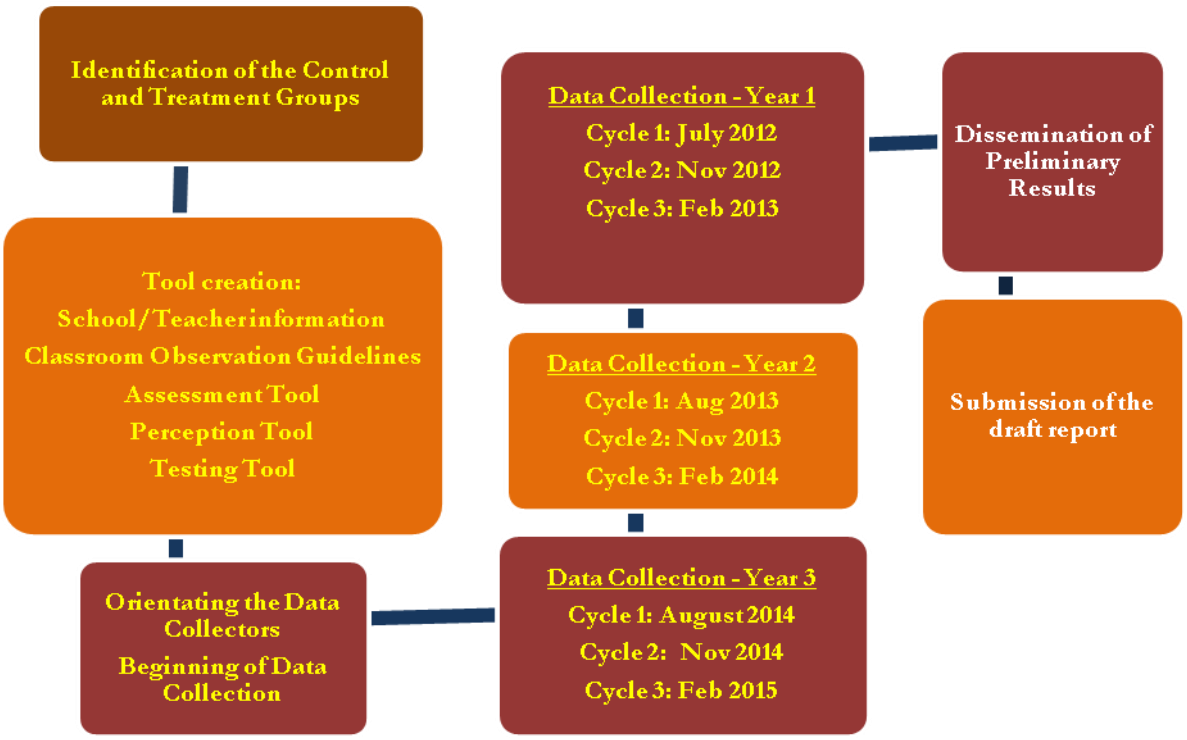
Annexure 5 shows that the teachers in the treatment schools were far more likely to be female and far less likely to have had teacher turnover since the mid-line test. The Grade4 treatment teachers were also more likely to have a BA, MA or D.Ed than did control teachers, and the Grade 5 treatment teachers were rated significantly lower than the control teachers at the end-line in terms of their overall lesson performance and conceptual understanding of mathematics. Annexure 6 shows that the Grade5 students in the control schools were significantly more likely to belong to the scheduled castes, scheduled tribes, or other backward castes.

2.7 The geographic and demographic details of the research site



2.8 The data collection process: The trail of research activities

The present three-year longitudinal study employed a data collection process that was distributed across nine cycles. The field investigators visited the treatment and control schools thrice a year. The school visits, classroom observations, and the testing of the children were scheduled as baseline, midline, and endline cycles in an academic year. Typically, the baseline data collection happened in the month of July, the midline in the month of November, and the endline towards February in each academic year that extended from June/July of a calendar year to March/April of the next calendar year. The children of grades 1–5 formed the cohorts of the assessment. The overall evaluation structure was based on two dominant aspects: child assessments and classroom observations. The tests were designed to measure the children's competencies related to number concepts, addition and subtraction, money handling, measurements, geometry, and data handling, which encompassed the competencies included in the school curriculum, taught with the aid of the Akshara Ganitha program.



A school is a place where one learns about the totality, the wholeness of life. Academic excellence is absolutely necessary, but a school includes much more than that. It is a place where both the teacher and the student explore, not only the outer world, the world of knowledge, but also their own thinking, their own behavior. *J. Krishnamurti*

Section III
Findings of the Study: The Public Schooling System

This section focuses on the realities of the public schooling system, the classroom environment in Karnataka in general, and that in the Akshara Ganitha intervention classes in particular. The section aims to provide an overview of the context in which the program was implemented.

3.1 Inside the schools and classrooms

Many education philosophers as well as the policy documents on school education in India envisage that learning takes place within a web of social relationships as teachers and pupils interact both formally and informally. Schools are institutional spaces for communities of learners, which include both students and teachers. The key persons contributing to character building in a school are the teachers and the headmaster, who plan and carry out daily routines, and the examinations and special events that mark the school calendar. Any intervention would eventually become part of school planning and the calendar. The degree of attention paid to organizing the school and classroom environment depends on a school's functionaries. A school's ecosystem consists typically of interactions; support for learning; enhancing the quality of teaching and learning; and nurturing the academic space in the context of children feeling safe, happy, and wanted, and of teachers finding it meaningful and professionally satisfying. The physical and psychological dimensions of the environment are important and interrelated. This section attempts to provide a broad picture of the schools under observation for the nine cycles of data collection, followed by specific observations on the intervention of Akshara Foundation.

Government-managed elementary schools in Karnataka have been categorized as lower primary schools (LPS), which comprise Grade 1 to 5, and higher primary schools (HPS), which comprise Grade 1 to 7. There is a lower primary school in a radius of one km and a higher primary school within three km. As per the Right to Education (RTE) Act a lower primary school must have a teacher for every 30 children. For the higher grades, it is required that a subject teacher be appointed in each school.

In reality, however, many of the RTE compliances may be difficult to achieve. For instance, if a higher primary school has less than 30 children spread across different grades, then the issue is the practical difficulty of appointing a subject teacher for Grade 6 and 7. As many surveys, including ASER 2014, have pointed out, small primary schools are a proliferating trend. This is more so the case in *hobli*[13] *head quarter* areas. As a result, the incidence of the single teacher in a multi-grade school is on the rise, which is a challenge.

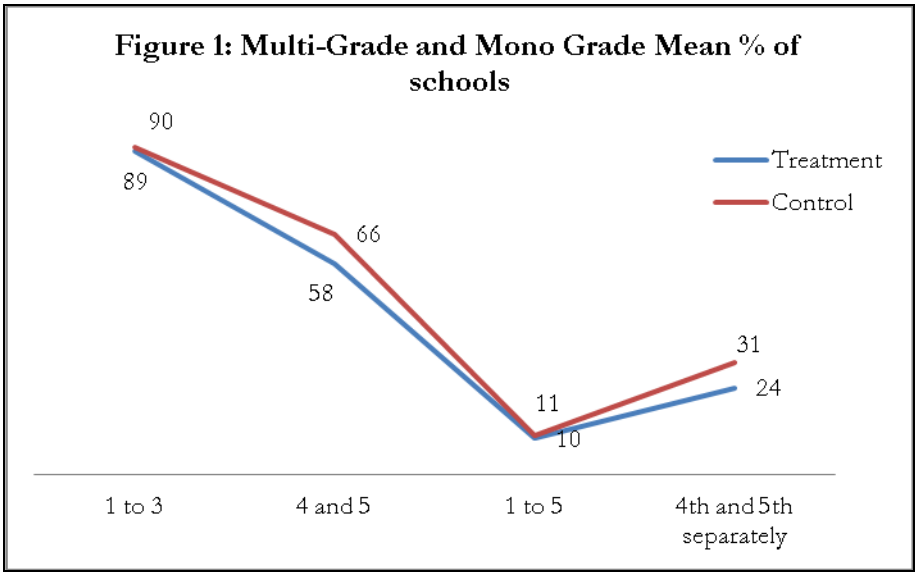
Single-teacher schools exist in all countries[14] irrespective of the level of economic and cultural development; it is certain that this type of school will exist in the future, although evidence shows that the number of such schools is reducing in developed countries. As per DISE 2015[15] around 12–14% of the primary schools in India are single-teacher schools. Multi-grade teaching is therefore a common necessity. Many teachers, even those with postgraduate qualifications,

[13] A hobli head quarter, is administrative head quarter of a cluster of adjoining villages administered together for tax and land tenure purposes

[14] UNESCO, Enhancing the effectiveness of single-teacher schools and multi-grade classes- Synthesis of case studies. Prepared by: Winsome Gordon and Lokisso Primary Education Section * Basic Education Division. Edited by: John Allen, UNESCO in collaboration with the Royal Ministry of Education Research and Church Affairs, Norway.

[15] DISE (District Information System for Education) 2014

face difficulties with multi-grade teaching. In the teacher training multi-grade teaching methods are not taken into consideration. While the issue of single-teacher schools has been recognized as a challenge, one does not see any national legislation or policy recommendations on handling this issue in training, in teacher incentivization, or in the curriculum that is followed. Often, these schools lack appropriate infrastructure and equipments that are aligned to multi-grade teaching. While the Nali Kali method is an example of multi-grade teaching, teachers are not trained with strategies on multi-grade teaching. The present study found that around 50% of the schools observed had multi-grade situations with a teacher handling grades 1 to 5, 1 to 4, or 4 and 5.



Our data from the nine cycles showed that around 90% of the schools in the treatment and control groups handled Grade 1, 2, and 3, which were merged according to the Nali Kali method. About 10–11% of the schools, one each in both the groups, were multi-grade schools, accommodating classes 1 to 5. Further, in around 60% of the schools, grades 4 and 5 were a combined class. Only 25–30% of the schools had separate classrooms and teaching transactions for 4th and 5th graders. This goes to prove that the situation at the local or ground level is different and complex, and that local monitoring, support, planning, and strategies may work effectively. We found a school where grades 1 to 5 were in a single classroom, and the teacher completely lacked focus, spent ten minutes with each class, and failed to capture the attention of any group of children. While she handled one group, the rest scattered all over and were not involved in any meaningful activity.

3.2 The school environment

Casting a net over the schools in the blocks provides an understanding of the ground reality. In the Hoskote block, around 80% of the government's primary schools had less than 30 children. A similar trend could be observed in the sample schools too. It was observed that 70% of the treatment schools and 45% of the control schools were higher primary schools. The average pupil-teacher ratio (PTR) was less than 1:20 in both the groups, as recorded during the last cycle of data collection. Out of the 11 schools in the control group, 60% had less than 30 children. Compared to this, 30% of the treatment schools had less than 30 students. Around 45% of the schools in the control group reported having playgrounds, as compared to 20% in the treatment group. Toilets did not seem to be an issue in both the groups of schools. Around 80% of the treatment schools and 65% of the control schools reported having a water connection. Nearly

70% of the schools in both treatment and control groups had access to transportation. However, some schools were located in interior rural areas, where access to public transportation was an issue. A majority of the teachers commuted 40 to 80 km a day.

The school scenario ranged between "close to ideal schools" to the "God save them" kind of schools. Some looked stage-managed, while some others had a "Don't care" attitude, irrespective of who visited the school. Everything depended on the school environment, school leadership, and the teacher's attitude. Often it was suspected that the observed schools were pre-arranged by the school staff to project a certain image. However, repeated observations were expected to neutralize this effect and reveal the real inside picture.

The School Bell

Some of the pedagogical disciplines include the timetable, lesson plan, and planning a school day or the sequence of events to be followed on a working day. The ringing of a **school bell** is a signal that tells students when to go to class in the morning and when it is time to change classes during the day. When the bell rings in the late afternoon, students are intimated that their school day is over. Typically the first bell tells students that it is time to report to class and the bell that rings shortly after means they are late. There may also be a warning bell between the first and the late bell, except in higher primary schools, where the school bell is a missing concept. Usually the school bell chimes thrice a day; for morning assembly, the midday meal, and at the time of closure. This may be due to a lesser number of teachers. Additionally, the visibility of a school is synonymous with the ringing of the school bell. It indicates a sense of time discipline among the school community. The concept of a bell is also an integral part of a majority of private schools. In fact, during an informal chat, some parents did mention that it is one of the indicators of a "good school."

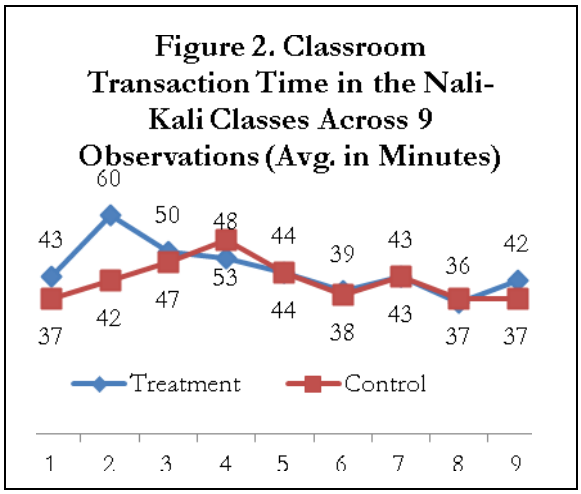
It is said that children constantly interact with the physical environment of their schools during their structured or unstructured time, consciously or unconsciously. Children perceive their world through multiple senses, especially the tactile and visual senses[16]. A three-dimensional space can offer a unique setting for a child to learn because it can introduce a multiple sensory experience to accompany the textbook or blackboard.

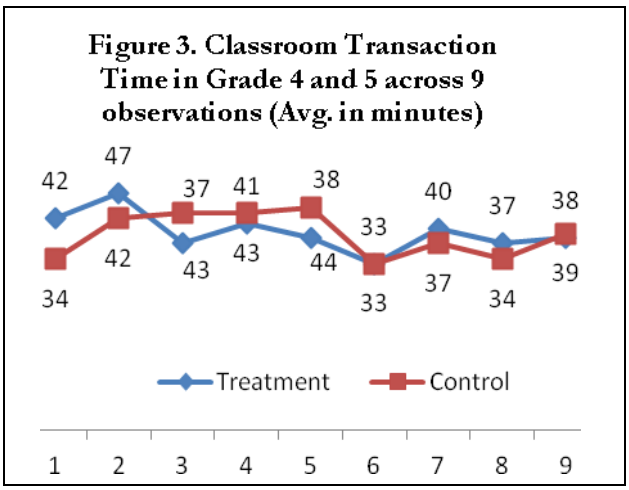
3.3 Teacher factors

Many surveys show that teacher absenteeism rates are high. The PROBE survey of 1999 found no or very little teaching activity happening in schools. A survey of rural India, conducted by Kremer et al. (2005) in 2003 found that, on an average, 25% of the teachers in government primary schools were absent on any given day. The current study showed that teachers were present in 80% of the control and treatment schools across the nine cycles. However, the disturbing factor was, in a majority of the schools, they would ask if a "class has to be taken" or "When do you want me to take the class?" or "For how many minutes should I take the class?" This clearly shows that despite the timetable being displayed in classrooms, teachers are ready to change their curriculum plans. It also shows that teaching activity has reduced to a minimum in terms of both time and effort. In most of the cases, it was just a question of minding children in a room rather than engaging with them in the teaching-learning process.

[16] NCF 2005.

Some of the interesting findings of the three-year observations included whether the same teacher was observed teaching the same grade for three years (nine cycles), the percentage of single-teacher schools, and average transaction time. In Karnataka, the *Nali-Kali* method stipulates 80 minutes of teaching time per subject. However, our data shows that the average transaction time in the Nali Kali grade was not more than 45 minutes. There is a possibility that teachers tended to restrict the class transaction to 40–45 minutes because their class was being observed, despite observers requesting the teacher not to deviate from her routine. Or this may just be the reality in the grassroots. This was observed in both control and treatment schools.





3.4 The mathematics teacher

Learners will always remain at the centre of all efforts undertaken to improve the quality of education. It is not possible to plan for improvement if the learner is not the essence of the way forward. Constructivism states that students learn more by experiences and active involvement than by observing (Brooks & Brooks, 1993). The NCF as well as the Nali-Kali classrooms (up to class 3) are envisaged around the learner's need to be supported by teachers in an ordered atmosphere. Teachers have to be prepared to awaken the urge to learn by guiding the class to enquire and discover, not only as a group/community, but also as individuals. Therefore, some of the prerequisites range from the teacher being professionally qualified to sufficiently trained, the teacher exercising self-discipline, overcoming the urge to lead the learner too much and stepping behind and directing her/him towards the chosen goal by allowing discovery.

Teachers who teach mathematics at the primary level are expected to be graduates in the subject, with a degree or diploma in teaching. During field observation it was found that in many cases, teachers with such qualifications were not available to teach mathematics. We observed that it is often taught by teachers who are not very confident of their mathematics. Even in cases where mathematics graduates or post graduates taught the subject, their conceptual understanding may be inadequate. Further, the teachers' attitudes to mathematics learning were very different from what is underlined in the NCF 2005. The lack of ability of teachers in mathematics is probably the result of their lack of preparation at the school and college level. It is also because of the inadequate time given to pre-service training and the way classroom teaching in pre-service training takes place. Furthermore, pre-service training lags behind in preparing these teachers across a gamut of situations like single-teacher schools, multi-grade schools, and small or big class size, among other factors.

All that Matters is a Teacher!

A single-teacher school with 12 children was managed by children since the teacher was late on the day of the visit. Despite the lack of adult supervision, the child monitors "were following" the task given to them. They opened the school on time, conducted an assembly, went to their respective rooms for Nali Kali and non-Nali Kali classes, and got engaged in the class work the teacher had instructed them to complete till she arrived. It almost looked like an auto-piloted school. Children, though less than 15 in number, could answer well and their level of learning was good. It was also found that the community was equally supportive of the school. Though the teacher belonged to the control group, she had accessed the teaching-learning materials provided by Akshara during the last cycle of the study. Our informal investigation revealed that she requested a treatment school that had two sets of the Mathematics kit to share one with her. It was also observed that she was making use of these TLMs. All that matters is a committed teacher!

3.5 The classroom environment and transactions

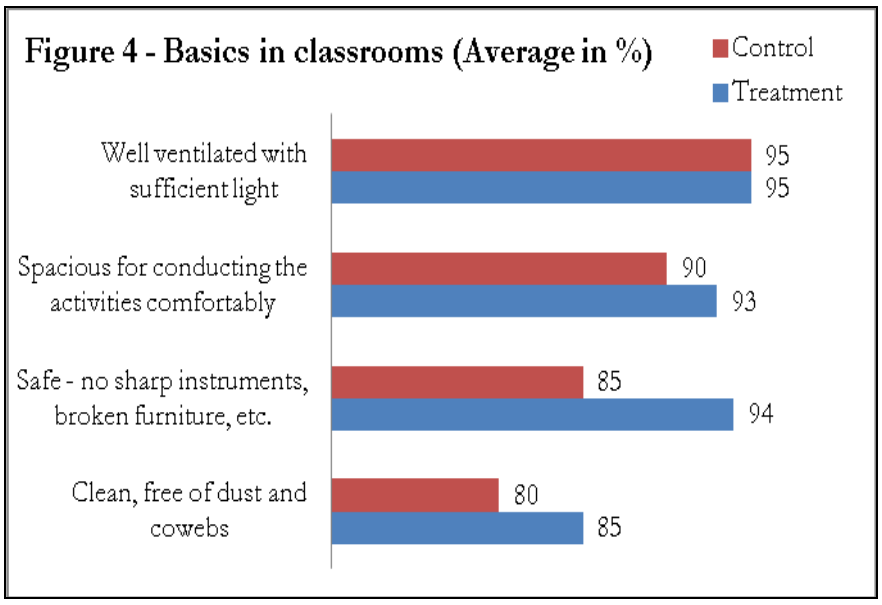
The NCF 2005 Position Paper on mathematics emphasizes that the mathematics classroom should be alive and interactive, one in which children articulate their own understanding of concepts, evolve models, and develop definitions. Following the recommendations of the Position Paper the subsequent books for elementary classes, including the text books of the Karnataka State syllabi, provide opportunities to learners to formulate principles and solutions in their own words. The assumption is that this helps develop and consolidate conceptual frameworks. The Akshara program also emphasizes the role of dialogue among peer learners and argues for opportunities for children to discuss and make presentations as a group. Another principle that the curricular document lays down is that learning mathematics is not about remembering solutions or methods but about feeling capable of doing mathematics and knowing how to solve new problems. It also realizes the importance of problem-posing in mathematics. The twin tasks of setting and solving help develop an understanding of the concepts and principles of mathematics. Therefore, it is important that classroom transactions are vibrant, interactive, and activity centered.

A study shows that the seating arrangement in classrooms typically follows a row and column pattern (Suman Bhattacharjea, Wilima Wadhwa, Rukmini 2011). It was observed in a majority of the schools, both in the treatment and control groups that the children were made to sit in rows, except in the Nali Kali classes. This was observed in small schools as well, which had less than 15 students. Girls and boys sat separately in many classrooms, particularly in Grade 4 and 5, but not in the Nali Kali sections.

Attention to detail is what matters in creating, utilizing, and maintaining the space within the classroom. It is generally observed that not enough attention is paid to the importance of the physical environment for learning. In some of the schools, it was observed that children were either confined to four walls or were let out to roam without any purpose. Except for the higher

primary schools located in *hobli* areas, most of the schools in the study had low enrolment, were less attractive, and were not sensitive towards children's needs. In fact, the physical environment, with some exceptions, seemed to be restricted merely to sheltering the children under a roof.

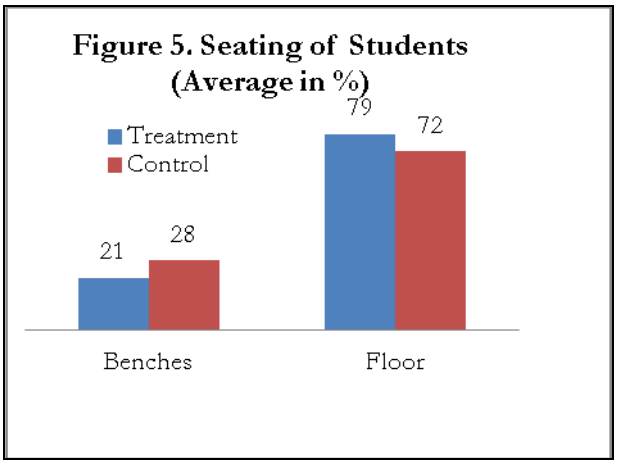
During the nine cycles of classroom observations, physical infrastructure, teacher preparedness, and classroom transactions were observed. One of the indicators for an interactive, child-friendly classroom is the way in which available resources are organized and seating is arranged. This can reveal a great deal about the extent to which the teacher has planned her students' learning. For example, did children sit in ways that facilitated learning from each other as well as from the teacher? Did boys and girls sit separately? Did the teacher employ the TLMs provided by Akshara effectively? Did she follow the instructions given during the training and the guidelines of the Teacher's Manual meticulously?



Almost all the classrooms observed were spacious, well ventilated and had sufficient light. However, cleanliness was an issue in some, and safety norms were a concern in some others.

The non-availability of space may be due to the dwindling student strength rather than a design shortcoming.

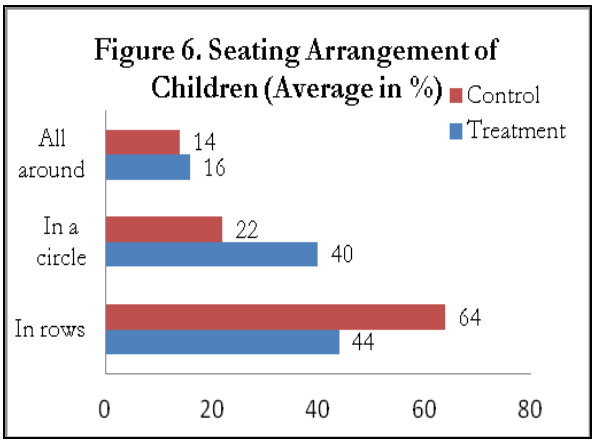
In around 70% of the classrooms, children sat on the floor. Many schools did not even have a floor mat. This posed a difficulty, especially during the rainy season, when children were made to sit on the floor without the convenience of a protective mat. Students in 16% of the treatment classrooms sat all around, in 40% in a circle or semi-circle, and in 44% they sat in a row. In contrast, in a majority of the classrooms in the control schools, the students sat in rows and columns.

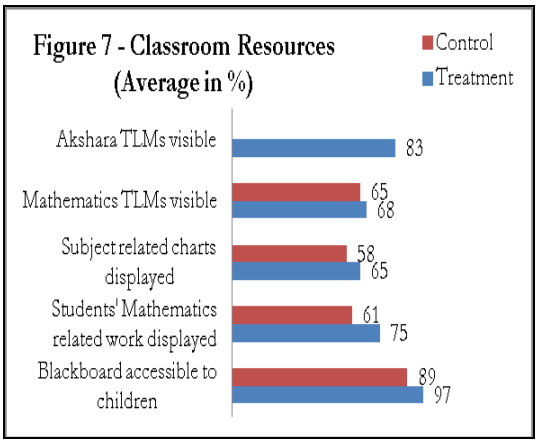


In a couple of schools, it was disheartening to observe the way multi-grade classes were handled. In one instance, the children of grades 4 and 5 sat in the same class. Children of Grade 4 sat in a row on one side to the teacher's right and those of Grade 5 to her left. While one grade was given a written assignment, the other group solved the mathematics problems put up on the blackboard.

Another multi-grade class with 8 children had all of them sitting together in the Head Master's (HM's) room, which also housed the midday meal rations, school records, and unused and broken furniture.

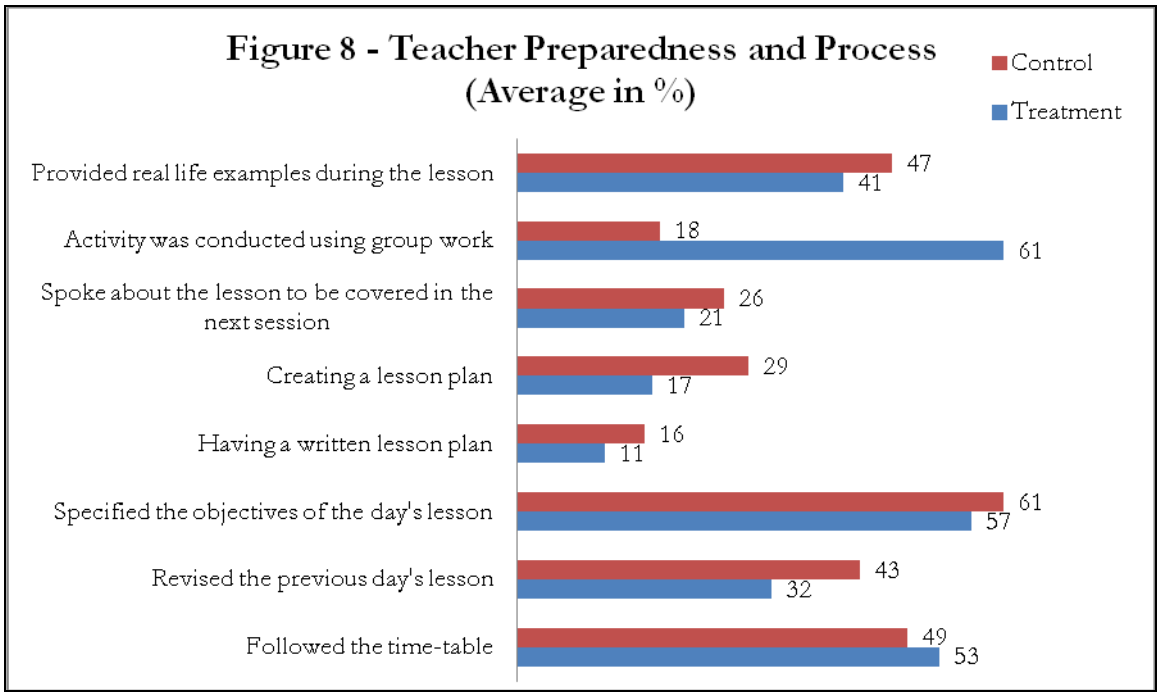
Most of the classrooms observed were highly decorated; in fact the Nali Kali classes were overloaded with resources prepared by both teachers and children. Charts relating to mathematical concepts, multiplication tables, and timetables with the week's schedule were found in 70% of the schools. However, it was also observed that around 40% of the classrooms did not have the appropriate TLMs for that day's lesson.



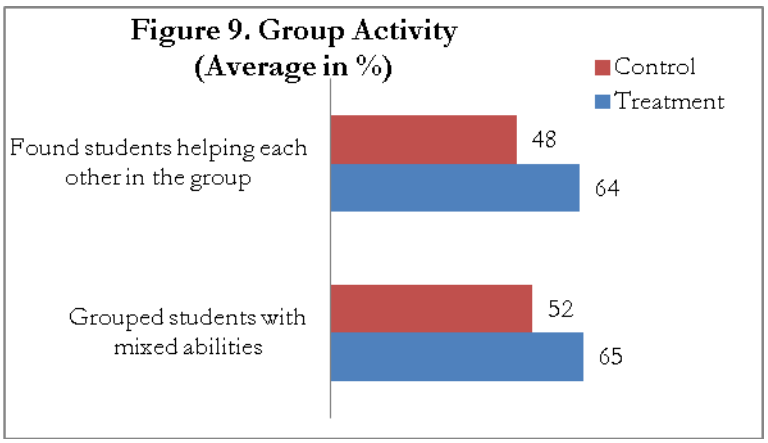


In each observation session, the observers rated the class that they observed on a scale of one to ten. Their ratings were averaged to indicate the reality in the classrooms. The basics were observed, viz., space, access to the blackboard, and display of the activity sheets completed by children. The treatment schools scored better so far as display of children's activities was concerned. On the whole, classrooms in the study had basic classroom infrastructure in place.

During Akshara's mathematics trainings it was suggested and demonstrated that the TLMs be used at appropriate occasions of concept introduction or in the reinforcement process, as decided by the teacher. During the training, the teachers were shown how to direct the children and group them after the introduction of the concept, and engage them in group work so that they would touch, feel, and demonstrate their understanding of a particular competency. The rationale was that, at the end of this process, children would be confident to address mathematical problems in different contexts. During group work, it was expected that the teacher would re-organize the seating arrangements of children in groups so that the activities would be interactive.



Teaching is all about the pedagogical strategy, i.e., the plan and instructional outline the teacher prepares for the class. It all starts with the lesson plan, informing children on the objective of the lesson, recapping the previous session, and so on, as the class unfolds. Teachers are trained in all these tasks during their professional pre-service training course and in some of the in-service trainings. However, in reality, our observations showed that, on an average, only 15% of the teachers had written lesson plans or were found using it. While in 50% of the cases, teachers followed the timetable stuck on the wall in the classroom. Further, 60% of the observations showed that they started the class by talking about the objective of the day's lesson, and we sensed a "low, not-so-good" level of teacher preparedness across our observations of the three years. Since some of these factors are systemic and human mindset issues, not much difference was seen between the treatment and control schools, except for the group work that was followed in treatment classrooms.

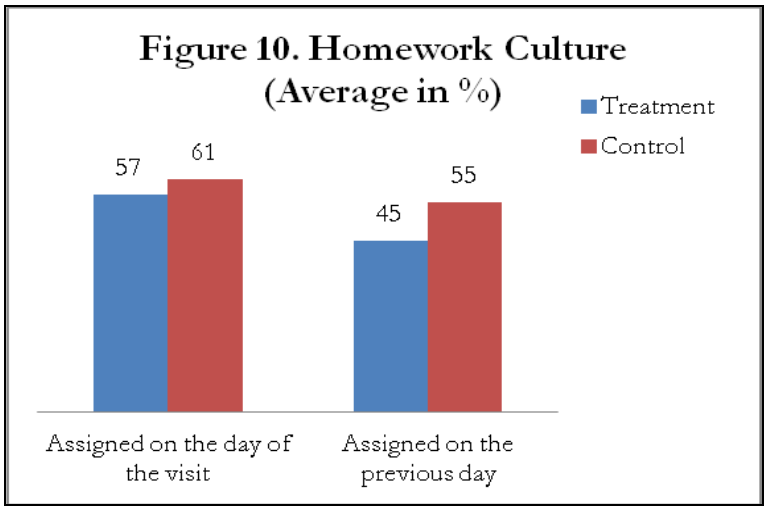


Co-operative Learning: Group activities are an integral part of Akshara's Mathematics Program. The rationale is that, through group activities, children will acquire skills like teamwork and co-operative learning.

It was observed that both treatment and control schools followed the group work method. This could be due to the *Nali-Kali* background of teachers. However, more treatment schools than

control ones were following the group learning concept. In more than 50% of the schools, the groups had children with mixed abilities, which is a positive factor.

Homework: The concept of homework in the primary stage is debated around the world. Homework can be viewed as any activity that seeks to forge effective links between home and school in order to support children's learning and development. This view may hold good in the case of children who come with the social capital of parents having had exposure to formal education. However, in the case of government schools, it should be considered as an exercise for children to practice the concepts taught in school. This requires the teacher's effort in terms of giving home assignments and following it up by correcting the completed work.



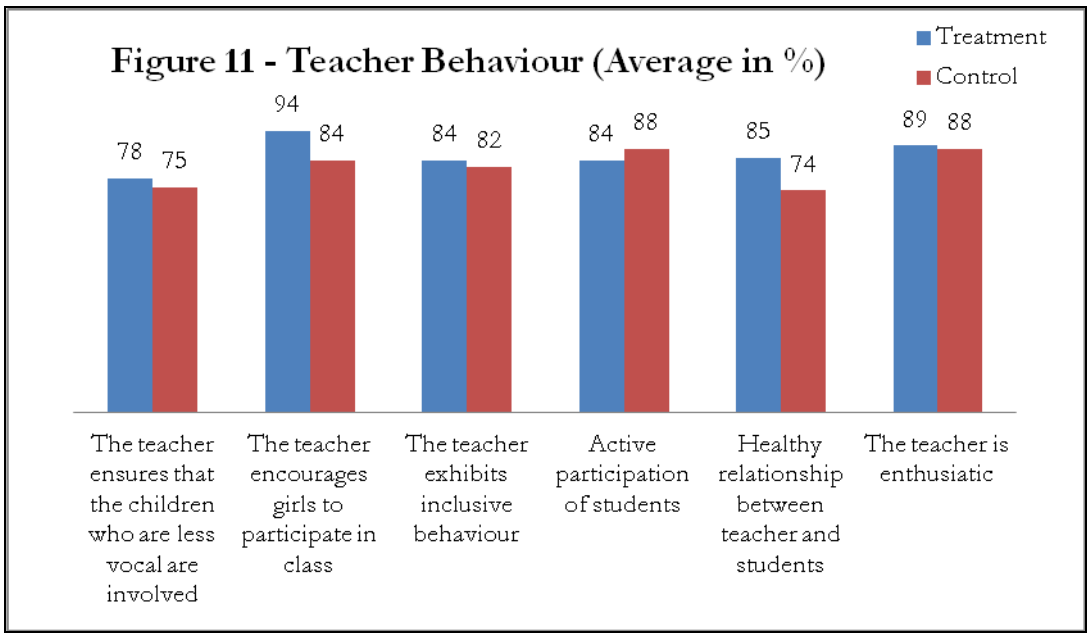
The culture of homework was followed in 50% of the schools and was relatively more visible in the control schools.

3.6 Observers' notes on classroom transactions

A field observer wrote, "children greeted me with the usual chorus of 'Good morning Miss.' I am always a little amused by this well-orchestrated welcome. I began my interaction by asking them about what they do in class, what they learned, and what they enjoyed. A few children appeared very enthusiastic, while some were a little bewildered and apprehensive about what was in store. I could also notice some shying away from me completely. In general, I could sense a sparkle, tinged with a little apprehension in the eyes of most of the kids. As my interaction continued, my initial excitement started waning. The teacher was waiting for my approval to start the class. To my dismay, I could hardly make out if she had prepared well for the class and was waiting to see if she had and if she followed the lesson plan … Nothing much happened during the class, there was not too much to talk about. In fact it was pretty dismal …" (Field Notes, November 2013)

Teaching transaction indicators reflect data on the instructional methods utilized by the teacher, transaction time, teacher preparedness, and her interaction with children during the observation. The field investigators were asked to identify the teaching-related activities that they had seen the teacher do even once during the entire period, regardless of whether that activity took three or all of thirty minutes. The field investigators explored questions such as: Did she start the process by recapping the previous class? Did she explain the objective of the lesson to be taught? Did she write on the blackboard? Did she use TLMs other than the textbook? These indicators covered both the instructional strategies known to be commonly utilized in primary school classrooms,

the explicitly recommended strategies of the NCF 2005, and the strategies suggested by Akshara Ganitha, such as small group work and TLM usage.



The above figure reveals that, on an average, the teachers' behavior was positive across the schools.

3.7 Akshara Ganitha in the classroom

This section emphasizes the linkages between instructional effectiveness[17] and learning outcomes since it is one of the key features of Akshara Ganitha. In government schools, multigrade classrooms are very common, and therefore, the processes observed were in combined classes of Grade 1 to 3, and 4 and 5. The repeated data collection cycles[18] allowed us to observe and estimate the learning processes going on in the classrooms. The indicators that were measured are listed below[19]:

a. If children's activities related to the lesson were displayed in the classroom,
b. If homework was assigned to the students,
c. Students' concentration levels in class,
d. If the teacher taught the lesson by citing real life examples,
e. If the teacher used cooperative teaching methods,
f. If teacher had good conceptual understanding,
g. Teacher enthusiasm,
h. Extent of TLM usage, and
i. Teacher Retention Rate (TRR).

[17] Instructional effectiveness is defined as teaching methodology and classroom processes. These are measured in percentages. Many of these indications are rated by observers based on their understanding. Since estimating people's perception is subjective, the level of accuracy of the data has been affected, which is one of the major limitations of this classroom observation analysis.
[18] There were three rounds of classroom observations each year. However, here we present information from the pre- and post-test cycles each year since most of the program impact discussed in this report is based on the differences between pre- and post-tests.
[19] The highlighted indicators show better impact in the treatment schools.

A majority of the classroom indicators revealed marginal differences in all the classes between the treatment and control schools. However, on comparing the teaching methodology used in both types of schools, it was found that the treatment schools were better than the control schools in all the classes[20]. Specifically, the teaching mechanisms such as teacher preparedness, teacher's use of cooperative methods, and teacher's conceptual understanding were better in the treatment schools.

It was also found that the TRR[21] was high in the treatment schools in the last two years (2013–14 and 2014–15) of the study period. On the day of the field study, 85% of the classrooms had the same teacher in the treatment schools as compared to 68% in the control schools. Grades 1 to 3 exhibited higher TRRs in both treatment and control schools than did grades 4 and 5, with better overall trends in the treatment schools. Though this data does not reveal much teacher attrition in most instances, teacher absenteeism during the day of data collection might have influenced our results[22].

Since quantifying some of these findings is not an easy task, some of the field investigators' perceptions on the teaching processes have been presented below:

3.8 Concluding Observations of Classroom Transactions

i. It is a field reality that majority of the schools are moving towards small size classes, but are spread across different grades.
ii. Single-teacher schools are a challenge and multi-grade teaching is inevitable. However, these issues need to be addressed through pre- and in-service trainings. Strategies for managing classrooms in such single-teacher schools and multi-grade teaching need to be evolved and built into the teacher capacity building programs. Guidelines need to be shared with such schools for re-organizing the resources, or such schools need to be provided additional resources and support.
iii. Some of the indicators for professionalism in teaching, which may include teacher preparedness, lesson plan, strategy for inclusiveness, etc., were observed in half of the teachers included in the study. Lack of these indicators could be due to the systemic challenges mentioned above.
iv. TLMs will provide additional support to teaching core subjects like mathematics; however, this has to be coupled with continuous field monitoring and support.
v. Qualitative investigation outlined another dimension of instructional practice, which is "step-wise learning followed by lesson activity," indicating the possibilities of better lesson impact on students. It was also evident that the key mechanism of the program was being followed, i.e., the TLMs were being used and the teachers were using cooperative methods of learning. These factors may have positively influenced the changes in the treatment schools.

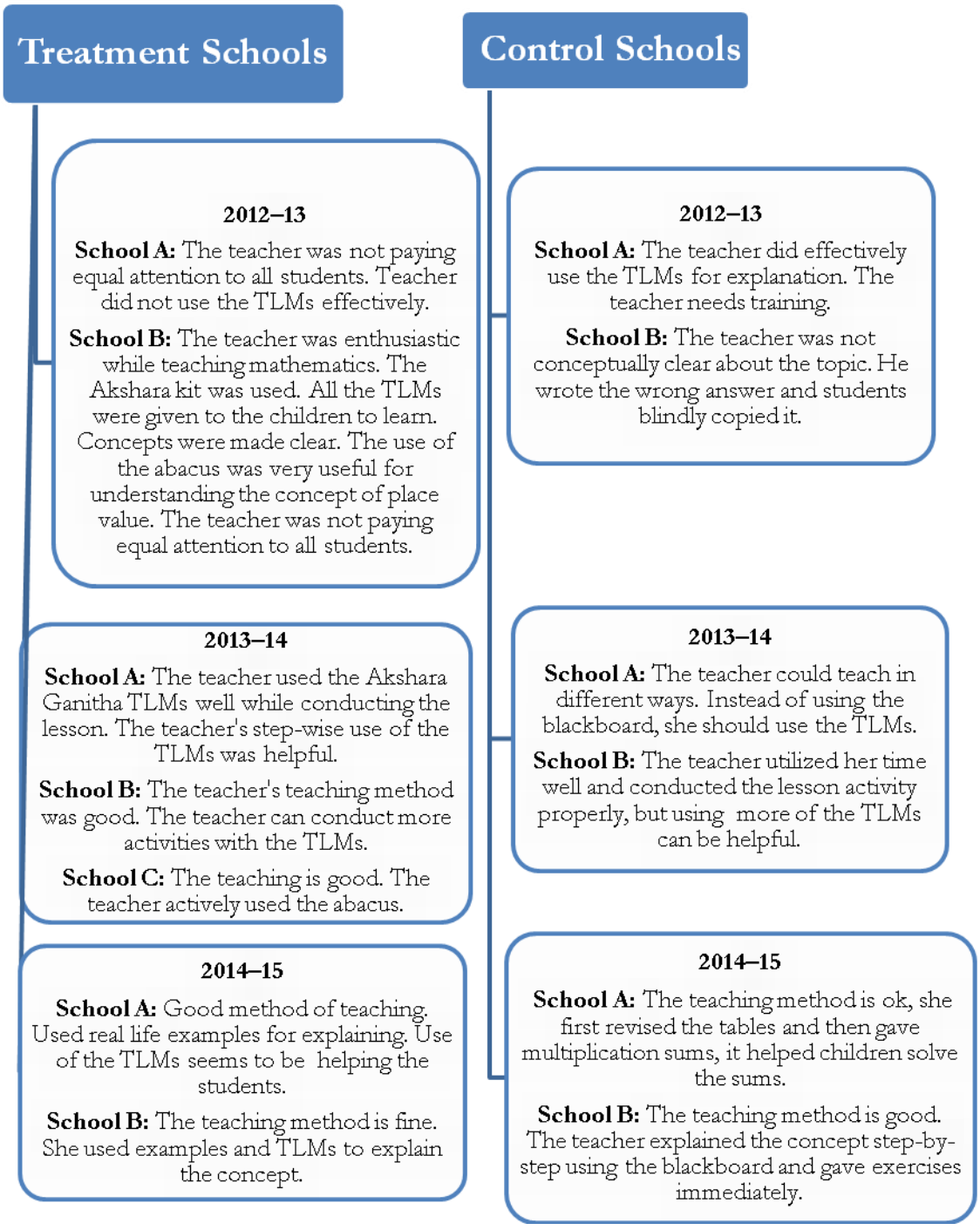
[20] Year-wise inconsistency exists.
[21] Field investigators observed the same teacher teaching the same class over the three cycles. In this study, the reference period to measure the teacher retention rate was the last two years of the study.
[22] Assuming student test scores are influenced by teaching methods, circumstances when the same teacher was not available in all the cycles have influenced classroom process ratings.

vi. Teachers who had not received training generally slackened during the implementation of the program. Teacher transfers also affected the program. Newly transferred teachers, not exposed to Akshara Ganitha, did not adhere to its methods, and were not interested in implementing it.

Comments on the content in the below box

A First-Hand Account....

The field investigators were asked to provide their impression after every classroom observations across the three years. An extract of their observations has been presented below:



The following section presents finding related to the data on learning outcomes of children spread across nine cycles over the three academic years.

Section IV
Findings of the Study: Learning Outcomes

This impact assessment study was designed to test the hypothesis that the implementation of new mathematics program would influence the level of mathematics learning among children due to the exposure to a learner centered pedagogy, teacher capacity building, and access to additional resources, i.e., the Mathematics Kit. A comparative assessment of the students' performance in mathematics is critical to establish the effectiveness of the program. This section discusses the results of the mathematics assessment in relation to these hypotheses.

The aim was to maximize the comparability of student achievement across the cycles and to compare them across treatment and control groups. This enabled us to accurately track students' natural improvement in specific competencies over the cycles and to identify areas where the intervention was particularly effective or ineffective. Care was taken to ensure that teachers were not left with a copy of the question paper as it would enable them to influence the results by either teaching the students answers to the test questions before the test.

All children in Grade 1 to 5 in the treatment and control groups underwent the pre- mid- and post-tests each year. During an academic year, pre-tests were conducted in June-July; mid-tests in November-December, and post-tests or end-line tests in January-February in the next calendar year. Thus, we conducted three assessments in a, academic year, one at entry level prior to the intervention, a mid-year test, and an end-line test at the end of the academic year.

The learning outcome analysis detailed the comparison between the treatment and control groups across overall mean scores and cohorts. Descriptive statistics (mean, median, and standard deviation) were computed for all cohorts. It was observed that the standard deviation was quite high in most of the variables, and the data showed skewed (asymmetric) distribution. **Additionally, the Shapiro Wilk's test for normality suggested that the data was not normally distributed. Therefore, non-parametric tests like the Mann-Whitney U test were carried out for comparing the control and treatment groups.**

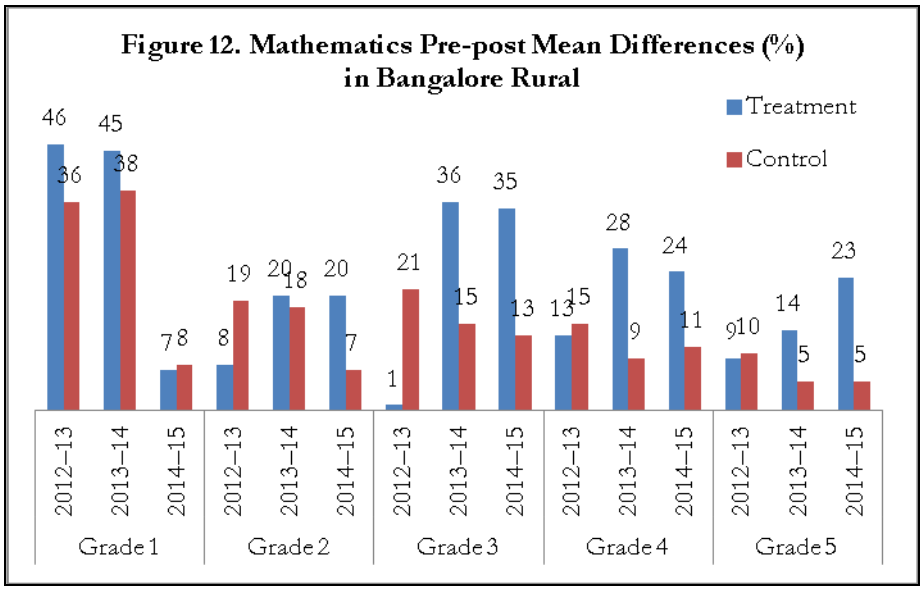
The data was analyzed from different angles to examine the effectiveness of the program. Two types of analyses were carried out. Firstly, the differences in mean scores were calculated to represent the percentage rate of improvements in the scores across treatment and control groups. This was expected to set the direction of the impact of the program on learning outcomes. Secondly, the data was re-arranged and analyzed using non-parametric techniques to gauge the learning outcomes of the cohorts.

4.1 Findings of the cross-sectional analysis

As mentioned earlier, the performance assessments were administered in all the classes of Grade 1 to 5 for three years. The analysis examined the impact on learning outcomes for a particular grade across the three years. The treatment schools in the Hoskote block scored better than did the control schools across all grades in all the three years of the study, with improvement in scores ranging from 8–46 percentage points in 2012–13, 14–46 percentage points in 2013–14, and 7–35 percentage points in 2014–15 across all grades.

Table 1. Average Percentage Scores

Year	Groups	Grade 1			Grade 2			Grade 3			Grade 4			Grade 5		
		Pre - test	Post- test	Dif.	Pre - test	Post- test	Dif.	Pre - test	Post- test	Dif.	Pre - test	Post - test	Dif.	Pre - test	Post - test	Dif.
2012–13	Treatment	16	62	**46**	27	35	**8**	39	40	**1**	10	23	**13**	24	33	**9**
	Control	17	53	**36**	15	34	**19**	22	43	**21**	13	28	**15**	20	30	**10**
2013–14	Treatment	30	76	**46**	33	53	**20**	27	63	**36**	11	39	**28**	22	36	**14**
	Control	26	63	**37**	22	40	**18**	24	39	**15**	17	27	**9**	29	34	**5**
2014–15	Treatment	73	80	**7**	47	67	**20**	40	75	**35**	19	43	**24**	31	54	**23**
	Control	43	51	**8**	30	37	**7**	28	41	**13**	19	30	**11**	28	33	**5**



The mean difference across grades from year 2013–14 showed that the treatment students scored much higher than did the control students.

4.2 Findings of the Grade-wise competency level analysis

This section shows the findings of the average percentage scores of the students in all competencies of Grade 1 to 5 from the treatment and control groups for the three year period: 2012-13, 2013-14 and 2014-15.

Grade 1 performed well in all competencies except in Addition. Grade 2 and Grade 3 performed better in Number recognition & writing number name and Time/Calendar respectively, and they scored less in Subtraction. Grade 4 scored good scores in Fraction concept and Grade 5 in Angles (Table 2, 3, 4, 5 and 6).

Table 2. Average percentage scores of competencies for Grade 1

Grade 1		Control group			Treatment group		
Competency	**Test**	**2012-13 (N=74)**	**2013-14 (N=72)**	**2014-15 (N=69)**	**2012-13 (N=114)**	**2013-14 (N=118)**	**2014-15 (N=117)**
Counting & recognition up to 1 to 10	Pre test	15	42	57	23	37	69
	Post test	53	58	60	58	76	83
Counting writing	Pre test	18	19	43	22	29	66
	Post test	63	58	60	62	67	82
Serial	Pre test	6	16	20	11	15	48
	Post test	45	47	46	47	61	81
Addition facts	Pre test	7	8	24	5	14	38
	Post test	19	25	35	26	38	76
Addition	Pre test	4	2	15	1	0	44
	Post test	24	25	31	29	47	68
Geometry	Pre test	29	35	47	19	48	72
	Post test	59	60	68	65	77	84

Table 3. Average percentage scores of competencies for Grade 2

Grade 2		Control group			Treatment group		
Competency	**Test**	**2012-13 (N=91)**	**2013-14 (N=65)**	**2014-15 (N=76)**	**2012-13 (N=126)**	**2013-14 (N=119)**	**2014-15 (N=126)**
Number recognition & writing	Pre test	48	78	75	80	73	73
	Post test	83	86	73	75	81	79
Place value	Pre test	12	22	30	28	26	48
	Post test	32	27	38	18	51	69
Number concepts	Pre test	6	7	20	17	16	30
	Post test	21	24	32	18	30	63
Even / odd numbers	Pre test	2	5	13	26	30	39
	Post test	20	36	33	24	49	61
Addition / subtraction	Pre test	16	18	28	33	31	43
	Post test	36	41	39	39	49	66
Addition with carryover	Pre test	1	3	22	11	11	26
	Post test	21	27	26	28	39	50
Subtraction with borrowing	Pre test	2	2	3	2	6	5
	Post test	10	11	11	15	19	39
Mental arithmetic	Pre test	7	8	16	12	8	29
	Post test	18	24	26	17	44	63

Table contd ...							
Grade 2		**Control group**			**Treatment group**		
Competency	**Test**	**2012-13 (N=91)**	**2013-14 (N=65)**	**2014-15 (N=76)**	**2012-13 (N=126)**	**2013-14 (N=119)**	**2014-15 (N=126)**
Recognition of 2D & 3D shapes	Pre test	27	67	61	42	64	64
	Post test	67	76	67	49	78	77
Differentiate curved flat surface	Pre test	4	3	7	5	1	24
	Post test	5	7	11	2	22	55
Informal measurement	Pre test	11	19	31	26	22	43
	Post test	41	46	43	33	59	68
Calendar	Pre test	8	7	14	12	22	26
	Post test	18	36	29	15	42	61
Money	Pre test	10	6	12	9	20	15
	Post test	16	21	22	15	34	50

Table 4. Average percentage scores of competencies for Grade 3

Grade 3		**Control group**			**Treatment group**		
Competency	**Test**	**2012-13 (N=83)**	**2013-14 (N=98)**	**2014-15 (N=74)**	**2012-13 (N=127)**	**2013-14 (N=138)**	**2014-15 (N=119)**
Place value	Pre test	41	35	33	58	40	45
	Post test	48	43	53	49	69	68
Comparison of numbers	Pre test	26	23	41	45	36	37
	Post test	35	37	42	36	62	73
Addition	Pre test	38	32	39	56	43	40
	Post test	51	53	65	63	68	72
Subtraction	Pre test	6	11	15	37	13	17
	Post test	24	23	28	34	46	60
Tables	Pre test	30	27	32	57	38	39
	Post test	41	43	55	49	70	76
Multiplication	Pre test	10	10	16	28	18	25
	Post test	19	17	27	25	46	73
Division	Pre test	8	20	22	20	14	20
	Post test	14	30	32	20	52	64
Multiplication Statement problem	Pre test	4	11	15	16	10	20
	Post test	18	22	20	21	45	74
2D / 3D shapes	Pre test	6	15	16	10	11	26
	Post test	18	25	28	14	39	73
Time / Calendar	Pre test	7	12	10	31	17	22
	Post test	26	31	31	23	53	77
Measurement	Pre test	6	11	18	20	11	24
	Post test	29	21	41	28	57	74

Table 5. Average percentage scores of competencies for Grade 4

Grade 4		Control group			Treatment group		
Competency	**Test**	**2012-13 (N=93)**	**2013-14 (N=81)**	**2014-15 (N=92)**	**2012-13 (N=133)**	**2013-14 (N=145)**	**2014-15 (N=140)**
Multiplication	Pre test	14	2	20	4	6	8
	Post test	26	24	35	16	39	41
Division	Pre test	9	9	9	3	2	8
	Post test	29	24	28	20	24	38
Multiplication / Division statement problem	Pre test	13	16	12	8	6	15
	Post test	34	30	30	24	35	44
Fraction concept	Pre test	22	44	43	20	24	36
	Post test	45	50	54	36	52	62
Fraction related problem	Pre test	6	19	15	6	7	8
	Post test	20	19	29	14	24	36
Circle related problem	Pre test	19	17	22	11	9	27
	Post test	35	28	37	28	33	50
Area perimeter	Pre test	5	5	3	2	13	7
	Post test	11	7	8	2	14	30
Measurement	Pre test	15	23	32	23	22	39
	Post test	28	33	48	23	54	57
Time	Pre test	7	0	4	2	0	3
	Post test	8	5	17	3	18	30
Daily life problem measurement	Pre test	6	5	3	8	1	4
	Post test	13	9	8	9	21	20

Table 6. Average percentage scores of competencies for Grade 5

Grade 5		Control group			Treatment group		
Competency	**Test**	**2012-13 (N=102)**	**2013-14 (N=99)**	**2014-15 (N=82)**	**2012-13 (N=126)**	**2013-14 (N=143)**	**2014-15 (N=138)**
Write the numbers in words & figures	Pre test	26	33	42	36	26	37
	Post test	40	39	40	39	36	60
Place value	Pre test	17	27	32	35	20	32
	Post test	24	25	30	32	31	61
Ascending descending numbers	Pre test	18	30	32	27	22	29
	Post test	26	28	31	29	28	57
Division	Pre test	21	29	28	31	16	27
	Post test	39	34	49	37	31	54
Daily life problem	Pre test	8	10	7	6	4	11
	Post test	14	12	21	13	18	37
Factorial numbers	Pre test	12	15	13	11	11	13
	Post test	14	18	30	24	24	45

Table contd ...

Grade 5		Control group			Treatment group		
Competency	**Test**	**2012-13 (N=102)**	**2013-14 (N=99)**	**2014-15 (N=82)**	**2012-13 (N=126)**	**2013-14 (N=143)**	**2014-15 (N=138)**
Equivalent fraction	Pre test	7	6	3	7	6	10
	Post test	11	15	14	8	16	46
Decimal concept	Pre test	20	25	24	14	21	21
	Post test	30	30	24	24	31	50
Angles	Pre test	25	33	26	20	21	33
	Post test	34	37	39	37	39	66

4.3 Findings of the cohort analysis

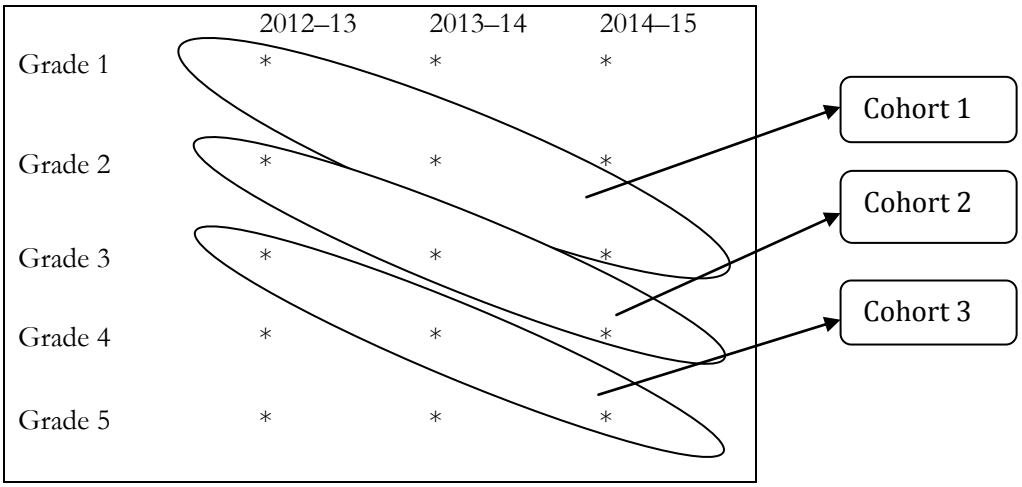
This section reports the findings of the analysis of the percentage scores of the students of Grade 1 to 5 from the treatment and control groups for the three-year period: 2012–13, 2013–14, and 2014–15. The following three cohorts of students who were exposed to the intervention for three complete years were identified:

Cohort 1: Grade 1, 2, and 3

Cohort 2: Grade 2, 3, and 4

Cohort 3: Grade 3, 4, and 5

Figure 13. Pictorial Representation of the Cohorts



A statistical analysis was conducted to examine whether there was a treatment effect, which would demonstrate whether the usage of the Akshara Ganitha kit influenced the performance of the treatment group as compared to that of the control group.

4.3.1 Results for Cohort 1

Cohort 1 is a group of students who were in Grade 1 in 2012–13, Grade 2 in 2013–14, and Grade 3 in 2014–15.

Table 7. Descriptive Statistics for Cohort 1 (grades 1, 2, and 3)

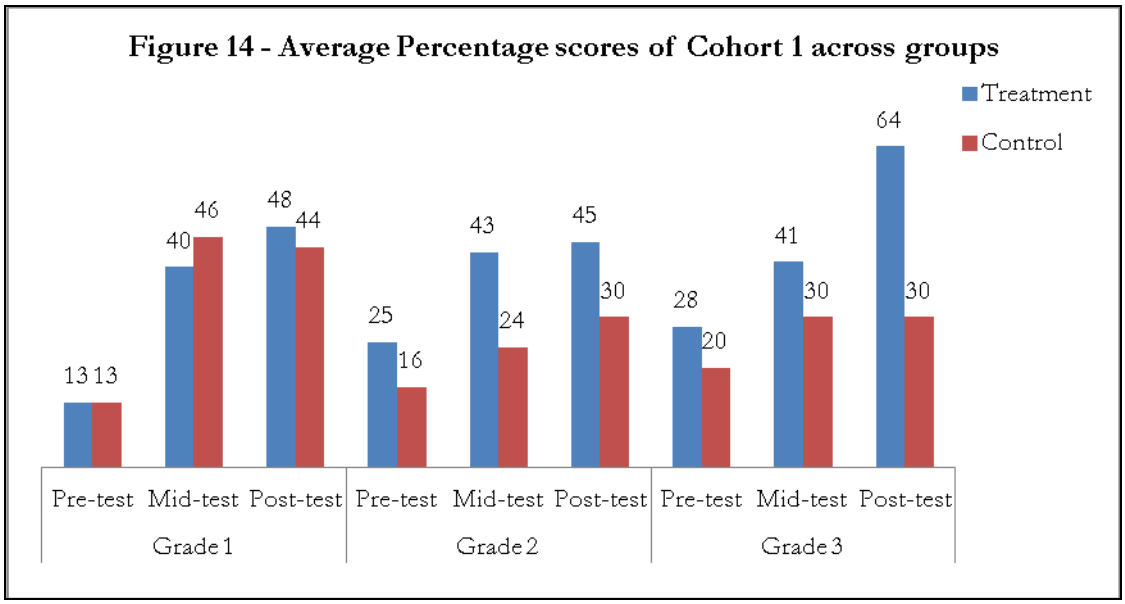
Mathematics - Cohort 1		Control (n_1 = 74)			Treatment (n_2 = 114)		
Grade	Test	Mean	Median	SD	Mean	Median	SD
Grade 1	Pre-test	13	0	21	13	0	22
	Mid-test	46	44	31	40	47	29
	Post-test	44	44	35	48	50	36
Grade 2	Pre-test	16	15	15	25	21	22
	Mid-test	24	21	24	43	47	32
	Post-test	30	23	29	45	46	31
Grade 3	Pre-test	20	11	23	28	15	31
	Mid-test	30	29	30	41	44	31
	Post-test	30	24	30	64	85	39

Table 8. Comparison between the Control and Treatment Groups for Cohort 1 (grades 1, 2, and 3)

Grade	Test	z-value	p-value	Effect size
Grade 1	Pre-test	-0.93	0.35	-0.07
	Mid-test	-0.94	0.35	-0.07
	Post-test	-0.71	0.48	-0.05
Grade 2	Pre test	-2.6	0.01*	-0.19
	Mid-test	-3.86	0.00**	-0.28
	Post-test	-3.22	0.00**	-0.23
Grade 3	Pre-test	-1.27	0.21	-0.09
	Mid-test	-2.53	0.00**	-0.18
	Post-test	-5.9	0.00**	-0.43

p-value indicates probability value * $p<0.05$, ** $p<0.01$.

According to the Mann-Whitney U test, there was no significant difference between the Grade 1 control and treatment groups (Table 8). **During the first year of the intervention, the program had no impact** on Grade 1 in the treatment schools during all the test cycles, and hence the effect sizes were very small. **As children moved to higher grades, there was a significant difference by the end of the last year, as evident from the post-test scores of Grade 3 students in the control and treatment groups. The effect size was moderate, r = -0.43. As a whole, in the treatment schools, this cohort exhibited modest improvement in test scores,** while **major improvement was evident in the Grade 3** mean score as compared to that in the control group (Table 7).



As evident from Figure 14, there was an improvement across the three assessment cycles in both the groups. The improvement was similar in the pre-tests of the first year (13%), but, by the end of the third year's post-test, the treatment group scored 64% while the control group scored 30%. This indicated positive treatment gains.

4.3.2 Results for Cohort 2

Cohort 2 is the group of students who were in Grade 2 in 2012–13, Grade 3 in 2013–14, and Grade 4 in 2014–15.

Table 9. Descriptive Statistics for Cohort 2

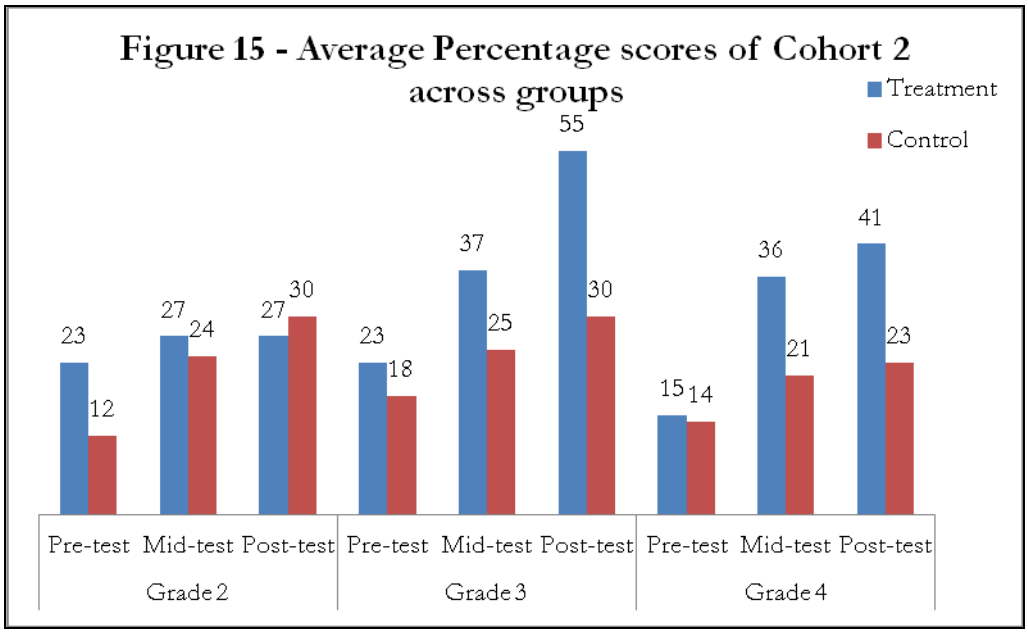
Mathematics Cohort 2		Control (n_1 = 91)			Treatment (n_2= 126)		
Grade	Test	Mean	Median	SD	Mean	Median	SD
Grade 2	Pre-test	12	3	17	23	18	21
	Mid-test	24	21	20	27	23	23
	Post-test	30	23	24	27	21	26
Grade 3	Pre-test	18	9	22	23	20	21
	Mid-test	24	21	24	37	36	30
	Post-test	30	24	28	55	67	31
Grade 4	Pre-test	13	3	18	15	10	16
	Mid-test	21	13	23	36	37	27
	Post-test	23	17	25	41	40	31

Table 10. Comparison between the Control and Treatment Groups for Cohort 2 (grades 2, 3, and 4)

Grade	Group	z-value	p-value	Effect size
Grade 2	Pre-test	-4.74	0.00**	-0.32
	Mid-test	-0.95	0.34	-0.06
	Post-test	-1.37	0.18	-0.09
Grade 3	Pre-test	-2.43	0.02*	-0.16
	Mid-test	-3.12	0.00**	-0.21
	Post-test	-5.53	0.00**	-0.38
Grade 4	Pre-test	-1.69	0.09	-0.11
	Mid-test	-4.03	0.00**	-0.27
	Post-test	-4.05	0.00**	-0.27

p-value indicates probability value * p<0.05, ** p<0.01.

According to the Mann-Whitney U test, there was a significant difference in the Grade 2 scores of the control and treatment groups (Table 10). **The first year's intervention impacted the second year's Grade 2 pre-test scores,** and the effect size was moderate at r = -0.32. A significant difference was noted by the end of the third year. **As the children moved to higher grades, the Akshara Ganitha program continued. The post-test treatment scores for Grade 4 showed a medium effect size of r = -0.27, indicating an increasing treatment effect.** Other classes too reflected this trajectory. **The treatment group's mean score, when compared to the control group's score, indicated that there was a major improvement owing to our intervention** (Table 9).



The bar graph (Figure 15) shows that there was an increase in scores across the pre-mid-post-test cycles in both the groups, but significant improvements were seen in the treatment group, particularly in grades 3 and 4. Total post-test scores were 55% for Grade 3 and 41% for Grade 4.

4.3.3 Results for Cohort 3

Cohort 3 is the group of students who were in Grade 3 in 2012–13, Grade 4 in 2013–14, and Grade 5 in 2014–15.

Table 11. Descriptive Statistics for Cohort 3

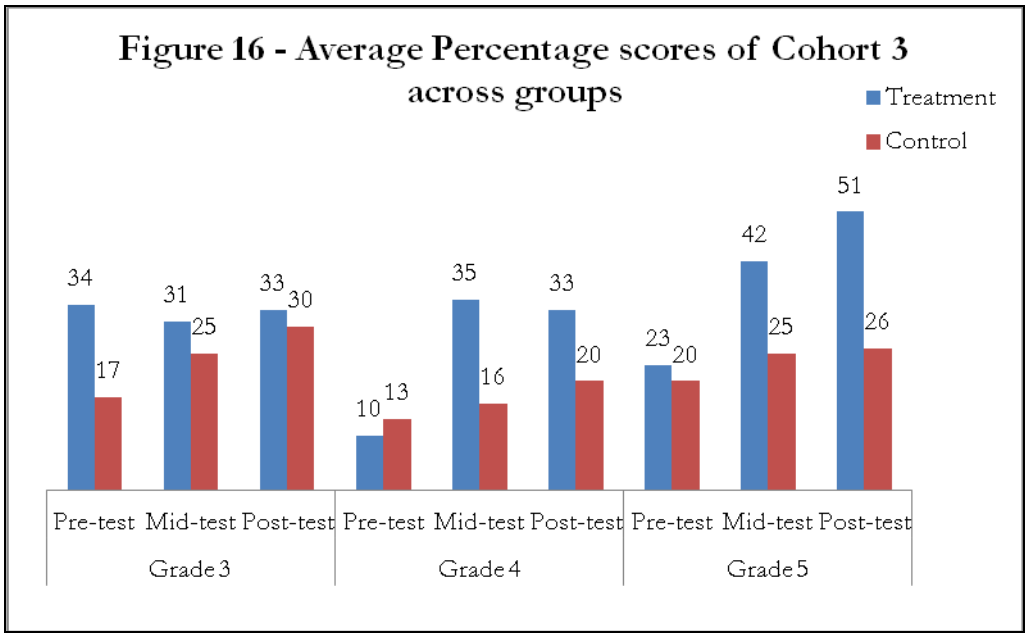
Mathematics - Cohort 1		Control (n_1=83)			Treatment (n_2=127)		
Grade	Test	Mean	Median	SD	Mean	Median	SD
Grade 1	Pre-test	17	12	16	34	33	24
	Mid-test	25	21	24	31	33	22
	Post-test	30	30	27	33	33	25
Grade 2	Pre-test	13	10	14	10	7	9
	Mid-test	16	10	19	35	30	27
	Post-test	20	13	22	33	30	26
Grade 3	Pre-test	20	11	21	23	15	26
	Mid-test	25	19	28	42	44	31
	Post-test	26	15	28	51	63	34

Table 12. Comparison between the Control and Treatment Groups for Cohort 3 (grades 3, 4, and 5)

Grade	Tests	z-value	p-value	Effect size
Grade 3	Pre-test	-5.25	0.00**	-0.36
	Mid-test	-2	0.05	-0.14
	Post-test	-1.22	0.22	-0.08
Grade	Tests	z-value	p-value	Effect size
Grade 4	Pre-test	-0.54	0.59	-0.04
	Mid-test	-4.76	0.00**	-0.33
	Post-test	-3.75	0.00**	-0.26
Grade 5	Pre-test	-0.92	0.36	-0.06
	Mid-test	-4.06	0.00**	-0.28
	Post-test	-4.91	0.00**	-0.34

p-value indicates probability value * p<0.05, ** p<0.01.

According to the Mann-Whitney U test, there was a significant difference in Grade 3 scores between the control and treatment groups (Table 12). **As the third year of implementation began, we found that the program had created a positive momentum in the pre-test scores of Grade 3 students in the treatment schools, a carryover from the intervention conducted in the previous two years.** The effect size was medium at r = -0.36. **Post-test scores of the Grade 5 scores showed a moderate effect size of r = -0.34, which is significant when compared with that of the control group. Our analysis indicated that Cohort 3 in the treatment group showed significant improvement, which was evident in the mean scores of all the grades in the treatment groups as compared to those in the control group** (Table 11).



The bar graph (Figure 16) indicates that there was a gradual increase in scores across the pre-mid-post-test cycles in both the groups, but a major chunk of the improvement was observed in the treatment group. The total post-test score of the treatment group for grades 3 and 4 were the same at 33%, while it was 51% for Grade 5.

The above results indicate improvements across the cohorts. Cohort 1 was relatively better positioned, with an edge over the other two, indicating that children exposed to Akshara Ganitha's methods at the entry level may have derived a greater advantage though the instillation effect. However, the effect of continual program exposure in grades 2, 3, 4, and 5 cannot be discounted. The effect sizes revealed the positive impact of the intervention on the cohorts, but there was an inconsistency within Cohort 2 and 3.

4.4 Concluding Observations of the Learning Outcomes

i. The descriptive statistics [mean, median, and standard deviation (SD)] were computed across the three cohorts. The SD was quite high for most of the variables, and the data showed skewed (asymmetric) distribution. Additionally, the Shapiro Wilk's test for normality suggested that the data was not normally distributed. Therefore, non-parametric tests like the **Mann-Whitney U test** was used to compare the control and treatment groups.

ii. The effect size of the Mann-Whitney U[23] was calculated for Cohort 1, 2, and 3 (Table 3, 5, and 7). Table 3 reveals that there was no treatment impact in Cohort 1, i.e., in the first year during all test cycles. Therefore, the overall effect sizes found in this study were very small in the first year. However, there was a significant difference by the end of the last year, where the difference in the post-test scores (i.e., Grade 3) between the control and treatment groups, with a moderate effect size of r = - 0.43.

[23] Effect size = $z/\sqrt{N}$, where N is the total number of observations (n_1+n_2)

iii. Similarly, Table 5 revealed a significant difference in the first year pre-test scores in Cohort 2 (i.e., Grade 2) between the control and treatment groups, with a medium effect size, r = - 0.32. Further, there was a significant difference by the end of the last year, i.e., in the post-test scores (i.e., Grade 4) between the control and treatment groups, with a moderate effect size of r = - 0.27.

iv. Table 7 revealed a significant difference in the first year pre-test scores in Cohort 3 (i.e., Grade 3) between the control and treatment groups, and its effect size was medium, r =-0.36. Additionally, there was a significant difference by the end of the year, i.e., in the post-test scores (i.e., Grade 5) between the control and treatment groups, with a moderate effect size of r =-0.34.

v. The above results clearly indicate improvements across all the three cohorts, but Cohort 1 seemed to have a relative advantage as compared to the other two cohorts, indicating that children exposed to the method at the entry level may have a greater advantage. Effect sizes evidenced the positive impact of the program on the cohorts, but there was an inconsistency within Cohort 2 and 3.

"Teaching is my Favorite Profession"

To say that Veena is a dedicated teacher seems like a an understatement. There has to be some super word to describe her commitment. Veena, twenty seven, is the mathematics teacher for all 76 students in grades 1 to 7 in the Government Higher Primary School, Kurubarahatti, Hoskote block. A tall, frail, saree-clad person, a little wisp, a whiff of wind could blow her away. But the energy she brings to her work is nothing short of amazing. The bright smile that lights up her face says many things. There is deference there, a large helping of old values, and a quiet pride in her work and what she has accomplished in her seven years as a mathematics teacher.

She arrived at the school in Kurubarahatti "six years and eleven months ago," she says, with the exactitude of a mathematics teacher. She came with a Diploma in Education (D.Ed) from Shira, Tumkur District, armed with some theoretical knowledge but no practical know-how. Burning in her was the resolve to be a teacher, "because I love children," she says. "Teaching is my favorite profession." She commutes 40-50kms everyday to this school.

"With Akshara's TLMs I'm Teaching Happily"

Veena is a self-energizing unit all by herself. A tightly knit team of three teachers propels the school forward. Akshara Ganitha's TLMs brought new vitality to the school. This is the fourth year of Akshara's mathematics program here. Veena embraced the change that was sweeping over clichéd mathematics in her classroom, change that at the same time supplements the textbook and supports blackboard practices. "I don't feel any resistance to new approaches. I am all for it," says Veena. "I like new methods. I have no problem accepting them."

Veena's respect for Akshara's TLMs is such that she keeps some of them like the abacus, the counters, number line, and base 10 blocks on a vivid table in her crowded classroom for Grade 6 and 7 though are not covered under the program.

Every day is a challenge with children, helping them deal with mathematics and its mystifying though straightforward ways. "Akshara's teaching-learning materials are very useful for all the children," says Veena. "Even the 1st Grade child understands place value and number positioning. Every concept is made comprehensible. Data handling and statistics are made so easy - where to place numbers, how to organize them. Before, we used to prepare some TLMs ourselves. They got destroyed so easily. Akshara's materials are long-lasting, permanent, and easy to use. The counters only have to be dipped in water and they stick to the blackboard. With Akshara's TLMs I'm teaching happily."

"I like mathematics. I used to be a little dull in mathematics. Every day I learn the subject again to come and teach my students," says Veena. "I know their levels, the levels of all my 76 students.

Section V
Conclusions and Recommendations

Akshara Ganitha seeks to address a wide swath of issues. The fear of mathematics that holds children back; the limited methods of largely well-meaning but at times dogmatic teachers; the overdependence on the blackboard, textbook, and classroom rituals; the lack of stimulating resources; and often an absence of energy around mathematics dissemination and learning. The program attempts to address all these issues. It is purpose-built for inclusive mathematics and has managed to check the stagnation in many schools.

Akshara Ganitha's array of TLMs is designed to dispel fear and instills understanding. Its methodology encourages teacher-student participation, complete teacher involvement, and complete student participation.

This has been achieved to a large extent in the Hoskote block. Akshara has introduced a new dynamic, a change-agent in classrooms, and it is working. If there have been breakthroughs, there are disappointments too, but not failed hope. When programs are grafted into a long-established system, the fruits of success take longer.

Akshara Ganitha's successes, given the tired environment of government schooling and the challenges, are neither small nor fragmented. The results the present study highlights are testimony to its broad impact. An increase of 16% for Cohort 1, 14% for Cohort 2 and 18% for Cohort 3 are in fact substantial strides[24]. The average percentage scores of the treatment group are higher than control group in all the competencies across all the grades. In the larger scheme of things, these changes matter.

The lower pre-test scores for each progressive year could be due to the "summer vacation effect" of long, idle April-May, or the stumbles of an academic course beginning in June, when students are exposed to a new syllabus.

The government school children who participated in these evaluations are usually powerless in front of mathematics; a subject aspired to, never thoroughly grasped. A majority of them are first generation learners. Their parents are mostly illiterate and cannot provide the academic support their children need at home. A rapid learning curve is therefore unrealistic to expect. As for the teachers in the program they have not had the tools till now for easy interpretation of mathematics, with some of them still holding on age-old methods.

One of Akshara Ganitha's biggest successes was that it makes mathematics accessible and exciting. The study underlines the add-on value of the TLMs. The treatment schools ranked higher because of them. Teachers made more than superficial use of the TLMs and employed

[24] Difference of first year's and last year's post-test scores.

the program's cooperative methods. Appropriate TLM utilization was at the heart of the learning gains seen in the treatment schools.

Another key success was the well-balanced integration Akshara Ganitha achieved. Its resources and strategies now co-exist with prevailing government school practices. They harmonized with the syllabus and explored textbook concepts more comprehensively. They supplemented the activities of the teacher and incentivized children.

Learning outcomes are influenced by multiple factors. Above all are teacher competency and students' absorption capacity. Are children in the class slow or fast learners? Akshara Ganitha includes them all in an encompassing atmosphere of understanding by doing and peer learning.

To further ground its insertion, Akshara is engaging with the government to institutionalize the capacity building of teachers. Akshara Ganitha's training components are a part of Sarva Shiksha Abhiyan's[25] (SSA) training schedule. However, the reduced number of training days, now mandated by the Ministry of Human Resource Development (MHRD), Government of India, is an adversity Akshara has to overcome. Capacity creation has stalled. In the second year Akshara got no training days at all, and in the third year the allocation of half a day was hardly enough.

Along with enhancing teacher capacity in Akshara Ganitha usage, the training also focuses on their beliefs about teaching mathematics because a closer look at the data on classroom observations shows that many teacher-related factors are at work that cannot be externally controlled or manipulated.

For better results and larger impact Akshara believes government must own the program and this includes teacher training as well. The results of the longitudinal study influenced Akshara's strategy to involve Cluster Resource Persons (CRPs) in the delivery of the program. They are the Department of Education's quality monitoring personnel, in touch with schools on a regular basis, and the resource teams oriented them in Akshara Ganitha's methods. These are measures that Akshara hopes would lead to eventual government ownership and strengthen Akshara Ganitha's transformational potential.

5.1 Limitations

Akshara's staff administered three cycles of assessments every year, and theoretically, they are an accurate measure of students' achievement levels. However, in practice, it was difficult for investigators to run tests in the larger schools and prevent teacher interference. In some cases, it was difficult to control the teacher's involvement in helping her students during the test administration process. It was difficult to compress data collection into decisive time frames. Though teachers and managements were informed well in advance, many schools had to be visited more than once.

[25] Sarva Shiksha Abhiyan is Government of India's flagship program for the achievement of Universalization of Elementary Education (UEE) in a time bound manner.

Observers could not be certain that the teacher quality observed while assessing was the everyday norm in classes. Similarly, they could not be certain that the TLMs and other aids were used as a daily practice[26].

Contamination was another issue. By the end of the third year, neighboring control and treatment schools were exchanging information about the program. This was inevitable, though unforeseen. Akshara had not anticipated Akshara Ganitha's popularity. The intent had not been to exclude the control schools, but it so happened that investigators could not keep the data sanitized for purely observation purposes.

Systemic issues also may have impinged on the absoluteness of the study. Teacher transfers, CRP transfers, ad hoc trainings, and stage-managed classrooms fit this context. Other issues could well have mitigated the change effect, like low levels of field monitoring and support, multi-grade teaching environments, and single-teacher situations.

At the end of it all, Akshara tried its best to ensure the sanctity of data capture and verified the accuracy of the evidence at every juncture. The learning from this exercise will permeate other such studies it undertakes now and in the future.

5.2 Recommendations

Based on the findings of the present study, it is clear that Akshara Ganitha program is effective in bringing about change in children's mathematics learning outcomes. Additionally, the design of the program, specifically its TLMs and teacher training model was found appropriate for capacity building in mathematics teachers. However, the teachers' need for sustained support was evident. There are immense challenges in the governmental settings. However, based on the insights from the present study, the following recommendations are made:

- Pedagogical changes in mathematics education are a need of the hour. In order to make mathematics learning more interactive and enjoyable, it is necessary to introduce easy to use TLMs that are cost effective and easily available even in schools with limited resources.
- Teachers are central to the success of any program. Continuous interaction with teachers is a necessity. However, to bring about sustained capacity building in teachers, it is important to evolve strategies that involve the government functionaries in such interactions.

[26] It is to be noted that teachers used the TLMs as required. It is possible that some teachers may not have used the TLMs on the day of the visit.

- Government involvement is therefore necessary in terms of making TLMs available in all government schools, and in strengthening and utilizing the current teacher training resources and mechanisms to create an interactive model of teacher capacity building.

Post Script

Akshara Ganitha, a program that aimed at making mathematics a fun-learning experience was implemented successfully in 575 schools of Karnataka. Encouraged by this, the Government of Karnataka invited Akshara Foundation to partner in implementing the program under the "Ganitha Kalika Andolana" in all the government elementary schools i.e., in 7520 schools of Hyderabad-Karnataka, a region in north-east Karnataka, in the year 2014–15 as Phase 1.

In the Ganitha Kalika Andolana, many of the learnings of the present study were taken into consideration to revise the program to scale.

ANNEXURES

Annexure 1. Comparing the Akshara Ganitha Program and NCF 2005 Recommendations

Methodology/Desired outcomes	NCF 2005 Recommendations
1. Constructivist Learning: Developing conceptual understanding using a concrete-representational, abstract teaching. Akshara provides a mathematics kit with concrete TLM and worksheets to practice pictorial/representational problem solving. There is a shift from procedural and factual knowledge to development of conceptual clarity and application to real world problems.	• Shifting the focus of mathematics education from achieving "narrow" goals to "higher" goals.
2. Co-operative Learning: The Akshara Ganitha pedagogy uses a mix of teacher directed instruction, group and pair work, and individual work. The focus is to ensure that every child learns.	• Engaging every student with a sense of success, while at the same time offering conceptual challenges to the emerging mathematician.
3. Continuous Assessments: The assessments check for conceptual clarity rather than procedural or factual knowledge. They help teachers judge what the child already knows well and what he/she is now ready to learn.	• Changing modes of assessment to examine students' mathematization abilities rather than procedural knowledge.
4. Alignment with Karnataka State Syllabus and the *Nali-Kali* methodology: The program is designed to help teachers transact their day to day work. Care has been taken to ensure this does not add to the workload of teachers, rather it makes their regular work easier.	• Enriching teachers with a variety of mathematical resources.

Annexure 2. Demographic and Socio-economic Characteristics of the Control and Treatment Blocks

Characteristics	Control Block	Treatment Block
Number of Households	36,013	42,613
Average Household Size	5	5
Total Population	185,326	222,430
Urban Population (%)	28.6	16.3
Population (0–6 years) (%)	12.6	13.1
Sex Ratio	945	931
Sex Ratio (0–6 years)	942	929
Sex Ratio (SC)	968	959
Sex Ratio (ST)	949	949
Proportion of SCs (%)	23	22
Proportion of STs (%)	10	3
Literacy Rate (%)	68	69
Work Participation Rate (%)	48	46

Table contd …		
Characteristics	**Control Block**	**Treatment Block**
Main Workers (%)	40	39
Non-Workers (%)	52	54
Cultivators (%)	35	35
Agricultural Laborers (%)	27	22
Industry Workers (%)	2	4
Source: Indian Census 2011		

Annexure 3. Allocation of Treatment and Control Schools[27]

Boodigere Cluster, Devanahalli Block	**Sulibele Cluster, Hoskote Block**
GKHPS Boodigere	GKHPS Arasanahalli
GLPGS Boodigere	GKHPS Attibele
GKLPS Chowdappanahalli	GKHPS Giddappanahally
GKLPS Devanayakanahalli	GKHPS Janatha Colony
GKHPS Gangawara	GKLPS Kadarinapura
HPS Hardanahalli	GKLPS Kurubarahatti
GKLPS Hitharanahalli	GKLPS Sadapanahalli
GKLPS Kagglahalli	GKHPS Sulibele
GKLPS Kondenahalli	GKLPS Valagerepura
GKLPS Nagenahalli	GHPS Yanagunte
GHPS Somathanahalli	GLPS Siddenahalli*
GKHPS Bhattaramarenahalli**	GKHPS Bittahalli*

* School dropped before the mid-line test. **School added before the mid-line test (2011–12)

GKHPS: Government Kannada Higher Primary School
GLPGS: Government Lower Primary Girls' School
GKLPS: Government Kannada Lower Primary School
HPS: Higher Primary School
GHPS: Government Higher Primary School
GLPS: Government Lower Primary School

[27] The allocation of treatment schools suffered complications because 2 of the 12 schools in the Sulibele cluster originally allocated to the treatment group were re-allocated to a different cluster due to boundary changes in mid-2011.

Annexure4. School Characteristics in the Control and Treatment Groups, with Comparative p-values

School Characteristic Variables	Grade 4			Grade 5		
	Control Mean	Treatment Mean	p-Value	Control Mean	Treatment Mean	p-Value
1. Distance to Centre (km)	2.86	2.31	0.57	2.55	2.17	0.66
2. School Building: Pakka	0.64	0.88	0.27	0.60	0.78	0.43
3. School Building: Half-Pakka	0.09	0.00	0.41	0.10	0.11	0.94
4. School Building: Kachcha	0.09	0.00	0.41	0.10	0.00	0.36
5. School Building: Other	0.18	0.13	0.75	0.20	0.11	0.62
6. Number of Languages Spoken	2.09	2.38	0.27	2.10	2.33	0.36
7. Number of Classrooms	0.18	0.50	0.16	0.20	0.44	0.28
8. Separate Classrooms	0.73	0.63	0.66	0.70	0.67	0.88
9. Electricity	0.82	1.00	0.22	0.80	1.00	0.17
10. Number of Sanctioned Teachers	3.18	4.50	0.27	3.30	4.22	0.44
11. Number of Teachers Working	2.91	4.25	0.26	3.10	4.00	0.44
12. Number of Teachers Present on the Day of Visit	2.36	3.00	0.50	2.50	2.78	0.77
13. Number of Female Teachers Present	2.27	3.38	0.18	2.40	3.11	0.39
14. Highest Grade Taught	5.73	6.50	**0.11***	5.80	6.33	0.27
15. Number of Working Days	243.0	239.25	0.58	243.0	239.25	0.58
16. Separate Library	0.09	0.25	0.38	0.10	0.22	0.49
17. Separate Laboratory	0.09	0.13	0.82	0.10	0.11	0.94
18. Separate Storeroom	0.09	0.38	0.15	0.10	0.33	0.24
19. Water Source – Tap	0.55	0.25	0.22	0.50	0.22	0.23
20. Water Source: Tank	0.27	0.50	0.34	0.30	0.44	0.54
21. Water Source: Other	0.18	0.25	0.74	0.20	0.33	0.54
22. Playground	0.36	0.25	0.62	0.40	0.22	0.43
23. Radio Program Timetable	0.36	0.50	0.58	0.40	0.56	0.52
24. Compound	0.36	0.63	0.29	0.30	0.56	0.29
25. Radio Program	0.91	0.75	0.38	0.90	0.78	0.49
26. Headmaster's Room	0.27	0.75	**0.04****	0.20	0.67	**0.04****
27. Headmaster's Room: Used or not	0.64	0.38	0.29	0.70	0.44	0.29
28. Staff Room	0.09	0.13	0.82	0.10	0.11	0.94
29. Separate Teachers' Toilet	0.36	0.88	**0.03****	0.30	0.78	**0.04****
30. Separate Teachers' Toilet: Used or not.	0.73	0.25	**0.04****	0.80	0.22	**0.01*****
31. Separate Girls' Toilet	0.73	0.88	0.46	0.70	0.78	0.72
32. Separate Girls' Toilet: Used or not.	0.36	0.25	0.62	0.40	0.22	0.43
33. Charts	0.91	1.00	0.41	1.00	1.00	1.00

Table contd …						
School Characteristic Variables	**Grade 4**			**Grade 5**		
	Control Mean	**Treatment Mean**	**p-Value**	**Control Mean**	**Treatment Mean**	**p-Value**
34. Maps	0.73	1.00	0.12	0.80	1.00	0.17
35. Models	0.45	0.88	**0.07***	0.50	0.89	**0.08***
36. Models in Use	0.45	0.88	**0.07***	0.50	0.89	**0.08***
37. Globe	0.64	1.00	**0.06***	0.70	0.89	0.34
38. Globe in Use	0.64	1.00	**0.06***	0.70	0.89	0.34
39. Notice board	0.73	1.00	0.12	0.80	1.00	0.17
40. Radio	0.91	1.00	0.41	0.90	1.00	0.36
41. Audio Recorder	0.73	1.00	0.12	0.70	1.00	**0.08***
42. Audio Recorder in Use	0.73	1.00	0.12	0.70	1.00	**0.08***
43. Television	0.36	0.63	0.29	0.40	0.56	0.52
44. Computer	0.27	0.63	0.14	0.30	0.56	0.29
45. Computer in Use	0.27	0.50	0.34	0.30	0.44	0.54
46. Other Materials	0.09	0.13	0.82	0.10	0.11	0.94
47. Other Materials in Use	0.09	0.14	0.75	0.10	0.13	0.88

Source: Pre-test survey of schools (2011–12)
Key: *** p<0.01, ** p<0.05, * p<0.1

Annexure5. Teacher Characteristics in the Control and Treatment Groups, with Comparative p-values

	Grade 4			**Grade 5**		
Teacher Characteristics	**Control Mean**	**Treatment Mean**	**p-Value**	**Control Mean**	**Treatment Mean**	**p-Value**
Teacher's Age	41.36	36.63	0.26	40.50	36.78	0.35
Percentage of Female Teachers	0.45	1.00	**0.01*****	0.40	0.78	**0.11***
Percentage of new Teachers since Mid-test	0.36	0.00	**0.06****	0.40	0.00	**0.03****
Years of Teaching	13.11	12.50	0.86	11.42	12.78	0.62
Years at current School	7.46	9.00	0.57	6.30	8.22	0.44
Years teaching mathematics to grades 4 and 5	6.09	4.88	0.68	4.80	6.00	0.66
Percentage with BA	0.18	0.63	**0.05****	0.20	0.56	0.12
Percentage with MA	0.00	0.25	**0.09***	0.00	0.22	0.13
Percentage with PUC	0.45	0.38	0.75	0.50	0.33	0.49
Percentage with D.Ed	0.00	0.25	**0.09***	0.00	0.11	0.31
Percentage with TCH	0.64	0.88	0.27	0.60	0.78	0.43
Enthusiasm Rating (1–10)	3.64	2.63	0.31	3.80	2.50	0.18
Teacher's Lesson Performance Rating (1–10)	3.86	2.56	0.20	4.05	2.33	**0.09***
Conceptual Understanding Rating (1–10)	3.18	2.06	0.20	3.40	1.94	**0.08***

Source: End-line Survey and Classroom Observations (2012)
Key: *** p<0.01, ** p<0.05, * p<0.1

Annexure 6. Student Characteristics in the Control and Treatment Groups, with Comparative p-values

	Grade 4			Grade 5		
Student Characteristics	**Control Mean**	**Treatment Mean**	**p-Value**	**Control Mean**	**Treatment Mean**	**p-Value**
Percentage of Female Students	0.48	0.45	0.77	0.52	0.57	0.49
Percentage of Muslim Students	0.03	0.09	0.11	0.08	0.10	0.70
Percentage of ST, SC, or OBC Students	0.28	0.18	0.15	0.29	0.12	**0.003*** **

Source: Pre-test Student Assessments (2011)
Key: *** p<0.01, ** p<0.05, * p<0.1

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