Can Technology Overcome Social Disadvantage of School Children's Learning Outcomes? Evidence from a Large-scale Experiment in India

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Abstract

Poor learning outcomes in developing countries are mostly attributed to low quality of teaching inputs in schools, primarily due to shortage of adequately trained teachers and rampant teacher absenteeism. Computer technology can be used to reduce these deficiency and provide high quality educational content even in schools in remote areas. We conduct a large scale randomized field experiment among 1823 rural government schools in India, in the state of Karnataka, where satellite-terrestrial technology is used to telecast additional interactive classes in english, maths and science. Results show that this intervention has a positive impact on student performance as measured through a standardized test in all three subjects. The improvement is most significant in science as compared to english and maths. The impact of the intervention is highest among the socially disadvantaged students particularly for girls from these sections of the society. We also find that schools with past performance level around or below the median tend to benefit most from the program.

JEL: C93, I28, I25, I29
Keywords: information and communication technology, field experiment, education, computer technology, government policy

1 Introduction

With the focus of the second and third millennium development goals on getting more children to school, enrollment rates have risen substantially in many developing nations. In India, enrollment rate among 6 to 14 year-olds has been over 96% for the past five years (Pratham [2015]). However, the teaching quality and school infrastructure have not kept pace with this increase. The school education systems in many developing countries remain fraught with multiple inadequacies like non-availability of adequately trained teachers, and rampant teacher absenteeism. Chaudhury et al. [2006] report up to 25% absenteeism among teachers in government-run schools in India and further point out that, only 45% of teachers assigned to schools are engaged in teaching at any given point.

These inadequacies in the education system are reflected in below par reading and arithmetic skills of school children as reported by many recent surveys. In India, 25% of children enrolled in grade 8 could not read at grade 2 level, and 55% could not do simple tasks of division (Pratham [2015]). Also, in a developing country like India, the socio-economically disadvantaged sections of the society depend heavily on the government services for education and health. Factors like teacher absenteeism or lack of quality teaching in government schools, has greatest adverse impact on these marginalized sections. Further, as these students are not in a position to purchase additional teaching inputs in the form of private tuitions or additional learning aids, the damage is often irrecoverable. Many studies attribute below par education attainment to poor performance of government schools. In comparison to the private schools, government schools both across India and in Karnataka, underperform in almost all measures of educational attainment and has been seeing a consistent decrease in enrollment rates. (Pratham [2015]). We analyze the impact of a large scale intervention that uses technology to deliver educational content through innovative pedagogy to government schools in rural Karnataka, India.

The importance of quality of teachers and teaching in determining school outcomes has been highlighted in many studies. Banerjee et al. [2007] and Muralidharan and Sundararaman [2013] show that the presence of an additional teacher significantly improves learning outcomes. Banerjee et al. [2007] studied a field experiment where an additional teacher from the local community (Balsakhi) was provided to the poorest performing students in government schools in Vadodara and in Mumbai. The students who received the intervention showed significant improvement in test scores. Similarly, in an experiment conducted in 100 schools in Andhra Pradesh, India Muralidharan and Sundararaman [2013] show that provision of an additional contract teacher increases pupil to teacher ratio (PTR) and reduces multi-grade classrooms in schools due to better teacher attendance and thus significantly improves student performance.

The pupil teacher ratio (PTR) in government schools is on average lower than that in the private schools. However, lack of motivation and high level of absenteeism are often cited as reasons for poor performance. Chaudhury et al. [2006] find that incentives like teacher salaries has little or no effect on improving teacher absenteeism. They find that teachers that live in distant towns and have longer commutes to school report higher incidence of absenteeism. Considering the remote location of many government schools in developing countries, providing additional qualified teachers may not be an effective way to improve quality of teaching inputs and learning outcomes. One of the solutions proposed to address this issue is the use of technology in delivering teaching inputs.

Several attempts to use information and communication technology (ICT) to improve teaching quality and learning outcomes have been made in many countries over the last two decades. However, very few field experiment studies exist to measure the impact of ICT use on attaining better learning outcomes among students. Notably studies by Angrist and Lavy [2002] on the use of computers among fourth and eighth grade students in Israel for Maths and Hebrew showed no evidence of any improvement in learning achievements. Provision of computers in schools led to higher use of computers but did not necessarily translate into higher test scores. On the other hand Banerjee et al. [2007] find a significant positive impact of the use of computers on maths scores in 55 schools in Vadodara, India. The experiment involved providing children of 4th grade with two hours of shared computer time per week. During this period the children could play computer games that developed basic competencies in maths. The intervention led to an increase in maths scores by 0.3σ at the end of two years and 0.6σ at the end of three years.

More recently Barrera-Osorio and Linden [2009] study the use of computers through the Colombian "Computers for Education" program and find no impact on student performance in 97 schools in Colombia. Under the program, schools were provided computers with new pedagogical techniques developed by the Universidad de Antioquia. While this increased the use of computers among students and teachers, less than 3-4% of it was for intended use. The impact on maths and spanish test scores was non-significant. The authors also note that only 42% of teachers from treatment schools had used a computer in class in the week before the survey. Barrera points out that successful use of computers in schools is critically linked to changes in pedagogy. Most programs involving the use of technology fail primarily because teachers are not trained or are reluctant to take advantage of the teaching aids that the technology enables. In studies that leave pedagogy to the discretion of the local teacher, it is difficult to identify whether the program impact was a result of use of technology or change in pedagogy or both.

The objective of this paper is to study the impact of a large scale intervention that uses technology to deliver educational content to government schools in rural Karnataka, India. The intervention that we study packages together, technology and pedagogical improvements and focuses on improving the quality of teaching in rural government schools. Satellite and terrestrial technology is used as an enabler to deliver additional interactive classes to the students in english grammar, science, and maths. The topics covered in these classes are part of the syllabus of the schools and thus act as a supplemental input. Classes are delivered by trained teachers and make use of video and animation technology that would otherwise be inaccessible to rural schools. The intervention involves broadcasting the classes live from the studio in Bangalore via an educational satellite of the government of India to treatment schools located in the most backward districts of the state.

A pilot test of the intervention was conducted in AY 2010-11 in Gubbi taluk of Tumkur district in Karnataka, India. After observing significant improvements in the student learning outcomes in the pilot, the Karnataka Education Department decided to expand the intervention to backward areas of the state, in the year 2014-15. We estimate the impact of this intervention using a randomized field experiment that covers 1823 rural government schools spread across 18 economically backward districts in Karnataka, India. Out of 1823, 1000 schools received the treatment while 823 were in control group.

We find a positive impact on test scores and pass percentages in schools after approximately three months of the intervention. A higher positive impact is noted for science in comparison to that for english and maths. We also find that the students belonging to the weaker sections of the society benefit more from the treatment than those from general category. Interestingly, this trend remains true even when we consider the impact of this intervention on girls belonging to the weaker sections. Using quantile regressions we also find that the impact is higher for the average performing schools than at either ends of the performance distribution.

The remaining paper is organized as follows - Section 2 discusses the Experiment Design and the context in which the intervention is done, Section 3 covers the estimation and results and Section 4 concludes.

2 The Satellite and Multimedia Interactive Education (SAMIE) Experiment

2.1 Background and Context

Karnataka is one of the relatively more developed states in India. The state's per capita income in the FY 2013-14 was about 14% greater than the national average (Economic Survey of India, 2014-15). Though the state has been performing better than national averages on many economic indicators, the story of quality of school education in the state is different.

In 2014 literacy rate in Karnataka was at 75.4%, higher than the national average of 73% (Economic Survey of India, 2014-15). Karnataka also outperformed national averages in school enrollment from 2006 to 2014.[1] Though enrollment rate has increased over time in Karnataka, it still struggles to match up with the national averages in many aspects of quality of education. Percentage of students in grade 5 who could read grade 2 text, read words and sentences or do division has been consistently lower than national averages (Pratham [2015]). [2] Of the total grade 2 students surveyed in Karnataka in 2014, 82% did not have reading ability expected of their grade. Though these numbers improve with grades, a large proportion of students still fall behind in their reading and comprehension abilities. Of the total children enrolled in grade 8, 75% of them could not read simple words and 30% of them were unable to read grade 2 text. Similar trends are also found in arithmetic abilities of students. Of the total children enrolled in grade 8, 69% found it difficult to recognize numbers higher than 10 and 72% of them could not do simple subtraction problems.

Table 1: Minimum Learning Levels of % of Children in Class VIII

	Reading Levels					
	Not even letter	Letter	Word	Std I text	Std II text	Total
India	1.8	4.5	6.2	12.8	74.6	100
Karnataka	2.7	3.7	6.5	16.6	70.6	100
	Arithmetic					
	Recognize Numbers					
	None	1-9	10-99	Can Subtract	Can Divide	Total
India	1.3	5.4	26.1	23.2	44.1	100
Karnataka	1.1	2.3	31.2	28.4	37.0	100

1) Source ASER 2014
2) Includes both government and private schools

Many studies attribute below par education attainment to poor performance of government schools. In comparison to the private schools, government schools both across India and in Karnataka, under-perform in almost all measures of educational attainment during 2007-2014 (Pratham [2015]). This is has led to an increasing enrollment rates in private schools during this period. As per ASER (2014) the number of students opting for private schools in the country and Karnataka has been on the rise. In 2006, 16% (national average of 18.7%) of the total enrollment in the state of Karnataka was attributed to that in private schools which rose to 25.5% (national average of 30.8%) in 2014.

Many traditional programs and schemes initiated by the government to improve quality of education in government schools have not been very successful. Increasing acceptance and adoption of Information, and Communication Technology (ICT) has provided a unique opportunity to promote education on a large scale. ICTs have been employed to reach out

[1] National enrollment rate in 2014 is 96.7% and that for Karnataka 98.3% (ASER 2014)

[2] Of the total grade 5 students surveyed in Karnataka in 2014 only 21% (national average of 24%) could read sentences and 20% (national average of 26.1%) could do simple division.

to a greater number of students, including those to whom education was previously not easily accessible. The problem of teacher absenteeism and the obstacle of geographical distance to obtaining education has been in many cases surmounted using ICT. ICT also provides students and teachers with innovative tools and educational content to enable and improve teaching and learning. Both central and state governments of India realize the importance of integrating ICT to improve the quality of education. Many programs like Gyan Darshan, Gyan Vani at the national level and policies of providing computers to schools are expressions of this realization. However, most of these programs and policies that only provide computers to schools have not found great success in improving test scores as reported by Barrera-Osorio and Linden [2009]. Anecdotal evidence from India suggests that such programs are often badly managed. During field visits for this project, we noticed that in many schools while CPUs were provided in an earlier ICT program, complete working units were rare. The SAMIE (Satellite and Multimedia Interactive Education) program that we study in this paper, was envisioned to not only add to computer infrastructure of the classroom but to also use ICT to improve and evolve teaching pedagogy in government schools in rural Karnataka.

Given the limited availability of internet connectivity in remote rural areas, a hybrid technology integrating satellite and terrestrial mode was used to telecast classes. This enabled two-way video and audio along with data transfer system by using satellite for forward path (in broadcasting/multicasting mode) and terrestrial mode for reverse communication, for student interaction. The project was implemented as a Public-Private-Partnership between the Department of Education, Government of Karnataka and the Indian Institute of Management, Bangalore (IIMB) consortium, and funded by the State Department of Education for a period of five years.

The program employed well-trained teachers and research teams with access to a broad range of knowledge resources and expertise in content delivery software. Teams of teachers would research a topic and develop a lesson plan which is passed on to content developers who would develop multimedia content to accompany the lesson. The classes were delivered by teachers at the government studio in Bangalore and telecast live to the treatment schools across the state.

Classes were delivered to cover syllabus prescribed by Karnataka state education department for english grammar, science, and maths for grades 5th to 10th. Each subject had two classes per week of 40 minutes duration for each grade and were held during the regular school hours. The regular school time allocation for each subject is on an average 5 hours per week. Thus the SAMIE intervention provides about 25% additional class-time to each subject per week. The schools were instructed to accommodate the time required for the SAMIE classes by taking time from recess and by extending the school day by an hour for the tenth grade. But some substitution in time allocation may have occurred between subjects at the school level. The medium of instruction of the classes was Kannada, which is the mother tongue of most children in Karnataka. Many do-it-yourself exercises and class assignments were suggested on the topic being covered. Examples and exercises used in the classes were selected so that children from rural areas across the state could relate to them. Every class was followed by an interactive session where students could ask questions to trained moderators. The questions were transmitted over a video chat using broadband connectivity wherever available or through a voice call.

2.2 Sampling, Randomization and Program Description

We focused on selecting schools in the economically most backward regions of the State. We used the classification done by the High Power Committee on Redressal of Regional Imbalances (popularly known as the Nanjundappa Committee) to pick 18 districts with the lowest development score. The Nanjundappa Committee Report classifies taluks in Karnataka into 4 categories (Relatively Developed, Backward, More backward and Most Backward) based on various development criteria. For each district, a development index was constructed based on the extent of backwardness of the taluks. 18 backward districts were chosen based on this index, and four taluks were randomly selected from each district starting from the most backward district. Some of these taluks selected are not necessarily backward taluks in the district. Two taluks out of these were randomly assigned to receive the intervention and two to the control group. Once the taluks were chosen, all government and government-aided schools [3] that satisfy the criteria of having a minimum level of facilities required to run a tele-education class were included in the treatment and control groups. These criteria were - (a) closed classroom in good condition with adequate security for the equipment, (b) working electricity connection and (c) A minimum of 20 students in each class. From the control taluks, 823 schools were included in the control group and 1000 were included in the treatment group. Thus, a multistage random sampling process was used to select the sample.

In this paper, we evaluate the impact of the program on the performance of students and schools on the standardized mandatory examination conducted in April every year for which students have to appear at the end of 10 years of schooling. This examination, Secondary School Leaving Certificate (SSLC), is conducted statewide by a government body, Karnataka Secondary Education Examination Board (KSEEB).

Among the 1823 schools included in the program, in both treatment and control groups, not all have grades up to 10. Out of the total 1000 treatment schools only 698 schools had secondary section (grades 9 and 10) and only 636 schools had secondary section in the control group. Out of the total 1334 schools that had a secondary section, 1135

[3] Government-aided schools are schools that are public funded and privately managed

schools were identified, using SSLC examination school codes, for this evaluation as some schools did not have students appearing for either 2014 or 2015 exams - 611 receiving the treatment and 524 in the control group.

Table 2: Experiment Design

	Control	Treatment
Schools in selected Taluks	8431	8464
(Upper Primary onwards)		
Schools in Experiment Group	823	1000
Schools with Secondary Sections		
Schools in selected Taluks	2475	2467
Students in Taluks in 2014	126362	125215
Students in Taluks in 2015	133438	132887
Schools in Experiment Group in 2014	529	610
Students in Experiment Group in 2014	33006	37007
Schools in Experiment Group in 2015	531	612
Students in Experiment Group in 2015	34251	38576

The school year begins in the first week of June in Karnataka. In the first year of its implementation (AY 2014-15), the SAMIE intervention started in the month of November 2014 and continued until the close of the academic year in February 2015. This evaluation is done on the cohort that was exposed to the intervention for about three months.

3 Estimation and Results

We obtain student level subject-wise scores on the exams conducted in April 2014 and 2015 for control and treatment schools. We take data on academic and physical infrastructure, gender-wise and social-category-wise enrollment for our treatment and control Schools from the database of the Karnataka State Department of Education. The two-sample t-test for school level characteristics and SSLC scores in 2014 exams indicate that the schools with grade 10 in control and treatment groups are statistically indistinguishable. Comparison on individual student scores between the control and treatment groups at the baseline is given in table (3). Similarly, comparison of some other school level characteristics such as proportion of students from various social categories and gender groups, academic and physical infrastructure is shown in table (4). Here too it can be seen that the control and treatment groups are similar in most aspects except proportion of STs and OBCs. Treatment schools have a higher proportion of STs while control schools have a higher proportion of OBCs.

Table 3: Comparing Control and Treatment Schools on Grade 10 Performance in April 2014

	Control Mean	Treatment Mean	t-statistic	p-value
English	47.29	47.69	-0.74	0.46
Maths	45.29	46.15	-1.73	0.08
Science	49.46	49.72	-0.51	0.61
Social Science	60.31	61.19	-1.37	0.17
Language 1	76.02	76.86	-1.07	0.29
Total Score	333.96	338.71	-1.58	0.12
No. of Students	62.39	60.86	0.71	0.48
Pass Proportion	0.87	0.88	-1.42	0.16

1) No. of Students measures class size in each school in grade 10
2) Pass Proportion is the proportion of students from each school that cleared the exam
3) The other variables are the average scores by students of a school in respective subjects in the exam held in April 2014.

Table 4: Comparing Schools in Control and Treatment with grade 10 on School Characteristics

	Control Mean	Treatment Mean	t-statistic	p-value
Pupil-Teacher-Ratio	10.96	10.85	0.10	0.92
Pupil-Classroom-Ratio	8.01	9.11	-0.97	0.33
Proportion of Girls	0.46	0.46	-0.43	0.67
Proportion of SC	0.23	0.24	-1.05	0.29
Proportion of ST	0.10	0.14	-4.23	0.00
Proportion of OBC	0.52	0.47	2.74	0.01
Proportion of Muslims	0.38	0.43	-1.71	0.09

1) Pupil-Teacher-Ratio and Pupil-Classroom-Ratio are computed for the entire school (i.e. all grades) as no separate data is available for grade 10. All other ratios are for grades 5 to 10
2) Proportion of Girls includes only 1138 co-ed schools to account for high standard deviation due to outliers (i.e. boys only or girls only schools)

3.1 Conceptual Model

We estimate the impact of the treatment primarily at school level and at individual student level. We use school averages of total scores, and english, maths and science scores and overall pass percentages for 2015 as the outcome variables. Pass percentage of a school is the proportion of children who successfully clear the SSLC exam in any particular year, across all subjects. Our default specification is of the form,

$$Y_{2015i} = \alpha + \beta_1 D_i + \beta_2 Y_{2014i} + \beta_3 X_i + \epsilon_i \tag{1}$$

where Y_{2015i}, the outcome variable of interest, is the average of students' SSLC scores for schools i for the April 2015 exam. D_i is a dummy variable at school level indicating treatment status. X_i are school level controls. The parameter of interest is β_1 indicating the impact of the school receiving treatment on the outcome variable Y_{2015i}. We include the test scores for the April 2014, Y_{2014i}, in the regression as the test scores are generally correlated over time. We further include controls for some school level characteristics such as pupil-teacher-ratio as an indicator of academic infrastructure, pupil-classroom-ratio as indicator of physical infrastructure, proportion of girls and proportion of students from scheduled castes as an indicator of the socio-economic background of students in the school. We also estimate equation (2) with the difference between 2015 and 2014 school average scores as a dependent variable. Equation (2) estimates the extent of value addition on account of the treatment and accounts for the fact that marginal impact of the treatment would be conditional on the baseline scores in 2014. The regression outputs are summarized in Tables (3) and (4) of the Annexure.

$$Y_{2015i} - Y_{2014i} = \alpha + \beta_1 D_i + \beta_2 Y_{2014i} + \beta_3 X_i + \epsilon_i \tag{2}$$

At the individual student level we check for the difference in scores between treatment and control groups for the exam held in April 2015. The t-tests in Table **??** show that both control and treatment groups are statistically similar at the baseline. Since the students happened to be member of one or the other group by virtue of a Taluk level lottery under the experiment design, a difference in scores in April 2015 can be attributed to the intervention. We make an important assumption here that the cohorts across the years are similar on various observed and unobserved attributes. The equation we estimate for checking the difference in the control and treatment groups in April 2015 exams is of the form,

$$Y_{2015ij} = \alpha + \beta_1 D_j + \beta_2 X_i + \beta_3 X_i * D_j + \beta_4 Z_j + \epsilon_{ij} \tag{3}$$

where, Y_{2015ij} is the SSLC outcome of student i in school j for the April 2015 exam. D_j is a dummy variable indicating treatment status of the school attended by the student. X_i are student characteristics and Z_j are school level controls. The student characteristics include socioeconomic characteristics and gender. The parameters of interest in this case is β_3.

The impact of such teaching input based programs is typically different across the cohort. In some programs students in the middle and lower range of initial score benefit more than those in upper range (Banerjee et al. [2007]), while in some other programs the better performing students could derive more benefit thus widening the gap between the better and the poor performers (Glewwe et al. [2009]). We check the impact of our program at school level using quantile regressions with specification given in equation 1.

3.2 Results

The students in treatment schools have overall a better performance in April 2015 exams as compared to those in control schools. Analysis at school level shows that the average test scores of students from treatment schools increases by 0.7 points in english, 0.5 points in maths and 0.9 points in science. The impact is significant in case of english and science. Schools with higher proportion of students from socio-economically backward communities (classified as Other Backward Castes (OBC), Scheduled Castes (SC) and Scheduled Tribes (ST)) in India have benefited more from the intervention (Tables (3) and (4) of Annexure). Students from these categories typically come from more disadvantaged backgrounds and are often disproportionately represented in rural government schools. The benefit to these communities is significant in case of maths and science. Schools with a higher proportion of girls seem to benefit more from the intervention. The impact is highest of 7.2 points in case of the category ST in maths and more than 5 points for SCs in both science and maths subjects. The treatment thus has helped students from these communities to overcome their social handicap to some extent. Also government aided schools have benefited more than the government schools. These are schools that are privately managed, but publicly funded. These results do not change significantly when we use the value added specification (Table (4) of Annexure)

As regards the differential impact of the intervention across the distribution, the effect of the treatment is different across subjects and is also different across various quantiles. The treatment effect peaks around the median. The quantile regressions (Tables (5) of Annexure) show that the impact of intervention has been more on the lower and the middle quantiles, except in case of maths where the impact is seen across the distribution. Typically, the impact is significant between quantiles 30 to 70. Schools in the lower and middle range of the distribution would typically be schools that are likely to be at a disadvantage either in terms of academic or physical infrastructure. A positive and significant impact of the intervention on these schools is in line with the objectives of the SAMIE program. The impact on total scores is muted as these include scores for other subjects such as Social Sciences, first language (mostly Kannada) and third language (mostly Hindi).

At the individual student level the intervention leads to a difference of about 0.8 to 0.9 marks on average in individual subjects. However, the significance of the impact in all regressions is lost on clustering at the Taluk level. Here too the impact is positive on the socio-economically backward communities with an addition of between two to seven marks per subject. Performance of girls though in general is better than the boys, when it comes to the impact of the intervention, girls, seem to have had a poorer result than the boys. Table (7), (8) and (9) shows that girls from socio-economically backward communities are at particular disadvantage. However, when it comes to the effect of intervention, the impact on them is positive. Though, in many cases, especially in case of girls from SC and ST communities, the impact is not as yet big enough to overcome their initial disadvantaged position.

4 Discussion and Conclusion

The interventions started in November 2014. Typically, the students of Class 10 complete their classes for the school year and are on a study leave from the end of January. Thus effectively, their exposure of 10th graders to the program in the AY 2014-15 was for a short period of three months. It is not therefore fair to comment on the success or failure of the program solely based on evaluation of grade 10 batch performance in the SSLC results. Nevertheless, the estimated coefficients give some valuable pointers as to the direction of the impact. The simple OLS regressions give a positive coefficient for the treatment dummy in all cases. The treatment dummy is also significant in case of english, science and pass percentages, though the effect size is small. The effect size ranges from 0.5 points in maths to 0.9 points in science with three months of treatment.

There are however, two important impacts that are seen. Firstly, the students from lower socio-economic backgrounds are seen benefiting more from this program. Low performing students, especially when they come from such disadvantaged socio-economic backgrounds cannot afford to purchase additional teaching input in form of private tuitions, additional learning aids, etc. Such students are also likely to benefit from an intervention of this nature.

So also, schools with higher proportion of students from such backgrounds are benefiting more from the program. Schools serving these socio-economically disadvantaged communities are also likely to be in remote and underdeveloped areas with low academic and physical infrastructure. An additional input like the SAMIE program is likely to generate relatively higher marginal returns for these schools. This is seen in the quantile regressions. The effect of the treatment is different across subjects and also varies across quantiles. The treatment effect seems to peak around the median. As can be seen from Tables (5) for english and maths, schools in the 60th percentile appear to get maximum benefit. Similarly for science, it can be seen that schools from 30th to 60th percentile seem to get the maximum benefit. The positive and significant effect size seen in the quantile regressions for quite a few quantiles within three months of the intervention looks encouraging.

Another point to note is that the treatment effect is subdued when we consider total average marks that would include marks from three other subjects apart from the ones for which treatment was offered. The effect is more pronounced when we consider marks in only those subjects for which the extra lectures were given.

Thus, overall, while it may still be a bit premature to look for the impact of the intervention, the preliminary results as noted above do show that the impact is in the right direction. Further, the quantile regressions show that the Intervention is making an impact among the right strata of the schools i.e. those which are in the middle range of the scoring hierarchy. The impact is positive in schools at the lower end of the distribution, though non-significant. The intervention is designed as an additional teaching input delivered over and above the teaching time allocated for a subject. Its success remains conditional on teaching input and guidance by local teacher. It is likely that in schools at lower end of the distribution, even basic teaching and infrastructure facilities are not present. This may limit the impact of the intervention.

The detailed test results conducted under the project would give far richer data to analyze the impact across grades, gender and socio-economic background of the students. Nevertheless, the present paper shows that the intervention is a step in the right direction.

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Annexure

1 School Level Analysis

Table 1: Comparison of Schools in Control and Treatment groups on Observable Characteristics

	Control Mean	Treatment Mean	t-statistic	p-value
Pupil-Teacher-Ratio	10.92	10.44	0.41	0.68
Pupil-Classroom-Ratio	8.05	9.18	-0.96	0.34
Proportion of Girls	0.46	0.47	-0.49	0.63
Proportion of SC	0.22	0.24	-1.32	0.19
Proportion of ST	0.11	0.14	-3.68	0.00
Proportion of OBC	0.53	0.47	3.05	0.00
Proportion of Muslims	0.38	0.43	-1.66	0.10

SC-Scheduled Castes; ST - Scheduled Tribes; OBC - Other Backward Castes - These castes are considered socio-economically disadvantaged in India.

Table 2: Comparison of Control and Treatment Schools on Baseline SSLC Performance (School Average Marks - April 2014)

	Control Mean	Treatment Mean	t-statistic	p-value
English	47.29	47.69	-0.74	0.46
Maths	45.29	46.15	-1.73	0.08
Science	49.46	49.72	-0.51	0.61
Social Science	60.31	61.19	-1.37	0.17
Language 1	76.02	76.86	-1.07	0.29
Total Score	333.96	338.71	-1.58	0.12
No. of Students	62.39	60.86	0.71	0.48
Pass Proportion	0.87	0.88	-1.42	0.16

No. of students gives the average size of the grade 10 batch in control and treatment schools. Pass proportion gives the proportion of students who could clear the exams in April 2014.

Table 3: OLS on School Level Average Scores With School Characteristics as Controls

	School Average April 2015 Scores			
	English	Maths	Science	Pass. Perc.
	(1)	(2)	(3)	(4)
Treatment Status	−2.204	−4.651**	−0.810	−0.045
	(2.075)	(2.271)	(2.232)	(0.047)
Proportion of OBC*Treatment	2.220	3.804**	3.886**	0.071**
	(1.470)	(1.549)	(1.523)	(0.032)
Proportion of SC*Treatment	1.693	5.480**	5.117*	0.086
	(2.546)	(2.678)	(2.637)	(0.055)
Proportion of ST * Treatment	−1.301	7.201**	1.448	0.138**
	(3.029)	(3.189)	(3.132)	(0.065)
Proportion of Girls * Treatment	2.681	0.862	−2.752	−0.032
	(3.107)	(3.271)	(3.215)	(0.067)
Pupil-Teacher-Ratio * Treatment	0.010	−0.053**	0.004	−0.0003
	(0.021)	(0.024)	(0.023)	(0.0005)
Pupil-Classroom-Ratio * Treatment	−0.027	−0.027	−0.034	−0.001
	(0.021)	(0.022)	(0.022)	(0.0005)
No. of Students in Grade 10 * Treatment		0.014	−0.008	−0.00005
		(0.012)	(0.012)	(0.0002)
Tribal Social Welfare.*Treatment	−2.914	1.652	−1.886	−0.017
	(2.432)	(2.603)	(2.559)	(0.053)
Private-Aided*Treatment	0.936	0.770	0.780	0.016
	(0.762)	(0.801)	(0.787)	(0.016)
Observations	1,135	1,135	1,135	1,135
Adjusted R^2	0.333	0.312	0.352	0.262
Residual Std. Error	6.007	6.319	6.211	0.130
F Statistic	29.301***	24.410***	29.012***	19.284***

Note: *p<0.1; **p<0.05; ***p<0.01

All regressions include controls for baseline score and school characteristics wihout interaction for which coefficients have not been reported here.
Figures in brackets indicate standard erros.

Table 4: Value-add Specification with School Level Average Scores with School Level Controls

	Difference between April 2015 and April 2014 School Average Scores				
	Total Marks	English	Maths	Science	Pass.Perc
	(1)	(2)	(3)	(4)	(5)
Treatment Status	0.666	−0.760	−1.123	2.022	0.022
	(9.809)	(1.672)	(1.901)	(1.866)	(0.039)
Proportion of SC * Treatment	8.545	0.021	2.567	2.147	0.031
	(12.473)	(2.277)	(2.418)	(2.376)	(0.049)
Proportion of Girls * Treatment	1.023	2.652	0.770	−2.803	−0.034
	(17.075)	(3.117)	(3.310)	(3.248)	(0.068)
Pupil-Teacher-Ratio * Treatment	−0.036	0.011	-0.058^{**}	0.001	−0.0003
	(0.123)	(0.021)	(0.024)	(0.023)	(0.0005)
Pupil-Classroom-Ratio * Treatment	−0.182	−0.027	−0.029	−0.035	−0.001
	(0.116)	(0.021)	(0.023)	(0.022)	(0.0005)
No. of Students in Grade 10 * Treatment	0.001		0.018	−0.005	0.00002
	(0.061)		(0.012)	(0.012)	(0.0002)
Tribal Social Welfare.*Treatment	−2.973	−2.378	2.387	−0.938	−0.004
	(13.545)	(2.434)	(2.626)	(2.577)	(0.054)
Private-Aided*Treatment	1.773	0.971	0.700	0.783	0.014
	(4.168)	(0.762)	(0.809)	(0.793)	(0.017)
Observations	1,135	1,135	1,135	1,135	1,135
Adjusted R^2	0.337	0.390	0.351	0.346	0.164
Residual Std. Error	32.982	6.027	6.395	6.276	0.131
F Statistic	32.991^{***}	46.309^{***}	35.083^{***}	34.272^{***}	13.378^{***}

Note: *p<0.1; **p<0.05; ***p<0.01

All regressions include controls for baseline score and school characteristics wihout interaction for which coefficients have not been reported here.
Figures in brackets indicate standard erros.

Table 5: Quantile Regression on School Average Scores for English, Maths and Science

	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
English	1.12	0.93^{*}	0.85^{*}	0.76^{*}	0.76^{*}	1.22^{***}	1.02^{**}	0.47	0.16
	(0.69)	(0.51)	(0.43)	(0.40)	(0.43)	(0.45)	(0.49)	(0.48)	(0.52)
Maths	0.11	0.51	0.71^{*}	0.58	0.95^{**}	0.77^{*}	0.76	0.80	0.56
	(0.83)	(0.64)	(0.42)	(0.46)	(0.44)	(0.46)	(0.47)	(0.56)	(0.67)
Science	-0.11	0.65	1.08^{**}	1.26^{***}	1.24^{***}	1.36^{***}	1.15^{**}	0.89	0.55
	(0.76)	(0.66)	(0.48)	(0.46)	(0.45)	(0.45)	(0.48)	(0.61)	(0.75)
Num. obs.	1135	1135	1135	1135	1135	1135	1135	1135	1135
Percentile	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

All regressions include control for baseline score.
Figures in brackets indicate standard erros.

2 Student Level Analysis

Table 6: Comparison of Treatment and Control Groups on Student Level April 2014 scores, Clustered SE Taluk

	Control	Treatment	Difference	S.E.	p.value
Total Score	330.717	336.265	5.549	6.517	0.395
Maths	44.968	46.028	1.060	1.047	0.311
Science	49.002	49.585	0.583	1.193	0.625
English	46.806	47.345	0.539	1.125	0.632
Social Science	60.028	60.960	0.932	1.411	0.509
Language 1	75.124	75.975	0.851	1.819	0.640

Figures in brackets indicate standard erros.

Table 7: Student level April 2015 Maths scores on Treatment Dummy with Controls for Caste-Gender Interaction, Clustered SE Taluk

	Maths Scores in April 2015	
	OLS	Clustered SE
	(1)	(2)
Treatment Status	0.812 (0.356)	0.812 (2.438)
	t = 2.281*	t = 0.333
OBC	0.535 (0.282)	0.535 (1.730)
	t = 1.895	t = 0.309
SC	−1.232 (0.323)	−1.232 (1.415)
	t = −3.814**	t = −0.871
ST	−0.462 (0.407)	−0.462 (1.782)
	t = −1.134	t = −0.259
Girls	3.995 (0.352)	3.995 (0.761)
	t = 11.361**	t = 5.248**
OBC*Treatment	0.113 (0.413)	0.113 (2.207)
	t = 0.273	t = 0.051
SC*Treatment	0.456 (0.465)	0.456 (2.072)
	t = 0.980	t = 0.220
ST*Treatment	−0.042 (0.560)	−0.042 (2.341)
	t = −0.076	t = −0.018
Girls*Treatment	−0.879 (0.513)	−0.879 (0.912)
	t = −1.715	t = −0.964
OBC*Girls	−1.069 (0.415)	−1.069 (0.792)
	t = −2.575*	t = −1.349
SC*Girls	−3.246 (0.475)	−3.246 (0.836)
	t = −6.826**	t = −3.884**
ST*Girls	−2.189 (0.595)	−2.189 (0.963)
	t = −3.677**	t = −2.274*
OBC*Girls*Treatment	0.489 (0.595)	0.489 (0.995)
	t = 0.822	t = 0.491
SC*Girls*Treatment	1.102 (0.674)	1.102 (1.036)
	t = 1.634	t = 1.064
ST*Girls*Treatment	1.109 (0.806)	1.109 (1.162)
	t = 1.375	t = 0.954
Constant	48.938 (0.238)	48.938 (1.860)
	t = 205.842**	t = 26.315**
Observations	72,818	
Adjusted R^2	0.014	
Residual Std. Error	14.123	
F Statistic	69.728**	
Note:		*p<0.05; **p<0.01

Figures in brackets are standard errors.

Table 8: Student level April 2015 Taluk scores on Treatment Dummy with Controls for Caste-Gender Interaction, Clustered SE Taluk

	Science Scores in April 2015	
	OLS	Clustered SE
	(1)	(2)
Treatment Status	0.799 (0.377)	0.799 (1.930)
	t = 2.121*	t = 0.414
OBC	1.225 (0.299)	1.225 (1.178)
	t = 4.104**	t = 1.040
SC	−0.905 (0.342)	−0.905 (1.046)
	t = −2.650**	t = −0.865
ST	0.251 (0.431)	0.251 (1.495)
	t = 0.584	t = 0.168
Girls	5.535 (0.372)	5.535 (0.430)
	t = 14.885**	t = 12.880**
OBC*Treatment	0.218 (0.437)	0.218 (1.670)
	t = 0.499	t = 0.130
SC*Treatment	0.613 (0.492)	0.613 (1.678)
	t = 1.247	t = 0.366
ST*Treatment	−0.047 (0.592)	−0.047 (1.916)
	t = −0.080	t = −0.025
Girls*Treatment	−1.237 (0.542)	−1.237 (0.694)
	t = −2.282*	t = −1.783
OBC*Girls	−1.813 (0.439)	−1.813 (0.483)
	t = −4.132**	t = −3.757**
SC*Girls	−3.334 (0.503)	−3.334 (0.649)
	t = −6.631**	t = −5.137**
ST*Girls	−3.181 (0.629)	−3.181 (0.709)
	t = −5.053**	t = −4.488**
OBC*Girls*Treatment	1.055 (0.629)	1.055 (0.776)
	t = 1.677	t = 1.360
SC*Girls*Treatment	0.922 (0.713)	0.922 (0.897)
	t = 1.293	t = 1.027
ST*Girls*Treatment	1.396 (0.853)	1.396 (1.081)
	t = 1.637	t = 1.291
Constant	48.468 (0.251)	48.468 (1.466)
	t = 192.793**	t = 33.070**
Observations	72,818	
Adjusted R^2	0.020	
Residual Std. Error	14.934	
F Statistic	97.571**	
Note:		*p<0.05; **p<0.01

Figures in brackets are standard errors.

Table 9: Student level April 2015 English scores on Treatment Dummy with Controls for Caste-Gender Interaction, Clustered SE Taluk

	English Scores in April 2015	
	OLS	Clustered SE
	(1)	(2)
Treatment Status	0.343 (0.368)	0.343 (2.557)
	t = 0.933	t = 0.134
OBC	0.391 (0.292)	0.391 (1.871)
	t = 1.339	t = 0.209
SC	−0.760 (0.334)	−0.760 (1.701)
	t = −2.275*	t = −0.447
ST	0.086 (0.421)	0.086 (2.241)
	t = 0.203	t = 0.038
Girls	4.803 (0.364)	4.803 (0.573)
	t = 13.209**	t = 8.381**
OBC*Treatment	0.881 (0.427)	0.881 (2.148)
	t = 2.063*	t = 0.410
SC*Treatment	0.576 (0.481)	0.576 (2.061)
	t = 1.197	t = 0.280
ST*Treatment	−0.884 (0.579)	−0.884 (2.493)
	t = −1.527	t = −0.355
Girls*Treatment	−0.682 (0.530)	−0.682 (0.775)
	t = −1.287	t = −0.880
OBC*Girls	−1.561 (0.429)	−1.561 (0.633)
	t = −3.638**	t = −2.467*
SC*Girls	−3.503 (0.492)	−3.503 (0.668)
	t = −7.123**	t = −5.245**
ST*Girls	−3.366 (0.616)	−3.366 (1.016)
	t = −5.467**	t = −3.313**
OBC*Girls*Treatment	0.588 (0.615)	0.588 (0.885)
	t = 0.956	t = 0.664
SC*Girls*Treatment	1.138 (0.697)	1.138 (0.896)
	t = 1.632	t = 1.271
ST*Girls*Treatment	1.688 (0.834)	1.688 (1.213)
	t = 2.024*	t = 1.392
Constant	45.954 (0.246)	45.954 (2.258)
	t = 186.964**	t = 20.350**
Observations	72,789	
Adjusted R^2	0.016	
Residual Std. Error	14.603	
F Statistic	79.034**	
Note:		*p<0.05; **p<0.01

Figures in brackets are standard errors.

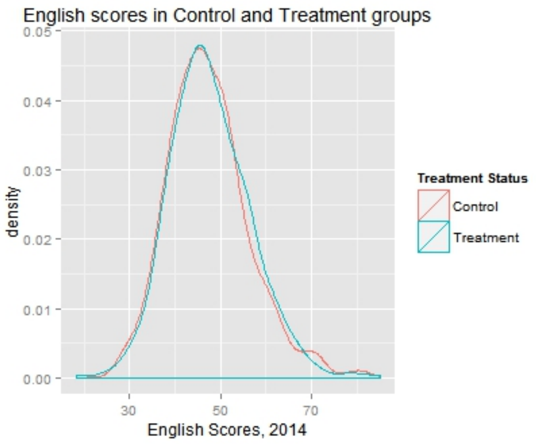

Figure 1: School Average English score, 2014

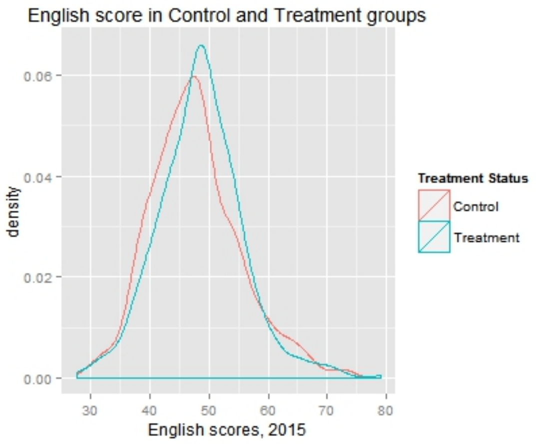

Figure 2: School Average English score, 2015

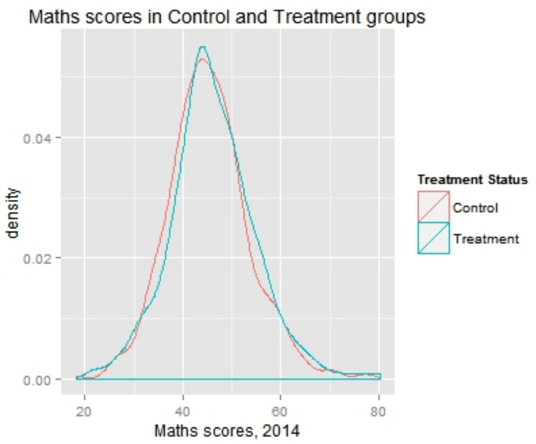

Figure 3: School Average Maths score, 2014

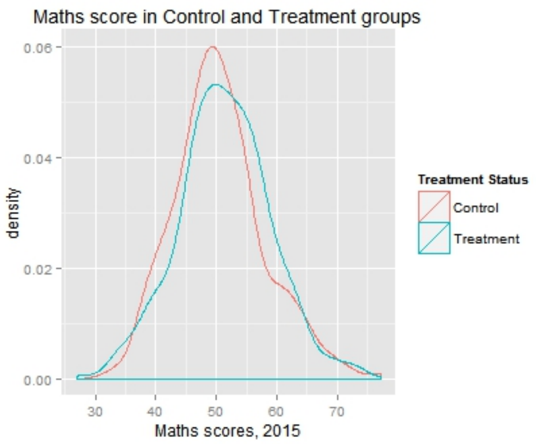

Figure 4: School Average Maths score, 2015

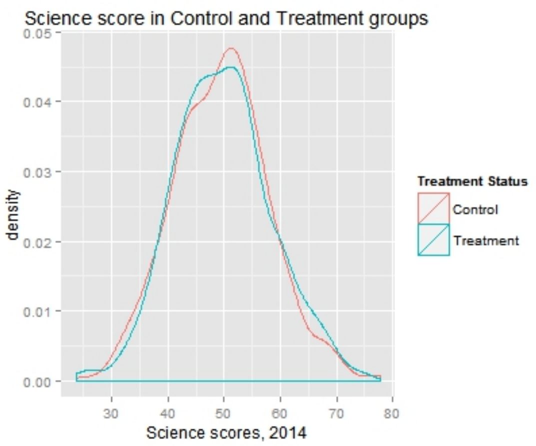

Figure 5: School Average Science score, 2014

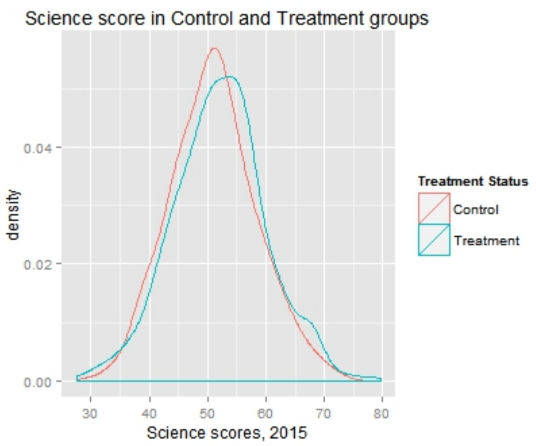

Figure 6: School Average Science score, 2015

Comparison of Distributions of School Average SSLC scores in Control and Treatment Groups in 2014 and in 2015