PLAYFUL PROGRESS TOWARDS NIPUN BHARAT: HARNESSING THE POTENTIAL OF EDTECH

Lessons from a teacher-led at-home learning programme for foundational literacy and numeracy

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EXECUTIVE SUMMARY

The transformative potential of Educational Technology (EdTech) or Computer-Aided Learning (CAL) in addressing educational disparities has attracted significant interest among researchers and policymakers globally. While studies showcase the positive impact of EdTech on learning outcomes, its efficacy remains unexplored in the formative years of younger children, especially in teacher-assisted remedial contexts as a home-based supplement to instruction. With the focus on foundational learning gaining momentum via the NIPUN Bharat Mission in India, it will be critical to explore how technology can be meaningfully integrated into educational programming to support learning.

This study delves into the efficacy of a teacher-assisted EdTech app, Chimple, focusing on first and second-grade students in India. The app, available in Hindi, focuses on foundational learning through a game-based approach, enhancing engagement, and enabling formative assessment to aid teachers in tailoring classroom instruction. The implementation of Chimple was led by the Bharti Airtel Foundation as part of their Satya Bharti Schools programme in the 2022-23 academic year.

Deploying a stratified randomised control trial across 34 Satya Bharti schools, this research assesses Chimple's impact on test scores. The findings shed light on how technology-aided supplemental learning can assist teachers in heterogeneous classrooms. Moreover, the study evaluates a teacher-led, at-home learning model that leverages WhatsApp to nudge parental engagement. Unlike hardware-focused studies, Chimple's integration as a supplement to classroom instruction presents a game-based, low-cost, and teacher-assisted approach, centred on formative assessment, potentially easing concerns about EdTech costs in LMIC contexts.

Overall, there is a 0.25 standard deviation improvement in Math test scores for grades 1 and 2. The study finds a 0.35 standard deviation improvement in test scores for grade 1 students in Math, with the lowest-performing learners at baseline benefitting the most. The study also finds a 0.24 standard deviation improvement in test scores for grade 2 students in English. The results indicate that an additional hour on the app increases Math test scores by 0.24 standard deviation for all students, and 0.36 standard deviation for first graders. For English, an additional hour on the app increases test scores by 0.20 standard deviation for second graders. The intervention was highly cost-effective at scale, and there are no observed differences by gender.

In this report, we provide details of the research undertaken to estimate the impact of the intervention on foundational literacy and numeracy outcomes. We describe the intervention deployed to carry out the research, the study design, and the research findings of the study.

INTRODUCTION AND BACKGROUND

India has the world's most extensive education system with around 260 million children taught by 8 million teachers, in 1.5 million schools. Over the last decade, it has made mammoth strides in inclusion and enrolment; however, despite an enrolment rate of over 95%, more than 56% of children in India are unable to read or understand simple texts at the age of 10.[1] As a result, students fall behind their peers and are unable to catch up, further hampering learning as they progress from grade to grade. In addition to poor learning outcomes, systemic challenges are prevalent in the country, including a shortfall of nearly 1.1 million teachers and poor retention as students move into higher grades.[2] The pandemic exacerbated these challenges, as India saw one of the longest school closures in the world, with schools partially or completely closed for over 18 months. Therefore, it is essential to intervene early to ensure that all students have mastered the foundational skills they need to have meaningful learning experiences as they grow older. To address these challenges, the Government of India launched the *NIPUN Bharat Mission* in 2020 to achieve universal acquisition of foundational literacy and numeracy skills at the primary level by 2025.

A growing body of evidence from around the world shows that EdTech has the potential to support learning for all stakeholders in the teaching and learning process: for teachers, EdTech has begun to reduce the burden of delivering quality lessons; for students, technology is helping them become more independent in their learning process and enabling them to learn as per their skill levels and at a pace that suits them; and for parents, EdTech is also facilitating meaningful parental engagement in their child's learning journey. EdTech has also shown promise in supporting continued learning at home during and after the COVID-19 pandemic. The agnostic nature of technology applications can be inclusive and such technologies have the potential to facilitate formative assessment, enabling teachers to help struggling students catch up.

Further, India presents an interesting playground for EdTech usage at home. Smartphone penetration at the household level across urban and rural India is likely to become ubiquitous over the next few years, and currently, 72% of children from low-income households have access to a shared device and 74% of children spend more than 30 minutes on any given day on their parents' phones.[3] Of this, 65% of girls and 55% of boys use their parents' phone daily. India also ranks lowest amongst countries on the cost of internet data – 1GB of data costs $0.10 in India. In this context, EdTech is a promising pathway to support classroom learning at home.

[1] *World Bank, Learning Poverty Index (2022)*

[2] *UNESCO, No teacher, no class: State of the Education Report for India, 2021*

However, the effective implementation of high-quality EdTech, particularly for low-income populations, is hampered by the lack of evidence for this context. While many studies have shown the positive effect of EdTech products on learning outcomes for older age groups,[4] there exists very little evidence of its efficacy for earlier grades, particularly in the Indian context. With the launch of NIPUN Bharat to ensure universal foundational learning, and the growing interest among governments to adopt technology solutions post-pandemic, it is paramount to build evidence around what works and find cost-effective solutions to unlock meaningful adoption. This evidence can be instrumental in exploring pathways around how technology can be meaningfully integrated into states' NIPUN Bharat Mission programmes, and how learning at home via technology can support in-school interventions to help children attain foundational learning skills.

To add to this growing body of evidence, a game-based app, Chimple was tested in collaboration with Bharti Airtel Foundation in a teacher-directed, at-home learning model. Several organisations and individual researchers came together to put the programme together and empirically assess its impact. The app and its content were developed by Chimple, and the interventions were deployed at 34 Satya Bharti schools in Haryana run by the Bharti Airtel Foundation. The monitoring and evaluation were done by independent researchers affiliated with institutions and organisations in India and the USA. Awadh Research Foundation collected the data. The ethics protocol was approved by the University of Virginia SBS IRB. Parental consent and child assent were taken to test the students.

[3] *Central Square Foundation, Bharat Survey for EdTech (2023)*

[4] *For example, Muralidharan et. al. evaluated the impact of a personalised technology-aided after-school instruction programme in middle-school grades in urban India using a lottery that provided winners free access to the programme. Lottery winners scored 0.37 standard deviations higher in Math and 0.23 standard deviations higher in Hindi over just a 4.5-month period (Muralidharan, Karthik, Abhijeet Singh, and Alejandro J. Ganimian. 2019. "Disrupting Education? Experimental Evidence on Technology-Aided Instruction in India." American Economic Review, 109 (4): 1426-60).*

CHIMPLE – LEVERAGING GAME-BASED LEARNING TO ENGAGE LEARNERS

Chimple is a game-based and personalised app for foundational learning that has been designed to provide learners with an engaging learning experience. Chimple is a two-part solution with a separate Child app and a Teacher app. This enables teachers to get valuable insights into students' progress through their app as children attempt their game-based assigned work on theirs. Chimple offers content in vernacular languages such as English, Hindi, Kannada, and Marathi. The app requires an internet-enabled smartphone, though select content packages are available for offline use.

Chimple was a finalist for the Global Learning X-PRIZE in 2017, and won $1M to build and test their solution. In Tanzania, the app showed ~17% & ~18.2% gains in literacy and numeracy respectively in a field trial led by UNESCO.[5]

CHIMPLE AS A GAME-BASED LEARNING TOOL FOR CHILDREN

For children, Chimple acts as a fun, play-based learning tool. Children learn better if the learning material is accessible and game-based approaches can be more engaging when attention spans are short. Hence, engaging games where the content along the learning ladder is mapped into actions are rewarding for them. They are also likely to engage for longer duration if the games also have reward and incentive systems.

As shown in Figure 1, Chimple uses simple games to enhance learning of foundational numeracy and literacy skills and is designed to be engaging and fun for a young child. Literacy activities cover letter recognition to comprehension and grammar, and numeracy activities cover number sense to analytical computations. Learning on the Chimple app is also supported via an interactive in-app mascot, the Chimple chimpanzee, which provides verbal nudges and prompts to guide the child through the learning experience. Learning is also encouraged via in-app rewards and encouragement nudges, such as badges and stickers, leaderboards and stories.

[5] *Global Learning X-PRIZE, Executive Summary Report (2019)*

Figure 1: **Chimple Child App**

CHIMPLE HAS THE POTENTIAL TO PROVIDE DATA FOR FORMATIVE INSTRUCTION

For the teacher, Chimple helps understand student progress better via a teacher's dashboard on the companion Teacher app, enabling teachers to augment their instruction appropriately. In this easy-to-use dashboard, as highlighted in Figure 2, teachers can assign activities and track how the students are doing on each activity – which students have mastered the content and which students are struggling. This information can help teachers plan lessons, including assigning remedial content to help struggling children, and assigning challenging activities for students who would benefit from additional practice. Another feature of the dashboard is that the teacher can view a specific student's learning trajectory (Figure 2 and 3). This way, they can take steps to prevent students from falling through the cracks. They can notify parents about the student's work and performance easily. The app lowers the cost of formative activities for teachers.

All content in the Chimple Teacher and Child app is mapped to the *National Council of Educational Research and Training* (NCERT) prescribed curriculum for grades 1 and 2. All names and labels for lessons and games are mapped to lessons and chapters described in the textbooks used in India. This enables ease of assignment and alignment with the teachers' lesson plans.

Figure 2: **Chimple Teacher Dashboard**

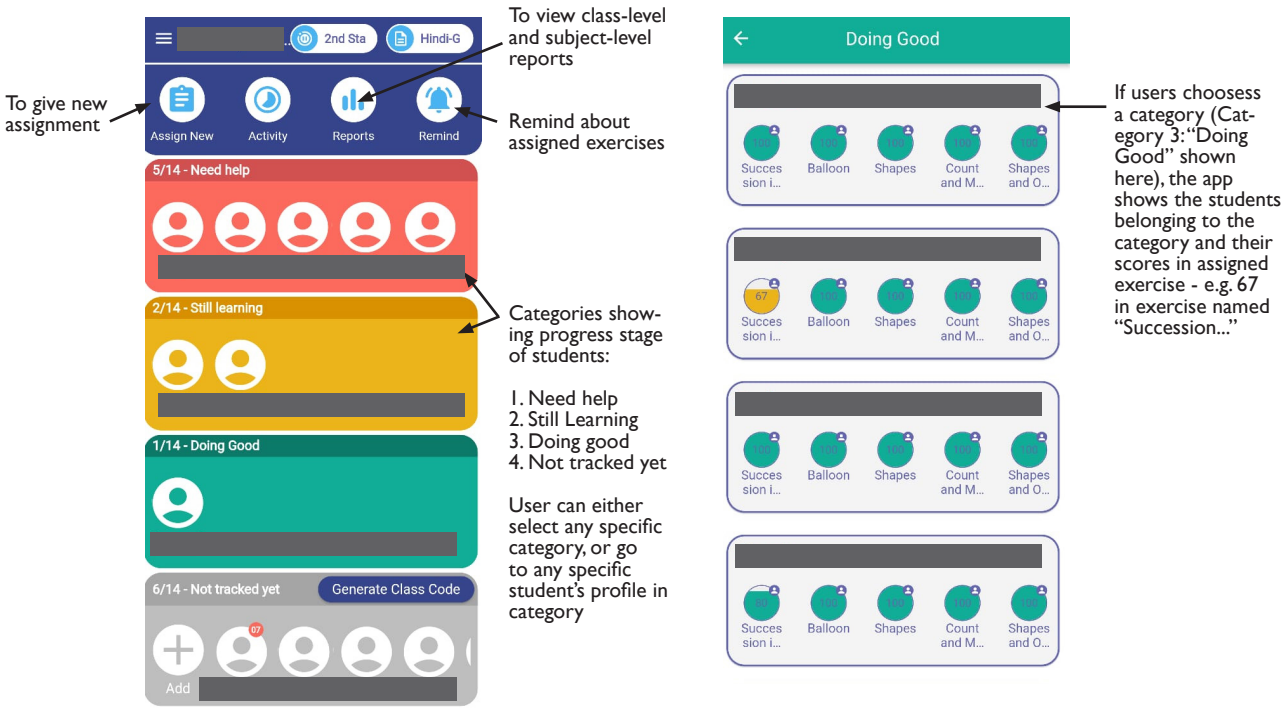
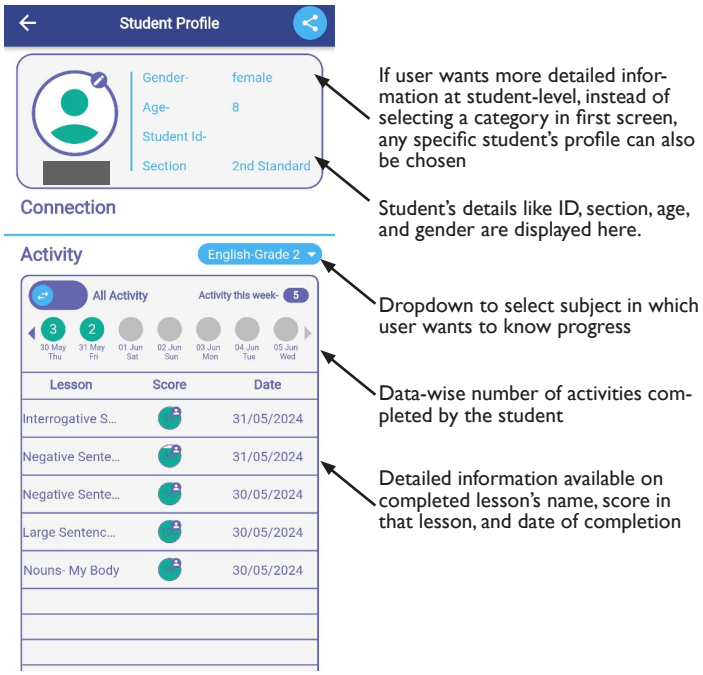


Figure 3: **Chimple Student Report on Teacher Dashboard**



BHARTI AIRTEL FOUNDATION – SUPPORTING TEACHERS TO DRIVE FOUNDATIONAL LEARNING

Bharti Airtel Foundation, the philanthropic arm of Bharti Enterprises, started its operations in the year 2000 with a mission to help underprivileged children and youth of India realise their potential. The Foundation works in the space of holistic quality education in rural India with a special focus on girl children; and also supports higher education programmes in partnership with premier institutions.

Since 2006, the flagship Satya Bharti School Program has been providing free quality education to thousands of underprivileged children in 173 schools in rural India across five states. Currently, over 40,000 children are enrolled in Satya Bharti Schools, of which 50% are girls. The impact of quality education has been widened by transferring the learning and good practices of this programme to more than 3.7 lakh students studying in 880 partnering government schools across 12 States/UTs, through the Quality Support Program (QSP), since 2013. In addition, several district and state-level education officers invited the Bharti Airtel Foundation to scale up some of the initiatives through QSP via state partnerships. The Foundation has also recently launched a new initiative, TheTeacherApp, an innovative technology solution for teachers and educators across the country.

Satya Bharti Abhiyan, the sanitation initiative, started in 2014 until 2021, has benefitted over 2 lakh beneficiaries by improving sanitation conditions across districts of Punjab, providing access to toilets and fostering behavioural change in communities.

The Foundation has been able to impact nearly 3 million children in a meaningful manner through its education programmes since its inception.

A study[6] conducted by the Bharti Airtel Foundation and Central Square Foundation during the pandemic found that in Haryana, 88% of Satya Bharti School students had access to at least one smartphone at home, and over 80% were connected to the internet via mobile data. Given this context, Bharti Airtel Foundation was keen to explore pathways on how students' foundational learning could be supported through technology at home, particularly of young children. Bharti Airtel Foundation, Central Square Foundation, and Chimple Learning signed a Memorandum of Understanding to implement and evaluate the Chimple programme in Satya Bharti schools on a pilot basis in Haryana, in collaboration with the research team.

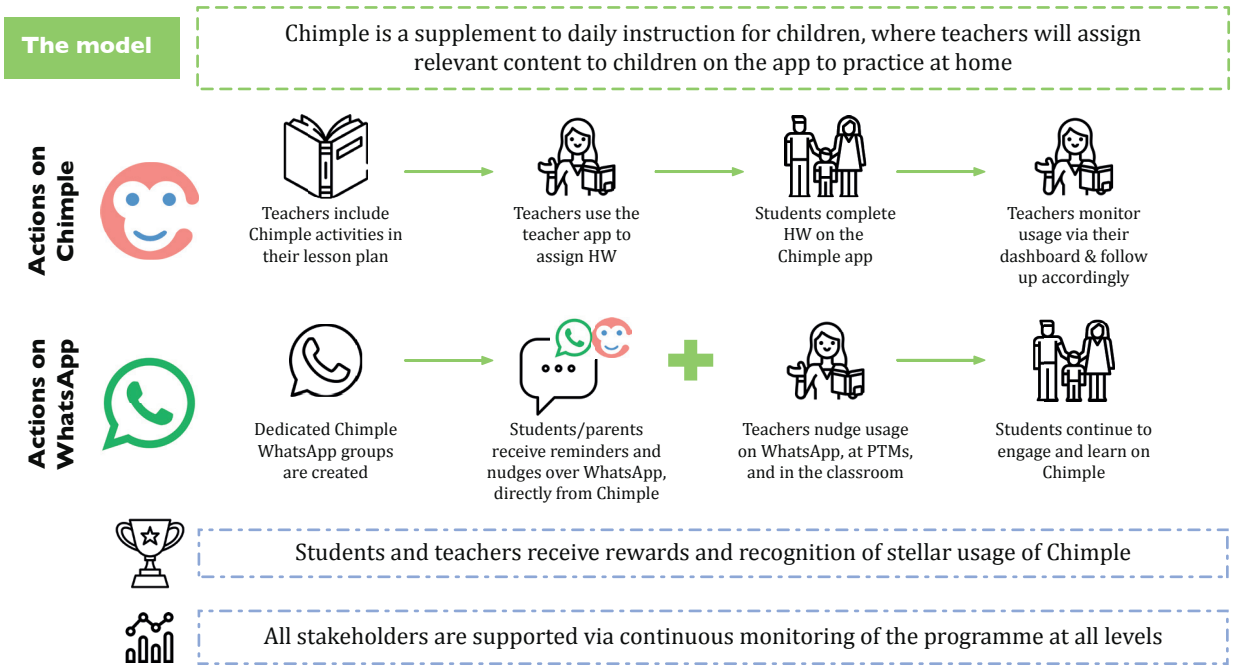
[6] *Central Square Foundation & Bharti Airtel Foundation, Remote Learning Case Study (2021)*

INTERVENTION DESIGN

The implementation of Chimple in Satya Bharti schools was in a teacher-directed, at-home learning model, wherein a teacher would remotely assign content on the app for children to practice at home, based on their lesson plans for the week. Using the data available on the app around student progress, the teacher was expected to monitor student data and continuously assign them relevant activities, and accordingly augment or change the pace of instruction in the classroom every week. Teachers also set up WhatsApp groups to inform parents about assignments that had been posted and remind them to have their children complete the activities. Figure 4 illustrates this model. Bharti Airtel Foundation administrators conducted monthly check-ins with the teachers, along with the district coordinators. There was also a field coordinator hired by Chimple who monitored how teachers used the app and conducted monthly reviews with teachers. The programme was discussed as part of head-teacher meetings, facilitated by cluster coordinators, as well.

Robust rewards and recognition mechanisms were an important source of motivation for continuous usage and engagement of the app. For students, this was operationalized in the form of 'Chimple contests' – for example, a competition was organised during the Christmas and New Year holidays, wherein students with the most usage of Chimple were rewarded with a virtual and physical certificate. For teachers, it was in the form of a 'Chimple champions' programme – for example, star teachers were rewarded with a 'Teacher of the Month' certificate for driving successful usage of the Chimple app. Bharti Airtel Foundation also recognized teachers through their 'Spot the Hero' campaign for stellar usage of Chimple. Students also received 'smileys' in class for continuous usage and good performance on Chimple. This reward and recognition mechanism was instrumental in sustaining engagement, particularly during school holidays.

Figure 4: **Chimple-Based Learning Model in the Intervention**



ON-GROUND TECHNICAL AND PROGRAMMATIC SUPPORT

Teachers were provided technical and programmatic training and support by Chimple and Bharti Airtel Foundation through a one-day training at the district level. This training involved hands-on exercises both from the students' as well as teachers' perspective. Among other things, it featured an in-depth demo of the Teacher and Student apps, with hands-on simulation exercises, allowing them to practise using the app both from a teachers' and students' perspective. The training from Bharti Airtel Foundation covered modules on the programmatic elements, including the mapping of the content, lesson planning, monitoring, and other support functions. Refresher training was provided every quarter to teachers and Bharti staff. Chimple teacher WhatsApp groups were formed to communicate important announcements and provide on-demand technological support.

Satya Bharti teachers also organised special Chimple Parent orientations during regular Parent-Teacher Meetings (PTMs). These gatherings were used to create awareness about Chimple, support with downloading of the app, encourage activation, add parents to the Chimple WhatsApp groups, and engage parents, particularly mothers, in their children's learning. Parents were able to ask questions in the WhatsApp groups, and teachers along with Chimple field coordinators would also conduct home visits to students' homes to address any app-related challenges.

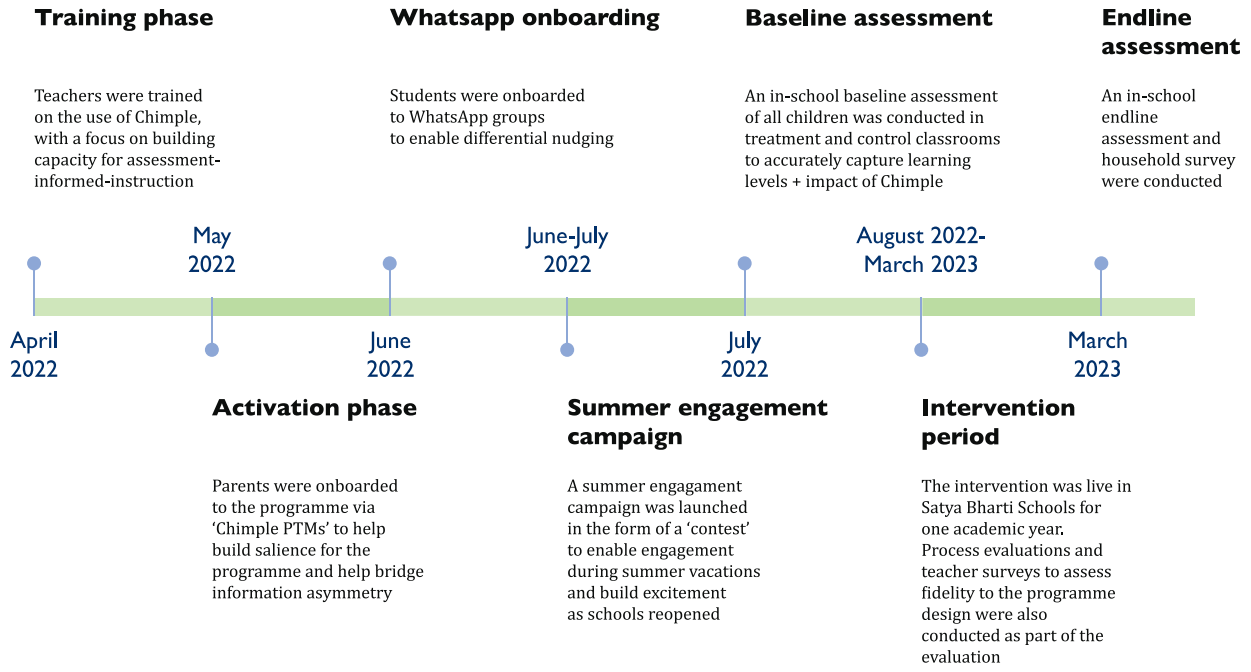
PROJECT IMPLEMENTATION

The Chimple evaluation was implemented in the 2022-23 academic year. Before the evaluation, the programme was piloted in four schools in Haryana in the 2021-22 academic year to stress-test and iterate on the programme design.

The research team randomised the classes that would receive treatment in March 2022, and teacher training was implemented thereafter. In April 2022, PTMs were held and activation started. During May and July, many resources were extended to encourage activation by offering star teacher recognition for maximum activation in a month and sending WhatsApp nudges to parents. Since pandemic-era measures were ending and schools were meeting in-person for the first time since 2020, Bharti Airtel Foundation offered a bridge programme in the summer holidays to help students get ready for the new school year. This ended in July 2022, at which point teachers began assigning activities on Chimple. The research team visited some schools in June 2022, and baseline testing of Math and English was conducted by the research team in August 2022. Several visits were made by the research team to spot-check that the fidelity of the experimental design was being maintained.

For the rest of the year, the programme was implemented as designed, including regular monitoring by teachers and Bharti staff, rewards and recognition programmes for both students and teachers, nudges and reminders, and refresher training. In November 2022, a Zoom-based teacher survey was conducted for all teachers in the study. The endline test in Math and English was conducted in March 2023 and administered independently by the research team.

Figure 5: **Timelines**

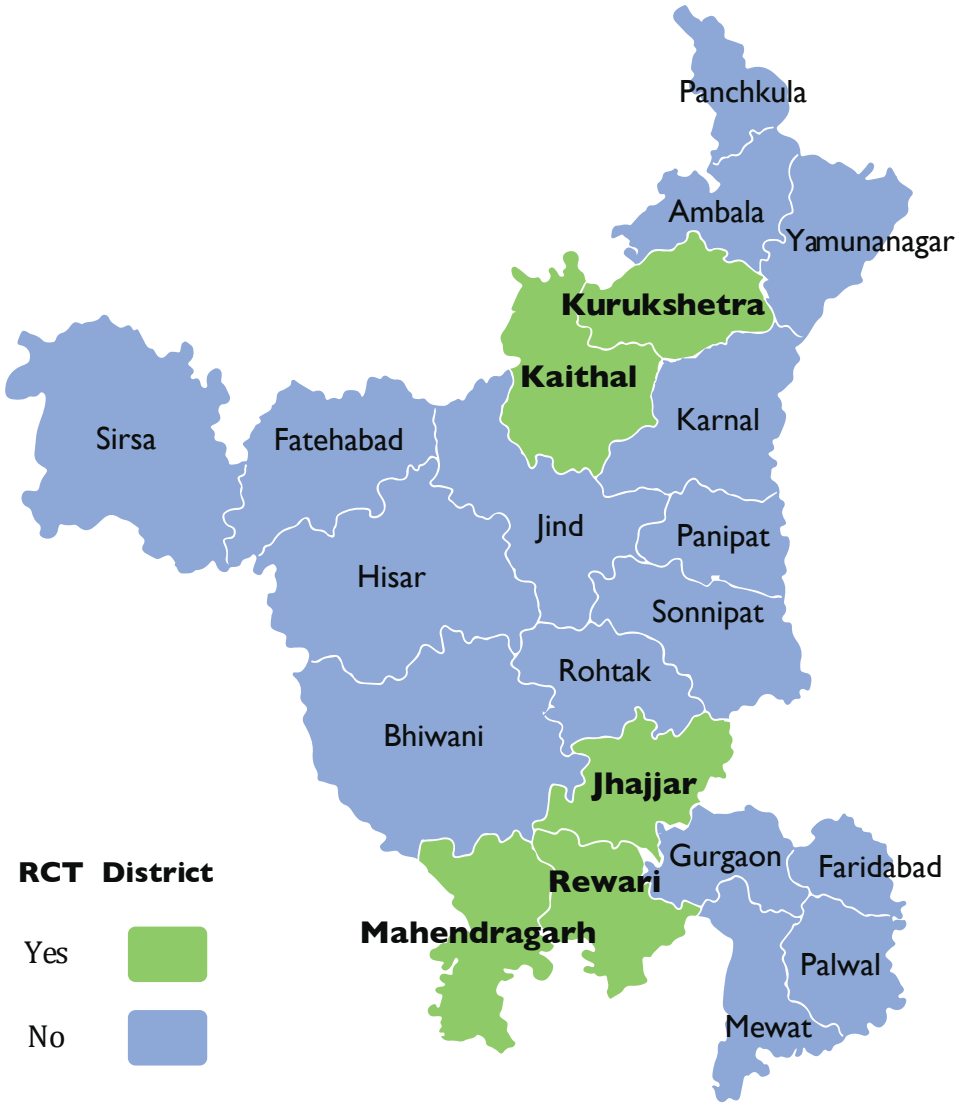


STUDY DESIGN, SAMPLING AND DATA SOURCES

Bharti Airtel Foundation operates 38 Satya Bharti schools in the state of Haryana, India. As mentioned above, the intervention and surveys were piloted in four of these schools in the 2021-2022 academic year, which were then excluded from the main study. The study sample consists of the remaining 34 schools.

Total enrolment across the sample was a little under 1,000 students per grade. More than 80% of children enroled are from disadvantaged castes, and 50% of households earn less than USD 1,300 per year. Approximately 88% of households have access to at least one smartphone that can run Chimple. Figure 6 plots the districts where the schools were located.

Figure 6: **Spatial Distribution of Satya Bharti Schools in Haryana**



A. STUDY DESIGN

We assess the impact of Chimple on children's test scores using a clustered stratified randomised control trial, where a grade within a school is the unit of randomisation. The sample includes 34 schools with one section each of grades 1 and 2, Chimple's target age group.

The grade-level randomisation was done at the end of March 2022 – before the start of the 2022-2023 school year – based on school administrative records from the previous academic year. Specifically, we used average test scores from the end of the academic year 2021-2022 to group schools in eight strata (seven groups of four schools and one group of six schools). In each stratum, 50% of schools were randomly chosen to offer the programme in grade 1; the remaining schools offered the programme in grade 2. The other classes, grade 2 in the first set of schools and grade 1 in the second, comprise the control group.

B. DATA SOURCES

Our primary outcome of interest is students' scores on independently administered tests of Math and English, designed by the research team and conducted by the commissioned survey agency. The research team designed the test questions following the recommendations in the Early Grade Mathematics Assessment (EGMA) toolkit from RTI International and included questions similar to those in Pratham-ASER tests. The tests also followed the same format and difficulty as regular assessments administered by Bharti.

We conducted an initial round of tests in August 2022, soon after students completed a bridge course helping to address learning gaps from the pandemic but very early into the Chimple intervention. This test provided us with a baseline level of student scores.

We conducted similar endline tests in early March 2023, immediately before Bharti's end-of-year tests. To minimise attrition, we offered the endline tests on two different days so that those absent on the first day could take the test on the second day.

In November and December 2022, in the middle of the intervention, we conducted Zoom interviews with all grade 1 and grade 2 teachers to collect data on Chimple usage, homework assignments, interactions with parents, and teachers' perception of the programme. From Chimple, we can also assess high-frequency data on student engagement with the app.

Finally, we received administrative data from Bharti on teacher and student characteristics, grade-level enrolment, as well as test scores from previous years. Table 1 provides summary statistics

from the sample, demonstrating that schools assigned to provide Chimple in grade 1 are not different from those schools assigned to provide Chimple in grade 2 on characteristics measured before the intervention, that is, at the end of the 2021-2022 school year.

SAMPLE DESCRIPTION

Table 1 provides the distribution of the tested sample across treatment and control groups by grade.

Table 1: **Sample Size of Students Tested**

Endline Sample	Total	Grade 1	Grade 2
Treated	745	368	377
Control	785	445	340

The sample included 1677 students, with 818 treatment and 859 control students. Of these, 147 students were not tested or had attrited. Attrition is balanced across treatment and control with 73 and 74 students, or 0.89% and 0.86% of the total students in the group, respectively. The remaining 1530 were tested with 745 in treatment and 785 in control.

The average age of the children was 6 years and 50% were female. Almost 90 percent had access to a mobile phone at home.

EXPERIMENTAL FIDELITY

We compared a wide range of characteristics across treated and control classes and report averages for treated classes in column (1) of Table 2, and control classes in column (2). We checked whether the difference in means is statistically significant and reported the P-values in column (3). As column (3) shows, all the characteristics are balanced across treated and control groups.

Table 2: **Balance Across Treatment and Control Grades**

	Treatment	Control	Standard P-value
	(1)	(2)	(3)
% male teacher	0.118	0.147	0.714
% general teacher	0.500	0.529	0.814
% OBC teacher	0.412	0.353	0.613
% SCST teacher	0.088	0.118	0.696
% MA teacher	0.412	0.441	0.812
% BA teacher	0.206	0.279	0.500
Average teacher age	38.	37.	0.274
HH Phone hours	3.	2.	0.649
% male students	0.527	0.501	0.351
% general caste students	0.176	0.171	0.911
% OBC caste students	0.359	0.351	0.863
% SC caste students	0.465	0.478	0.786
Age	7.	7.	0.879
% migrant students	0.032	0.036	0.750
% High income students	0.637	0.652	0.853
% below PL students	0.185	0.199	0.719
Mean score in SDs in 2021	0.005	0.017	0.9:36
Number of grades	34	34	

A. TAKE-UP AND SPILLOVER FROM TEACHER SURVEY

Findings from our teacher survey show that the uptake of app-based homework was 100% in the treatment group and 6% in the control group (Figures 7 and 8). We observe little evidence of spillovers in the control group. While 100% of the teachers in treated classes reported giving app-based homework to their students, only 11% of grade 1 control teachers and none of the grade 2 control teachers (who did not receive the Chimple intervention) reported giving app-based homework.

Figure 7: **Evidence on Spillovers - Teachers Assign App-Based HW in the Overall Sample**

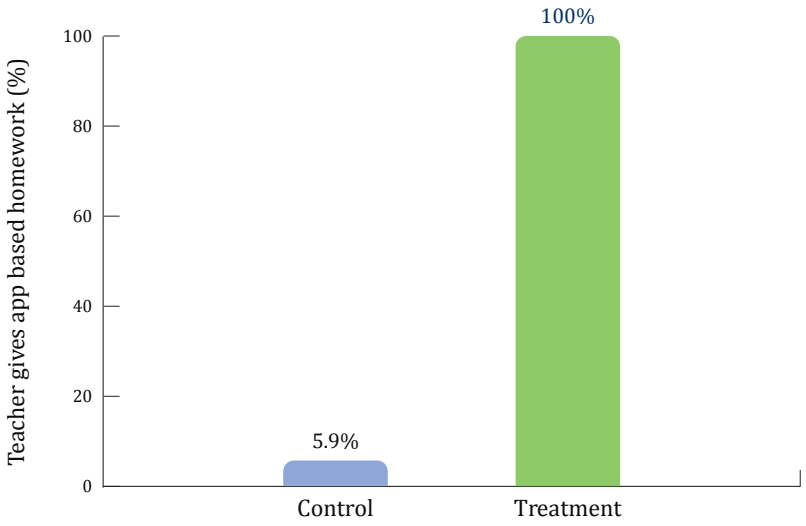
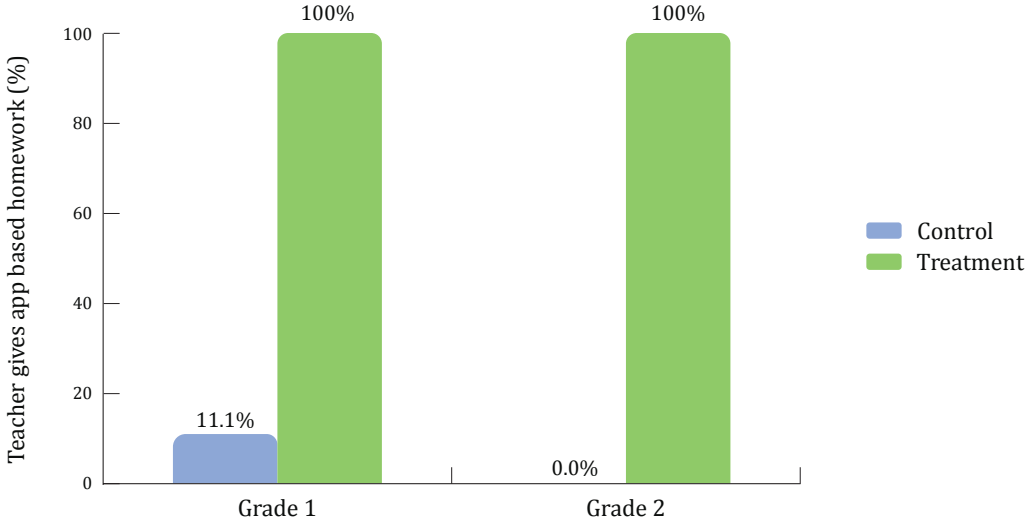


Figure 8: **Evidence on Spillovers - Teachers Assign App-Based HW by Grades**

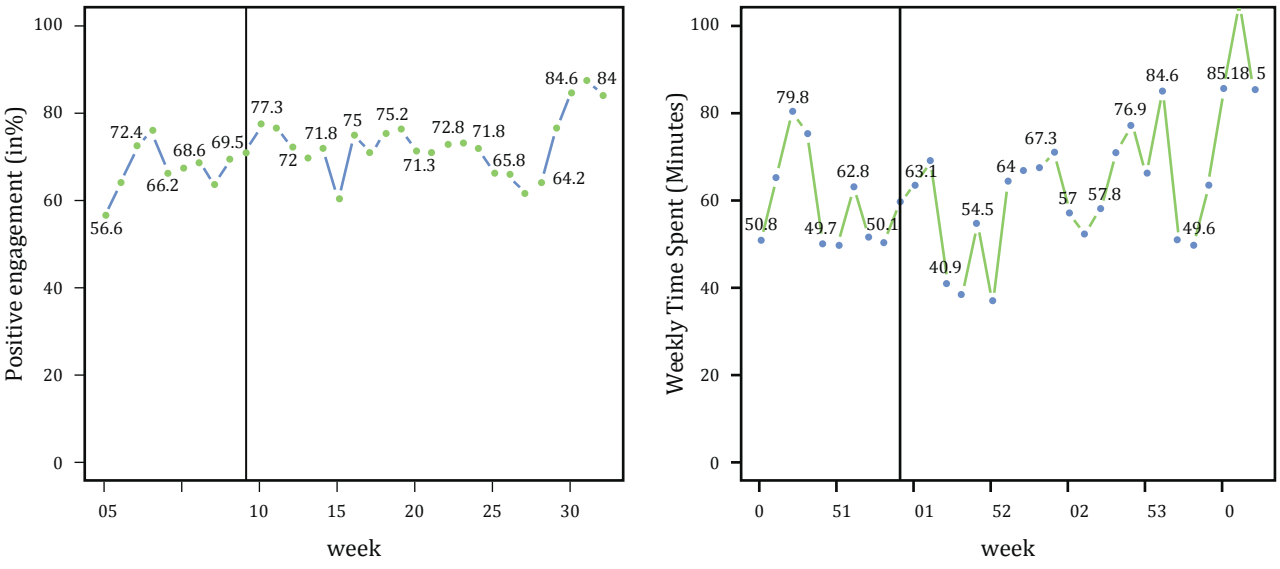


B. ENGAGEMENT

Our goal was to achieve positive engagement rates of at least 80% of students actively using Chimple each week and around 10 minutes of Chimple activity per day, or approximately 60 minutes per week. We arrived at this goal based on the average usage observed in the four-school pilot, as well as in the X-PRIZE intervention in Tanzania. Lessons from the pilot also highlighted the need for Bharti and Chimple coordinators to provide incentives for children and teachers early in the intervention in order to help parents and children get onboard, and build a routine for teachers. Therefore, a recognition and rewards system was introduced as highlighted in the intervention design.

Panel A of Figure 9 provides a time-trend of positive engagement, demonstrating that approximately 60% to 80% of children engaged with the app each week. The vertical line indicates the end of the baseline survey and the beginning of the regular WhatsApp nudges encouraging children to complete their Chimple homework. Panel B demonstrates that students spent close to an hour on the app each week, rising towards the end of the intervention as the end-of-year exams approached. The spikes and lows in the two graphs often coincide with holidays and festivals.

Figure 9: **Weekly Time-Trends in Student Engagement**



(a) Positive engagement rates

(b) Weekly total time spent (minutes)

EVALUATION STRATEGY

In order to estimate the treatment effect on outcomes, we use the following equation -

$$Y_{igst_1} = \beta_0 + \beta_1 Treat_{gs} + \mu_k + \lambda_r + Y_{igst_0} + X_{igst_0}\Phi + \epsilon_{igst_1}$$

Where,

Y_{igst} is the relevant outcome for student i in grade g in school s and time t (t_1 for endline, t_0 for baseline)

$Treat_{gs}$ is the indicator that captures if the student is in the treated grade g of schools

β_1 is the coefficient of interest measuring the treatment effect on the outcome of interest

μ_k are strata fixed effects

λ_r are district fixed effects

X_{gst0} are predetermined characteristics including gender, caste, migrant family status, father's occupation (labour, agriculture or private job), mother's occupation (labour, housewife), special needs child, family income, BPL status, district categories, access to android phones, connectivity categories (4g, 3g, or 2g).

ϵ_{igst1} is the error term clustered at the school-grade level

FINDINGS

TREATMENT EFFECTS BY SUBJECT

Our empirical analysis indicates that the programme had a positive effect on foundational learning outcomes.

In Figure 10, we report the raw differences in test scores between the treatment and control groups for both Math and English. There are two key points of observation from this figure:

1. The test scores are higher for the treatment group across both subjects.
2. The difference in test between the treatment and control groups is higher for Math.

Our estimates by subject are reported in Table 3, where columns (1) through (4) report the results for Math, and (5) through (8) for English. We begin by reporting the estimate for a specification where we control for grade-fixed effects and strata-fixed effects. We sequentially control for our baseline test scores, Satya Bharti School-administered test scores, and demographic characteristics.

Grade-by-school clustered standard errors are reported in parentheses and randomised inference errors are in brackets. We observe a positive effect for both Math and English. In Column (4), we discern a 0.25 standard deviation increase in Math scores which is statistically significant at the 5 percent level. The analogous estimate for English shows a treatment effect of 0.14 standard deviation, although it is not statistically significant at conventional levels.

Figure 10: **Overall Raw Mean Scores Over Time**

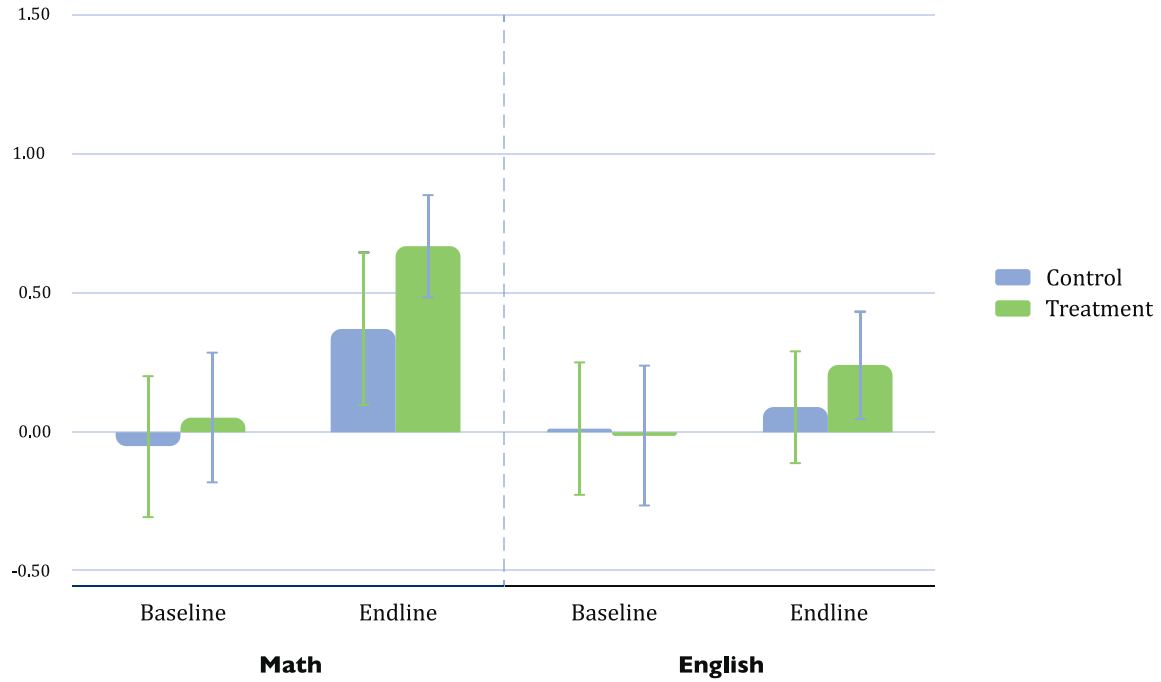


Table 3: **Overall Treatment Effect by Subject**

	Math				English			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.24	0.22	0.23	0.25	0.13	0.11	0.13	0.14
	(0.08)*	(0.10)*	(0.08)*	(0.03)**	(0.30)	(0.36)	(0.30)	(0.23)
	[0.13]	[0.15]	[0.14]	[0.10]*	[0.32]	[0.39]	[0.34]	[0.33]
Observations	1528	1528	1528	1528	1528	1528	1528	1527
R-squared	0.09	0.13	0.17	0.24	0.09	0.14	0.19	0.24
Grade FES	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Strata FES	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline scores	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Bharti scores	No	No	Yes	Yes	No	No	Yes	Yes
Demographic controls	No	No	No	Yes	No	No	No	Yes

In Figures 11 and 12, we examine the raw mean differences for Math and English separately by grade. These suggest that there was an improvement in Math scores in grade 1 and an improvement in English scores in grade 2.

Figure 11: **Raw Mean Differences in Grade 1 and 2 in Math**

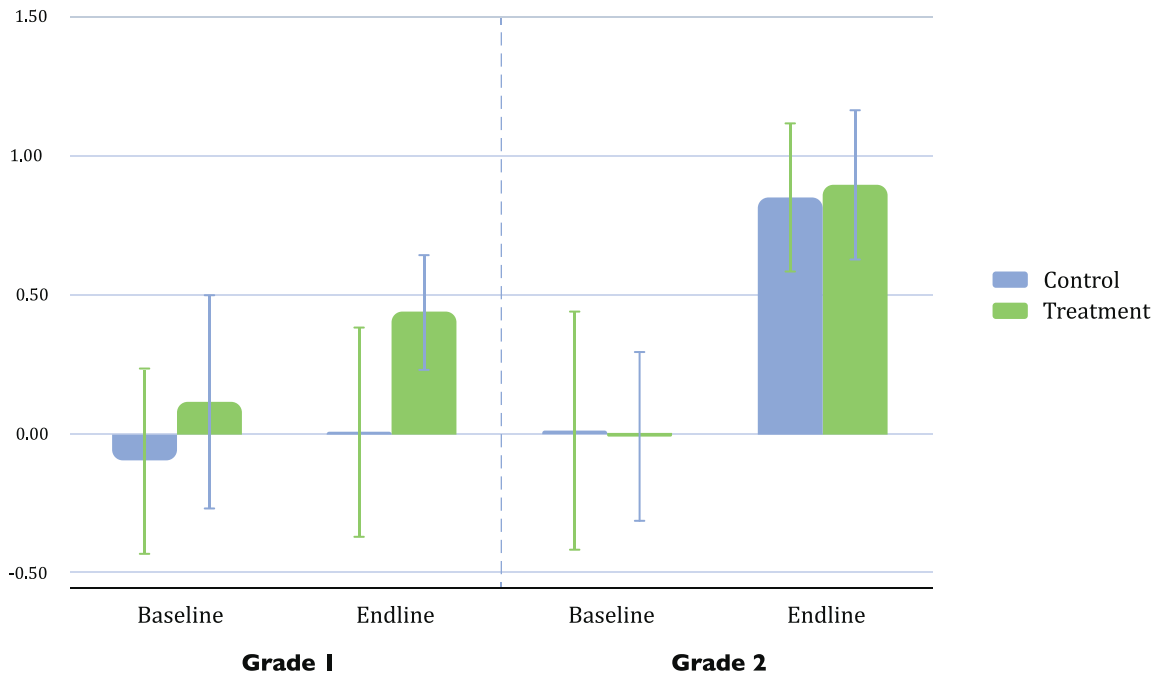
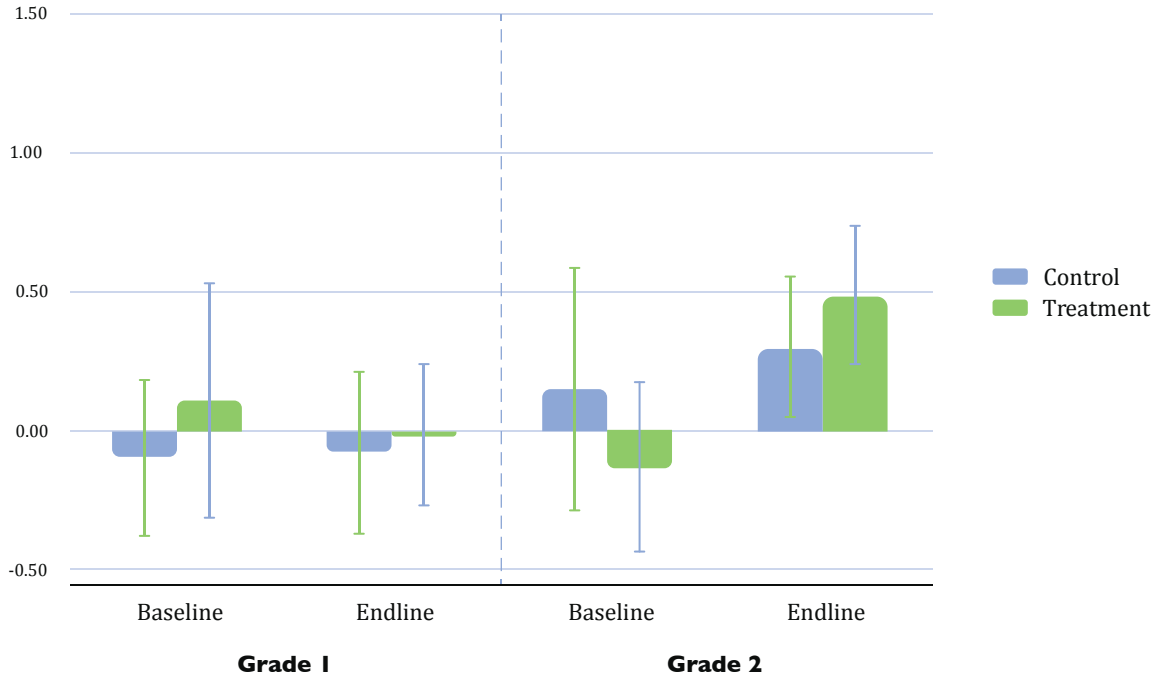


Figure 12: **Raw Mean Differences in Grade 1 and 2 in English**



In Table 4, we report the estimates from our regression analysis by grade. The top panel reports the grade 1 effects and the bottom panel reports the grade 2 effects. Columns 1 through 4 are the effect on Math with different specifications, and columns 5 to 8 are the analogous effects for English. Consistent with the raw means, we do not find any effect in English in grade 1 but a very large and statistically significant effect of 0.35 standard deviations in Math. This trend flips for grade 2. The treatment effect is 0.24 standard deviation in English and null in Math.

Table 4: **Grade by Subject Treatment Effects**

	Math				English			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Grade 1							
Treatment	0.40	0.35	0.39	0.35	0.00	-0.04	-0.01	-0.05
	(0.03)**	(0.03)**	(0.01)**	(0.02)**	(1.00)	(0.78)	(0.94)	(0.72)
	[0.08]*	[0.08]*	[0.04]**	[0.09]*	[1.00]	[0.81]	[0.94]	[0.79]
Observations	811	811	811	811	811	811	811	811
R-squared	0.12	0.21	0.28	0.34	0.10	0.15	0.23	
	Grade 2							
Treatment	0.07	0.06	0.06	-0.03	0.24	0.27	0.30	0.24
	(0.71)	(0.77)	(0.75)	(0.79)	(0.14)	(0.08)*	(0.07)*	(0.07)*
	[0.76]	[0.82]	[0.80]	[0.85]	[0.20]	[0.13]	[0.12]	[0.22]
Observations	717	717	717	716	717	717	717	716
R-squared	0.13	0.14	0.17	0.34	0.14	0.21	0.24	0.31
Grade FES	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Strata FES	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline scores	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Bharti scores	No	No	Yes	Yes	No	No	Yes	Yes
Demographic controls	No	No	No	Yes	No	No	No	Yes

RESULTS BY TIME SPENT ON CHIMPLE

We estimate a two-stage least squares specification, by subject and grade to provide treatment on the treated estimates in Table 5. The endogenous variable is the average number of hours spent on Chimple per week from May 2022 through February 2023. We use time spent across all activities since time spent on English could theoretically improve test scores in Math as well and vice versa. As seen in the bottom two rows, the first stage indicates a strong correlation between treatment and time spent on the app; children in the treatment group spend approximately 1 hour per week on Chimple. Given this first stage, as expected, effects of time spent on Chimple are very similar to our main results. An additional hour on the app increases Math test scores by a statistically significant 0.24 standard deviation (0.36 standard deviation for first graders) and English test scores by a statistically insignificant 0.13 standard deviation overall and a marginally significant 0.20 standard deviation for second graders.

Table 5: **Relationship between Time Spent and Test Scores**

	Math			English		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Grade 1	Grade 2	All	Grade 1	Grade 2
Weekly time spent (in hours)	0.24	0.36	-0.03	0.13	-0.05	0.20
	(0.03)**	(0.02)**	(0.79)	(0.23)	(0.72)	(0.10)*
Observations	1527	811	716	1527	811	716
R-squared	0.148	0.233	0.243	0.140	0.217	0.167
First stage coef.	1.030	0.950	1.190	1.030	0.950	1.190
F-statistic	216.5	161.2	158.3	216.5	161.2	158.3

Note: This table reports 2sls estimates. The endogenous variable is the average time spent per week on the app across all types of activities. Columns 1 and 4 include all children and Columns 2-3, 5-6 estimate these results by grade. Standard errors are clustered by school-grade and conventional p-values are in parentheses. * Significant at 10%; ** Significant at 5%.

COMPETENCY RESULTS BY SUBJECT CONTENT

We assessed which competencies are influenced by the treatment. In Math, we categorised the test questions under number recognition, arithmetic computations, word problems, and analytical questions. In English, we categorised the test questions under spelling, vocabulary, comprehension, and grammar (only for grade 2). The outcome is the fraction of correct answers in the competency category.

Table 6 summarises the overall results on competencies for Math and English for grades 1 and 2. For grade 1, in Math, there is no effect on number recognition. However, there is a significant positive effect of the treatment on other mathematical competencies including arithmetic computation, word problems and analytical skills. English scores improve slightly only in comprehension but the estimate is not statistically significant. For grade 2, we find no effect of the treatment on Math scores except for number recognition, which is imprecisely estimated. We find a significantly large effect of the treatment on spelling. The magnitude for comprehension is comparable but imprecisely estimated.

Table 6: **Treatment Effect by Competency in English and Math**

	Math				English			
	(1) Number recognition	(2) Arithmetic computaion	(3) Word problems	(4) Analytical	(5) Spelling	(6) Vocabulary	(7) Comprehension	(8) Grammar
	Grade 1							
Treatment	-0.032	0.096	0.094	0.131	-0.025	-0.005	0.028	
	(0.40)	(0.00)***	(0.06)*	(0.00)***	(0.55)	(0.81)	(0.61)	
	[0.61]	[0.03]**	[0.18]	[0.06]*	[0.66]	[0.86]	[0.70]	
Observations	811	811	811	811	811	811	811	
R-squared	0.326	0.224	0.205	0.283	0.243	0.227	0.193	
	Grade 2							
Treatment	0.056	0.018	-0.039	-0.017	0.125	0.014	0.074	0.026
	(0.14)	(0.57)	(0.20)	(0.67)	(0.01)***	(0.58)	(0.11)	(0.57)
	[0.40]	[0.68]	[0.43]	[0.79]	[0.04]**	[0.74]	[0.29]	[0.73]
Observations	716	716	716	716	716	716	716	716
R-squared	0.212	0.282	0.279	0.297	0.404	0.248	0.254	0.312

HETEROGENEITY BY BASELINE SCORES

Formative assessment can help teachers target resources to help struggling students catch up with the rest of the class. In order to shed light on heterogeneity by baseline performance, we explored treatment effects by baseline test scores.

Specifically, we divided the sample into quartiles based on performance on the baseline English and Math tests (separately) and estimated treatment effects on each group of children. Figure 13 presents the estimates with confidence intervals for grades 1 and 2 for English. The bottom panel reveals that benefits for English accrued to better-performing students in Grade 2. Math treatment effects are depicted in Figure 14. Consistent with our results above, we see no treatment effect in grade 2. In grade 1, we see larger treatment effects for the lowest-performing students. In the top panel of Figure 14, we observe a large effect of almost 0.5 of a standard deviation accruing to the bottom two quartiles in grade 1.

Figure 13: **English Treatment Effects By Baseline Scores for Grade 1 and 2**

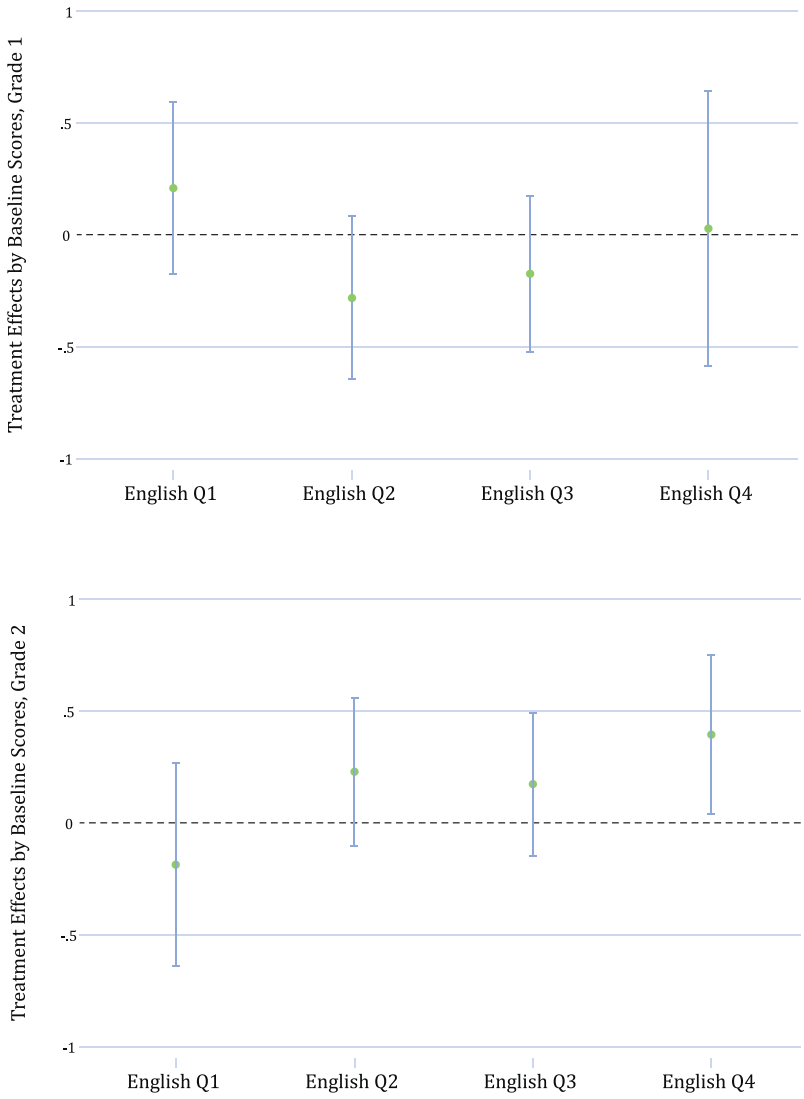
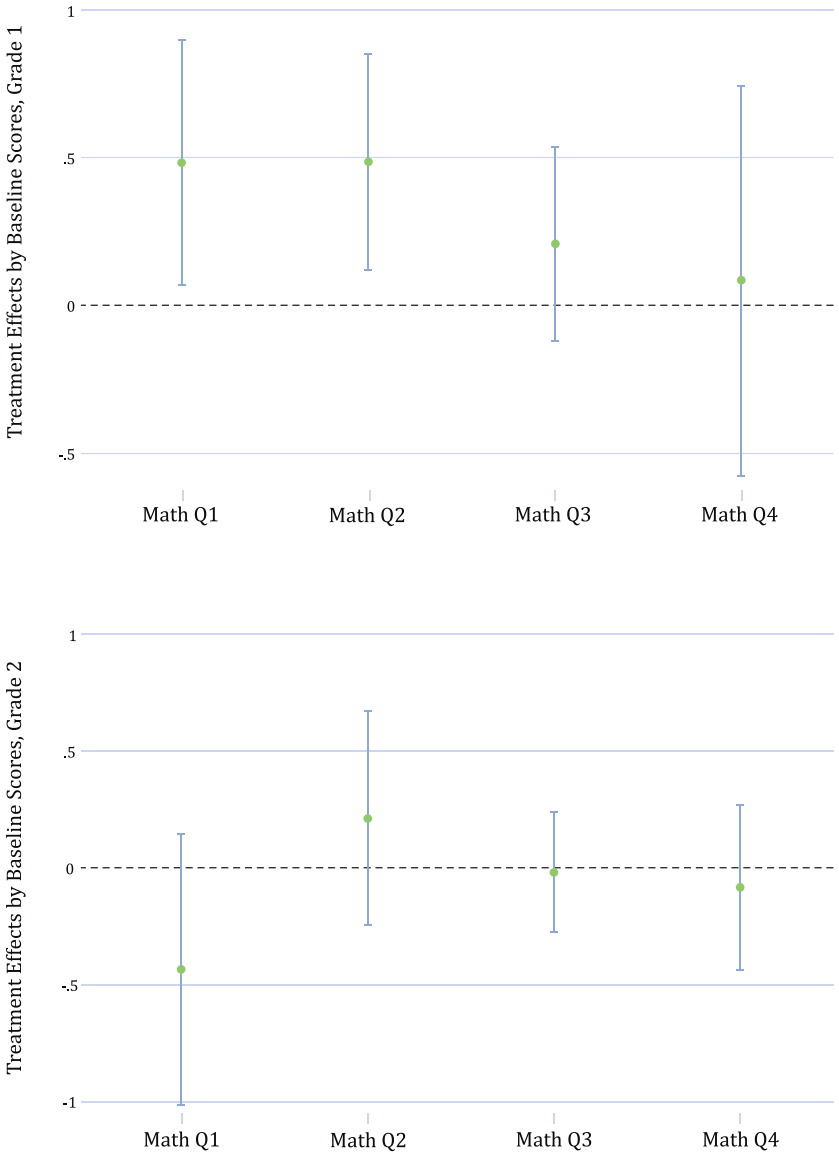


Figure 14: **Math Treatment Effects By Baseline Scores for Grade 1 and 2**



INSIGHTS FROM CHIMPLE ENGAGEMENT

The Chimple dashboard data enabled the research team to measure the average daily engagement (in minutes) of treated students on the app, for all subjects between May 2022 and February 2023. Figures 15 and 16 present the difference between the normalised endline and baseline scores in standard deviations. Figure 16 suggests that the difference between the baseline and endline Math scores is relatively higher for those who spend more than 0-7 minutes on the app. However, there were no significant differences in English scores by time spent on the app (Figure 16).

Figure 15: **Mean Differences in Math Test Scores by Time Spent**

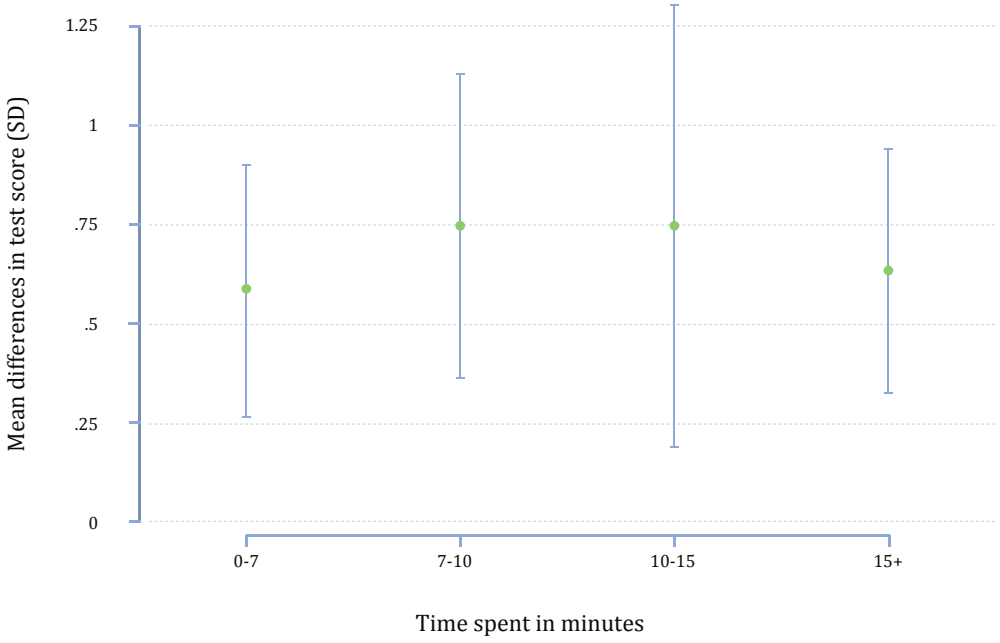
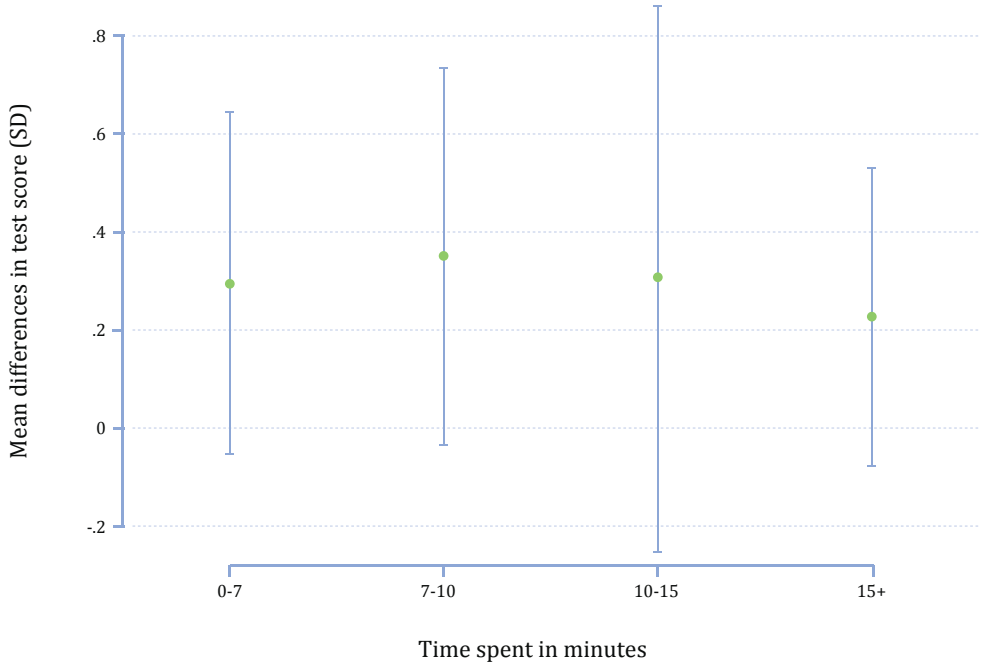


Figure 16: **Mean Differences in English Test Scores by Time Spent**



INSIGHTS FROM THE TEACHER SURVEY

The survey asked how often teachers used Chimple and the overwhelming majority said they used it regularly (Figure 17). Majority of the teachers also felt that students completed the Chimple homework (Figure 18). The teachers survey reveals that while 64% of the grade 2 teachers reported that they used the Chimple dashboard to help struggling students, only 43% of grade 1 teachers reported using the dashboard for this purpose (Figure 19). Grade 2 teachers were much more likely to assign difficult problems using the Chimple dashboard (Figure 20). 94% teachers agreed that Chimple helps students learn better and 84% thought that Chimple was fun because of puzzles and games. Teachers viewed Chimple activities as complements to other homework given as part of regular instruction (Figure 21).

Figure 17: **How Often did Treated Teachers Use Chimple Dashboard**

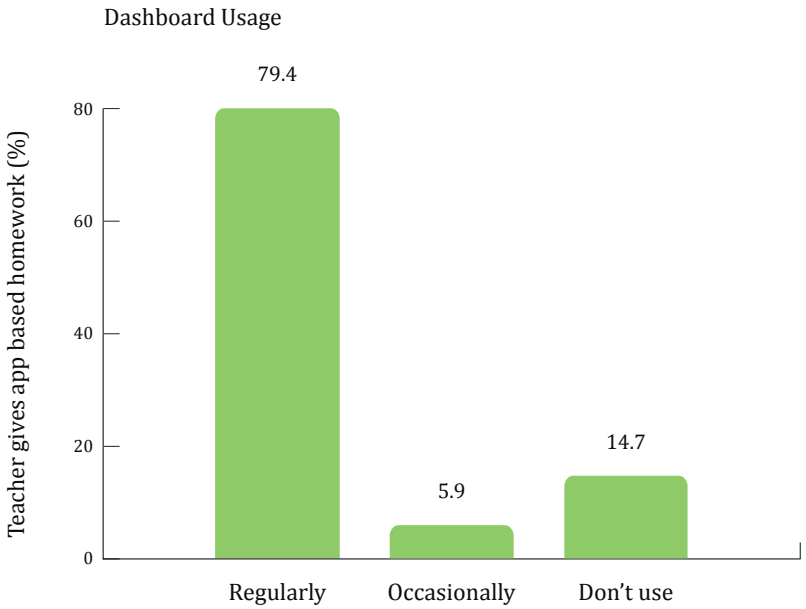


Figure 18: **Teachers' Perception of Chimple Homework Completion**

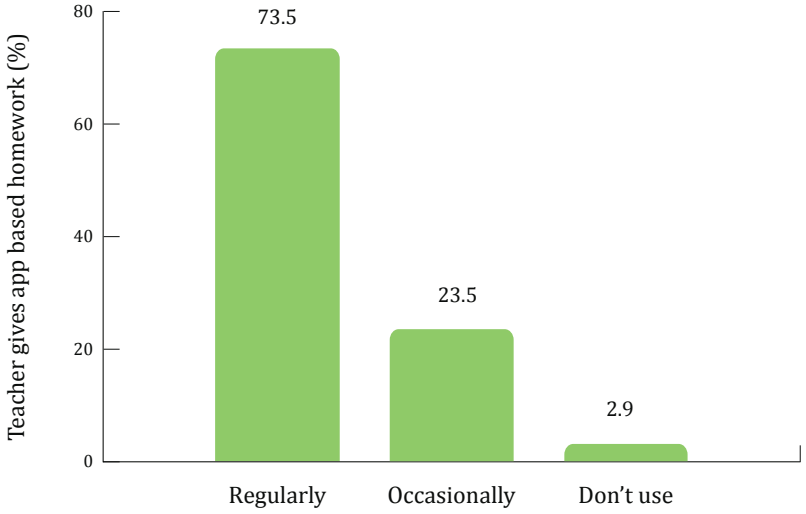


Figure 19: **Percentage of Treated Teachers Using Chimple Dashboard to Help Struggling Students**

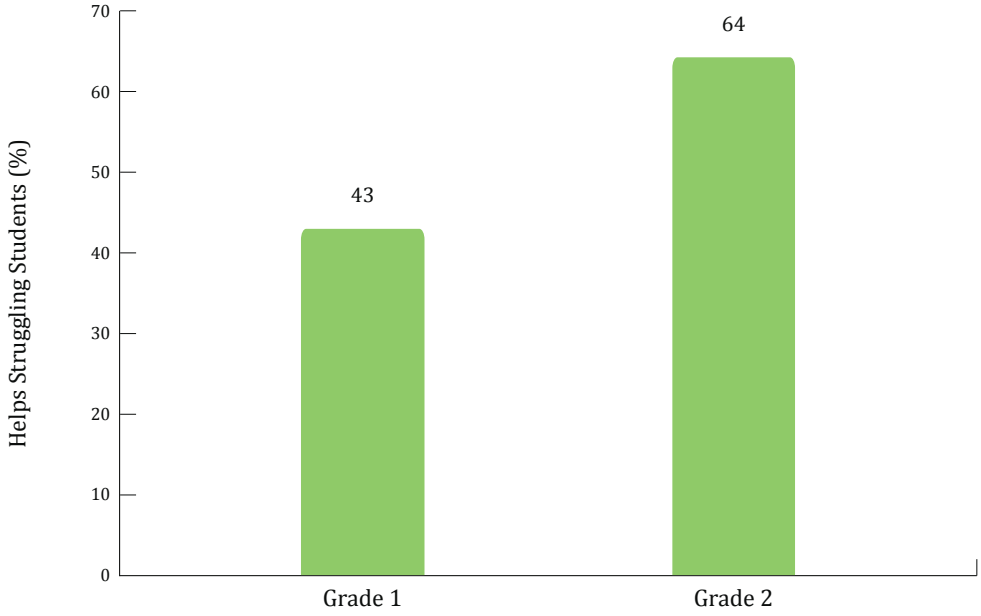


Figure 20: **Percentage of Treated Teachers Who Use Chimple to Assign Challenging Problems**

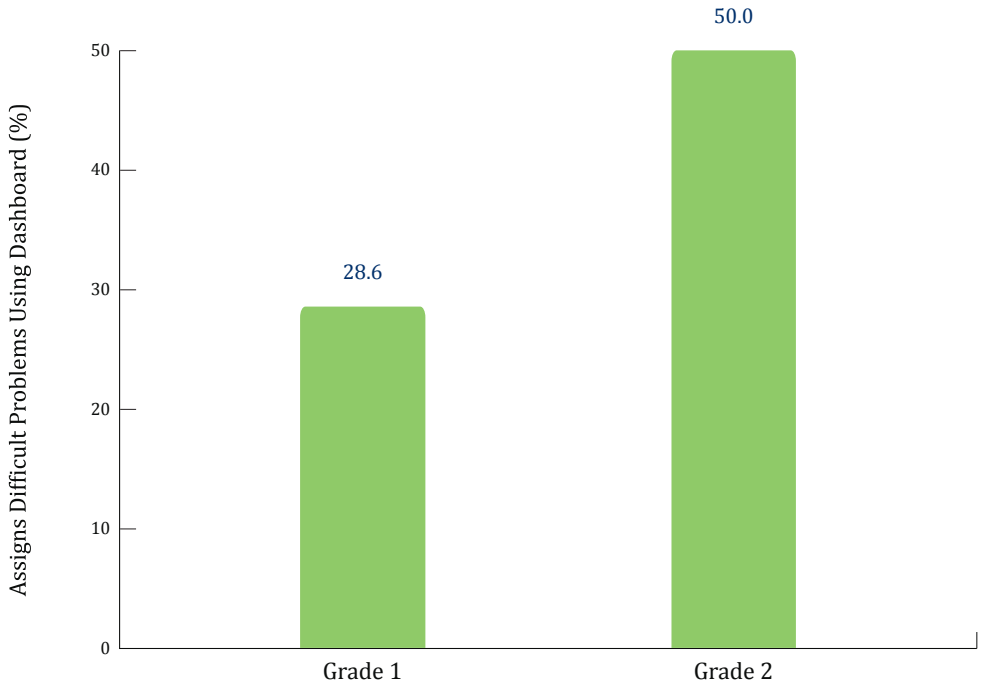
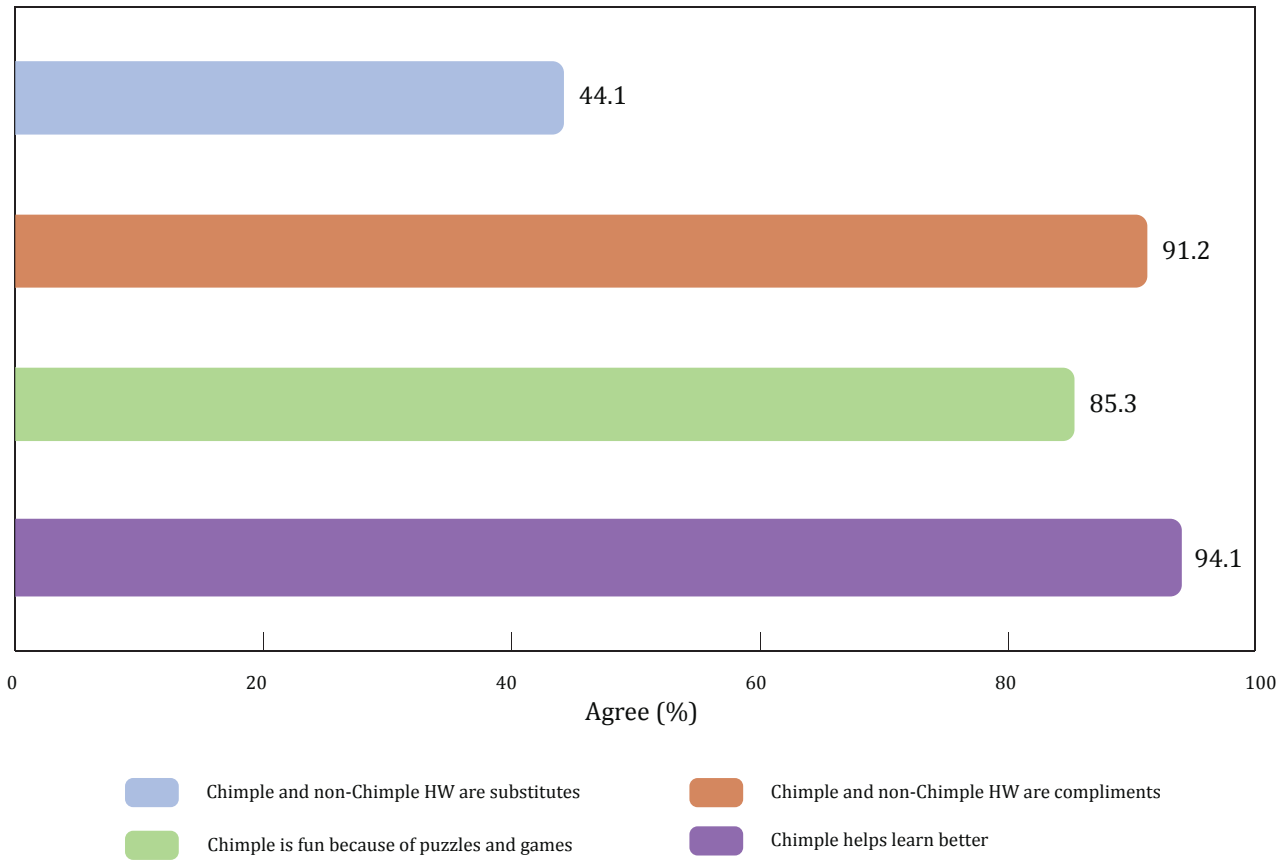


Figure 21: **Percentage Agreeing with Features of Chimple**



INSIGHTS FROM THE HOUSEHOLD SURVEYS

To better understand take-up, potential spillovers and parental perception of Chimple as a learning tool, we conducted household surveys in May 2023 (after the endline tests). We included treatment and control households from 62 villages with 10 or more Satya Bharti school students. We find that while between 64% and 70% students in the treatment group were using the Chimple app for homework, only 24%-26% students were using the app in the treatment group. According to the survey, in the treatment group, 86% parents of grade 1 students and and 93% parents of grade 2 students believed that the Chimple programme increased learning among children.

Figure 22: **Use of Chimple for Homework or Academic Purposes (%)**

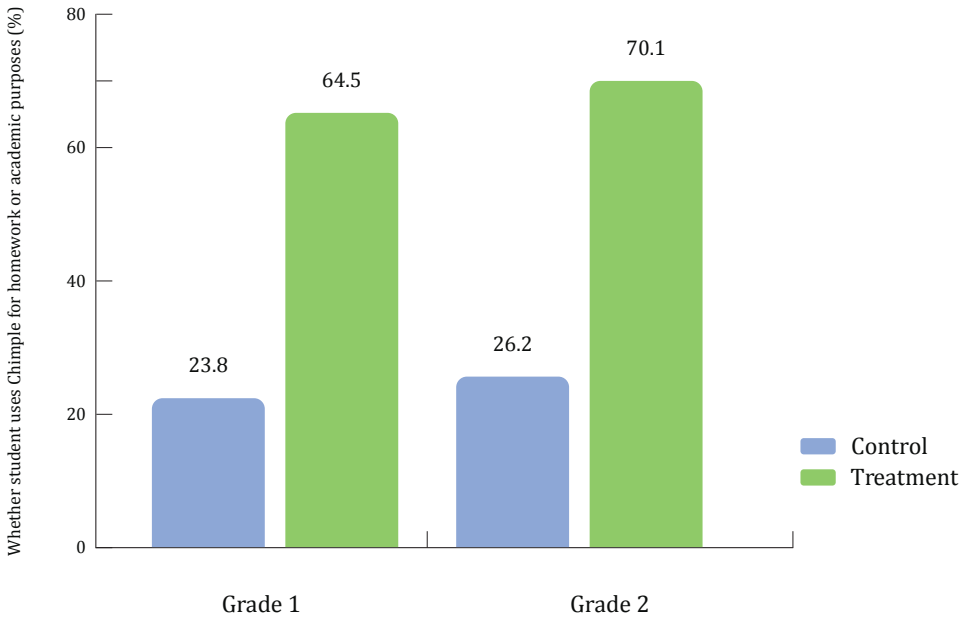
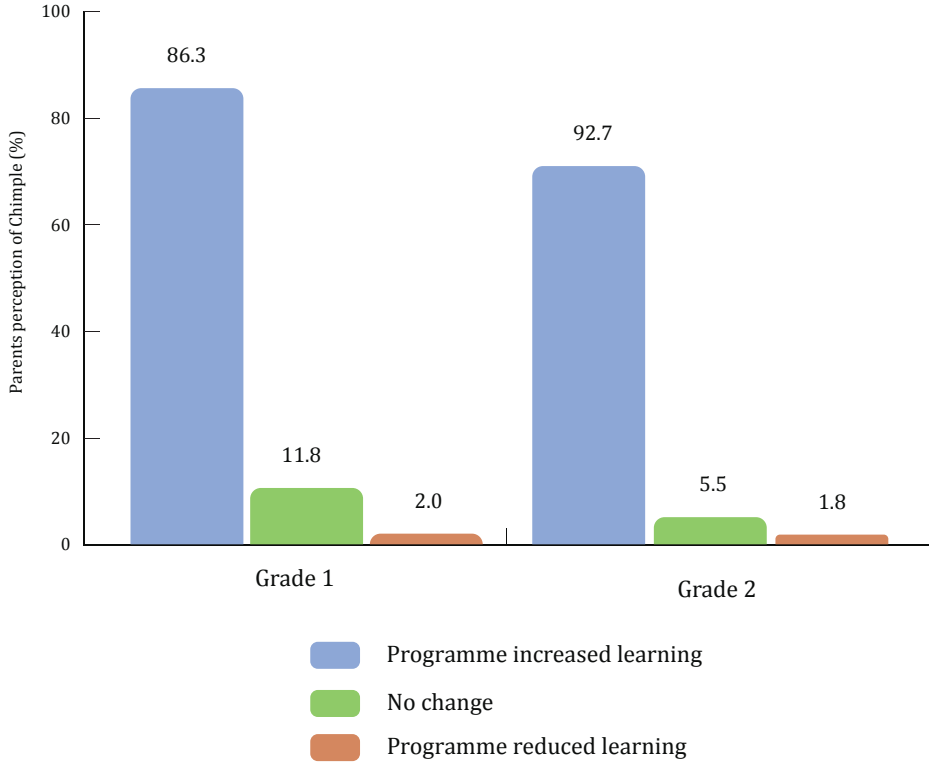


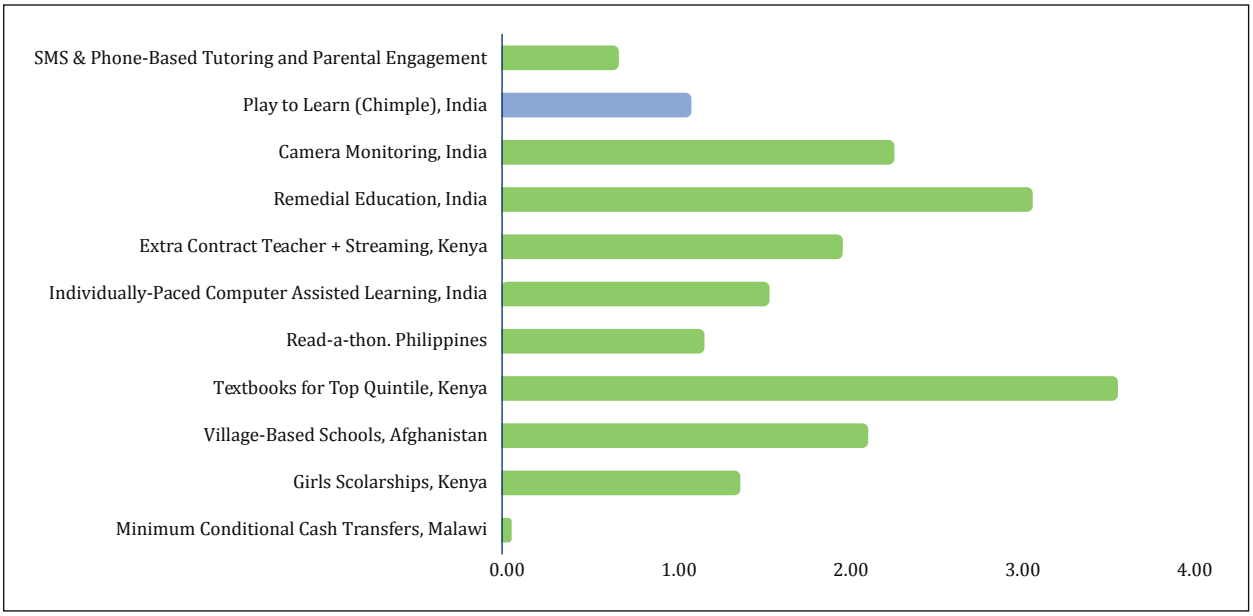
Figure 23: **Parent Perceptions of Chimple (%)**



UNDERSTANDING COST-EFFECTIVENESS

We find a one standard deviation gain per 100 dollars spent in Math outcomes. Angrist et. al (2022) provided SMS and phone-based support to parents to help educate their children in Botswana and this resulted in a 0.63 standard deviation learning gains per 100 USD. Our programme is comparable in cost-effectiveness to CAL- based remedial tutoring intervention in India which resulted in around 1.11 standard deviation gains in learning per 100 USD (Banerjee et al (2007)). In Figure 24, we compare the standard deviation gains relative to other studies. Even at the current scale, the programme was cost effective.

Figure 24: **Standard Deviation Gains Per 100 USD Spent**



KEY TAKEAWAYS

The primary outcomes of interest were test scores in tests administered at the end of the intervention by the research team to measure foundational literacy and numeracy skills. **The results showed that the intervention improved both Math and English scores with larger and more precisely estimated effects in Math**. Arithmetic computation, word problems and analytical competencies improved, but no effect was detected in number recognition, plausibly because this was a skill already mastered by the students. In English, spelling and comprehension were seen as areas of improvement although effects on comprehension were not precisely measured.

We do find evidence of heterogeneity in effects. First, in grade 1, poorly performing students at the baseline experienced a very large treatment effect in Math. Second, we explore heterogeneity

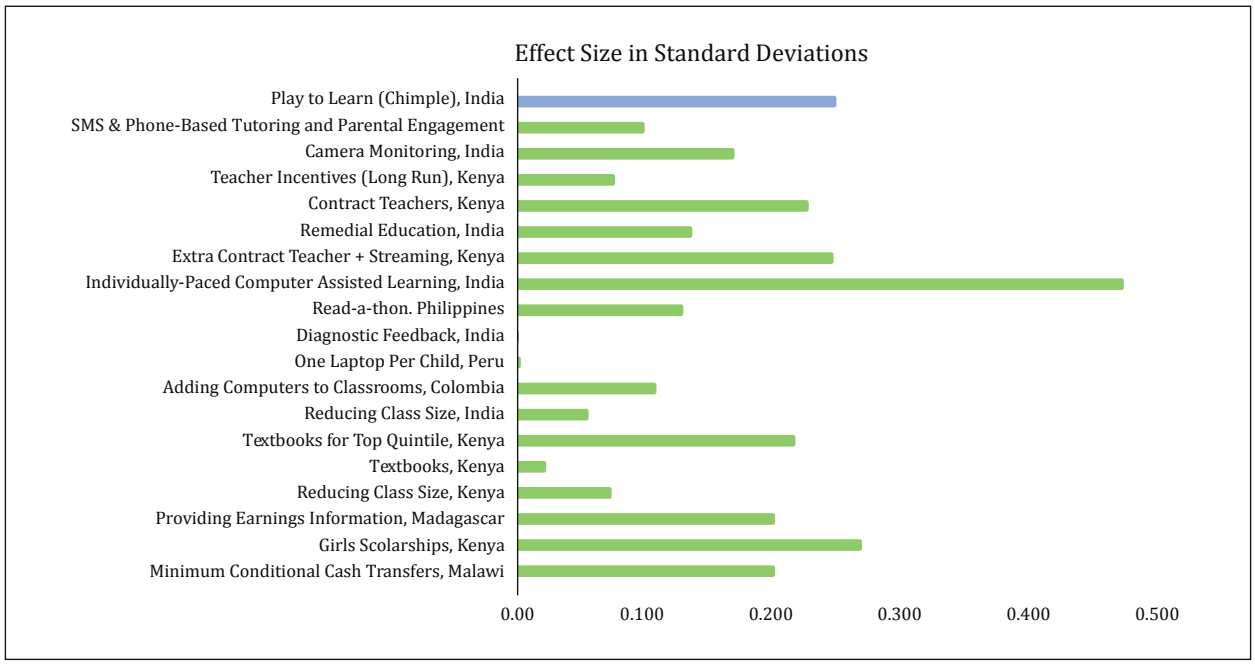
by grade. In Math, the large treatment effect is driven by grade 1, whereas in English, the effect is driven by grade 2. The results indicate that an additional hour on the app increases Math test scores by 0.24 standard deviation for all students, and 0.36 standard deviation for first graders. For English, an additional hour on the app increases test scores by 0.20 standard deviation for second graders. There were no differences by gender.

A review of 1942 effect sizes from 747 Randomised Control Trials with an education learning focus conducted by Kraft (2020) reveals that the median effect size was 0.10. Our intervention yields very large impacts in Math of 0.25 standard deviation. Impacts were larger for students struggling at baseline in Math in grade 1 (around 0.45 standard deviation).

Value added by one year of schooling in foundational learning grades captured by control group mean (raw) was 0.37 standard deviation. **In terms of schooling, we find substantially large effects. Years of schooling effect is an additional one year of schooling (treatment group mean in Math (raw) 0.67 standard deviations).** In Figure 25, we demonstrate the comparison of our impact relative to several studies. Relative to the distribution of gadgets, our impacts are substantially larger. **The impacts estimated in this study are large relative to several non-CAL approaches and comparable impacts to other CAL approaches.**

We also examined the engagement data from the dashboard. **This reveals that on an average, students were spending an hour a week on the Chimple app.** Further, for Math, we saw that **the difference between the baseline and endline Math scores increased with the time spent on the app.**

Figure 25: **Comparison of Impact Sizes with Other Studies**



DISCUSSION AND CONCLUSION

The programme was effective in improving foundational literacy and numeracy outcomes with only 10 minutes of usage per day, or 60 minutes per week. The programme did not require the distribution of any additional or new hardware/devices, and could be used on existing phones in the household, which are widely available across India at the household level. The students also worked on the app in the convenience of their homes, at times convenient to them and their parents. They did not need to travel to a centre at a specified time, making this approach flexible and inclusive.

In comparison to other initiatives used to improve educational learning outcomes in developing countries that leverage CAL, the effects are comparable to some or larger than other studies. The effects are larger than studies that do not deploy CAL. These findings imply that using Chimple as a tool to improve FLN outcomes is an effective lever. More research can shed light on the lowest-cost modalities of deployment.

Since the conclusion of this study, Chimple has been working to incorporate feedback from teachers and students to improve the learning experience on the app. Over the course of the last year, Chimple has incorporated a WhatsApp chatbot for teachers to enable adoption and engagement. The bot is a conversational tool that teachers can use to assign activities and view student reports through a platform that they are already comfortable using. Further, in order to improve the learning experience for each child, the app has also introduced additional gamification features to improve engagement. Chimple is also exploring the use of generative AI to generate content in new languages and curricula to enhance scalability, and improve engagement through personalisation and virtual assistants for the teacher.

This study represents a landmark moment for home learning interventions in India. Given the growing smartphone penetration in India and that young children are spending more time on their parents' smartphones than ever before, EdTech interventions such as Chimple can present opportunities for additional learning time and practice at home in a fun and engaging way. When these programmes are connected to what is happening in school, such as with Chimple, it can lead to even greater engagement, while also providing teachers with rich and relevant formative data to augment and pace classroom instruction. Further, with the involvement of parents and caregivers, there is an opportunity to engage parents in their child's learning and strengthen the parent-child relationship to create a supportive learning atmosphere.

As state governments build programmes to ensure that students achieve foundational literacy and numeracy in line with NIPUN Bharat, it will be critical to support teaching and learning in school with learning at home. This evidence is also particularly relevant as we think of

building more resilient education systems post-pandemic, and in the face of climate change. EdTech interventions present cost-effective, impactful, and scalable approaches to improve teaching and learning and ensure learning outcomes for all children.

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