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ABSTRACT

This paper examines a large-scale randomized evaluation of the One Laptop Per Child (OLPC) program in 531 Peruvian rural primary schools. We use administrative data on academic performance and grade progression over 10 years to estimate the long-run effects of increased computer access on (i) school performance over time and (ii) students' educational trajectories. Following schools over time, we find no significant effects on academic performance but some evidence of negative effects on grade progression. Following students over time, we find no significant effects on primary and secondary completion, academic performance in secondary school, or university enrollment. Survey data indicate that computer access significantly improved students' computer skills but not their cognitive skills; treated teachers received some training but did not improve their digital skills and showed limited use of technology in classrooms, suggesting the need for additional pedagogical support.

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I Introduction

Developing countries have made large investments to expand access to technology in schools with the aim of improving educational outcomes. For example, between 2006 and 2012, twenty countries in Latin America and the Caribbean distributed nearly 10 million laptops to public school students (Arias Ortiz and Cristia, 2014). One highly publicized initiative was the One Laptop per Child (OLPC) program, which provided personal laptops to students in 40 countries. These types of programs have garnered renewed interest since the COVID-19 pandemic as schooling was conducted remotely.[1] Notwithstanding the substantial investments in these programs, experimental studies have generally not found short-term educational effects of providing personal computers to students (Mo et al., 2013; Beuermann et al., 2015).[2] Similarly, a large-scale experimental evaluation of the OLPC program in Peru found no effects on academic performance or enrollment in primary school after 15 months of program implementation (Cristia et al., 2017).

Despite the absence of short-term impacts on academic performance, expanding access to technology in schools could nevertheless generate longer-term impacts along two dimensions. First, there may be dynamic effects on *schools* over time if teachers and principals need time to learn how to use technology effectively for pedagogical purposes (Lakdawala et al., 2023). Second, there may be long-term effects on *students* as they progress through the educational system if greater exposure to computers leads to changes in attitudes, behaviors, and a broader range of academic and non-academic skills (Yanguas, 2020a,b). Accordingly, this paper presents novel experimental evidence

[1] For example, the government of the Dominican Republic distributed 1.5 million devices to students and teachers in 2020-2022 (Latino, 2023), while the governments of Kenya and Peru distributed 1.2 million and 1 million tablets, respectively, during this period (Standard, 2021; MINEDU, 2022).

[2] Another set of studies has assessed the effects of specific learning platforms on academic performance, with more positive results especially when implemented after school and involving additional instructional time (Banerjee et al., 2007; Linden and MacLeod, 2008; Lai et al., 2012; Berlinski and Busso, 2013; Lai et al., 2013; Mo et al., 2014, 2015; Lai et al., 2015; Araya et al., 2019; Ferman et al., 2019; Muralidharan et al., 2019; Büchel et al., 2022; Ma et al., 2023).

on the long-term effects of expanding access to technology on both (i) academic performance and grade progression in schools over time and (ii) students' educational trajectories as they progress from primary to tertiary education.

We examine a large-scale randomized evaluation of the OLPC program as implemented by the Peruvian government in rural primary schools using administrative and survey data between 2007 and 2019. We focus on 531 schools that were randomized into treatment and control groups. Treatment schools were assigned to participate in the OLPC program which provided students with personal laptops (called "XO laptops") starting in 2009. Teachers in the treatment group were expected to receive a 40-hour training that focused on how to operate the laptops and use them for pedagogical purposes. Using administrative data, we show that the program increased the ratio of XO laptops to students in treatment schools from 0 to almost 1 by the end of 2009. Starting in 2011, some XO laptops were also distributed to schools in the control group so that the average ratio of XO laptops per student in these schools eventually reached 0.4 by 2019. Moreover, the ratio in treatment schools began declining in 2014 as some laptops were lost or broke down. Still, a sizable difference in access to XO laptops between treatment and control schools remained throughout this period, and students in control schools never reached the 1-to-1 access to computers in treatment schools. We show that our results hold in analyses that examine earlier years and older cohorts where differences in XO laptops between treatment and control groups are starker.

First, we analyze the effect of the OLPC program on schools' academic performance from 2009 to 2016 using data from annual second-grade national examinations. Results indicate small and insignificant effects without a clear pattern of differential effects over time. Pooling this data across all years, we can rule out positive effects greater than 0.05 standard deviations with 95 percent con-

fidence. Thus, there is little evidence to suggest that the OLPC program improved school academic performance over time. We then estimate effects on the fraction of primary students that advanced to the next grade between 2009 and 2016 using data from annual school censuses. The pooled estimate suggests a negative effect of 1.0 percentage point on grade progression.

Second, we assess the effect of the OLPC program on students' educational trajectories using data from 2nd, 4th and 8th grade national exams, 5th and 6th grade tests that we administered, and longitudinal administrative data on grade progression from primary to tertiary education. After adjusting for multiple hypothesis testing, there are null effects on national exams or test scores. We also find no significant effects on completing primary and secondary school, and on university enrollment. While there are marginally significant reductions in the likelihood of completing primary education on time (2.1 percentage points) and applying to university on time (2.2 percentage points), these become insignificant after adjustments for multiple hypothesis testing. The overall effect on completed years of schooling is also insignificant.

Why did the OLPC program not improve academic performance or educational attainment? To address this question, we use survey data collected from a subset of 140 schools in 2013. Teachers in treatment schools were 35 percentage points more likely to receive training in the use of XO laptops than teachers in control schools (with a mean of 28 percent). However, there were no significant impacts on the digital skills of teachers related to the use of the XO laptops, desktop computers, or the internet. Furthermore, the OLPC program generated a relatively small increase in classroom computer use.

Turning to student outcomes, we document that the program increased the use of XO laptops at home by 20 percentage points, with no effects on the use of other computers or the internet.

Consistent with this, we find large positive effects of 0.40 standard deviations on their digital skills in using XO laptops, but only marginally significant effects on digital skills for desktop computers and no effects on internet-related skills. Neither do we find positive effects on an index of cognitive skills based on the Ravens' Progressive Matrices, verbal fluency and coding tests. Thus, the absence of positive impacts on academic performance and educational attainment may be due to the limited adoption of the XO laptops in schools for academic purposes and the small effects on students' intermediate outcomes beyond their digital skills.

This study builds on the experimental literature examining short-term educational effects of providing personal computers to students (Mo et al., 2013; Beuermann et al., 2015; Cristia et al., 2017). However, our main contribution is to the nascent strand of the literature analyzing the long-term effects of expanding access to technology in schools. Regarding the dynamic effects on schools, Lakdawala et al. (2023) analyze how the provision of school-based internet access at the primary level in Peru affects their performance. Using an event-study approach applied to the same administrative data on second-grade academic performance that we use, they document modest positive effects of 0.02 to 0.03 standard deviations one year after schools receive internet, but growing and larger effects of 0.06 to 0.11 standard deviations after five years.[3] Regarding effects on students, Yanguas (2020a) evaluates the long-term effects of an OLPC program in Uruguay among students exposed during childhood. Exploiting cross-cohort variation in exposure to the program, she finds no effects on high school enrollment and graduation or tertiary enrollment but some evidence for a shift from science and technology majors to social science majors in university.[4] Our study contributes to this literature by presenting the first experimental evidence on the long-term

[3]Consistent with Lakdawala et al. (2023), Malamud et al. (2019) find no short-term effects on academic performance of providing personal laptops with internet for home use among primary school students in Lima, Peru.

[4]In a related paper, Yanguas (2020b) observes improvements in promotion and graduation from secondary school from increased access to computers and internet in Argentina.

effects of expanding access to computers (as opposed to the effects of internet access in Lakdawala et al. (2023)) on both school performance over time and student trajectories as they progress through the educational system.

We proceed with Section II laying out the study design. Section III presents the data and empirical strategy, Section IV discusses the results, and Section V concludes.

II Study Design

II.1 Education in Peru

Public education in Peru is free and compulsory for students from preschool through the end of secondary school but enforcement is lax. Children aged 6 to 11 are expected to attend primary school in grades 1st to 6th, and those aged 12 to 16 are expected to enroll in secondary school in grades 7th to 11th. However, it is common to find relatively older students outside these ranges due to the high rates of grade repetition. Between 2009 and 2018, public spending per student in constant 2015 USD rose from $461 to $733 for primary education and from $544 to $957 for secondary education (World Bank, 2024). During this period, primary school completion increased from 91% to 96% while secondary school completion increased from 73% to 84% (Inter-American Development Bank, 2022).

Academic performance in Peru has been improving, with the percentage of second grade primary students meeting the national mathematics standard increasing from 14% in 2009 to 34% by 2016 (MINEDU, 2016). Reading proficiency also improved, with the percentage of second grade students reaching the national standard rising from 23% in 2009 to 46% in 2016. Nevertheless, educational outcomes reveal pronounced disparities among student groups, particularly when dif-

ferentiated by residential location. For example, only 17% of rural students met the second-grade mathematics standard in 2016, compared to 37% of their urban counterparts.

II.2 Intervention

The One Laptop per Child (OLPC) initiative, conceived by a team at the Massachusetts Institute of Technology Media Lab, aimed to provide affordable laptops to children in economically disadvantaged regions of the world. Announced in 2005, these XO laptops were initially touted as "$100 laptops", but governments eventually purchased them for approximately $200 each. The program saw its greatest uptake in Latin America, where 82% of the laptops were distributed, including the two largest deployments (Peru with 902,000 laptops, and Uruguay with 585,000 laptops).

The government of Peru launched its national OLPC program in 2008, distributing 40,000 laptops to about 500 schools. The program targeted the nation's most impoverished regions, while ensuring that participating schools either had access to electricity or received solar panels when necessary. The program aimed to provide an XO laptop to every student in these schools. In terms of software, the government preloaded the laptops with around 200 age-appropriate e-books and included 39 open-source applications, organized into five categories: standard (write, browser, paint, calculator, and chat); games (educational, including Memorize, Tetris, Sudoku, and a variety of puzzles); music (to create, edit, and play music); programming (three programming environments); and other (including sound and video recording and specific sections of Wikipedia). The lack of internet access and the laptops' incompatibility with Windows prevented students from installing video games or other software.

II.3 Sample Selection

We focus on 531 primary schools that were randomized to receive the OLPC program (296 treated and 235 control). This sample differs from the one used by Cristia et al. (2017) to evaluate the short-term effects of the program, although both are derived from the same initial set of schools. The original sample included 956 primary schools that were public, rural, multigrade, had administrative data on inputs for at least one year between 2005 and 2007, and were in the poorest districts within each region. Schools were randomized stratifying by region, fraction of overage students, and school size, with 567 schools selected for treatment and 389 assigned to the control group. We apply two restrictions to this initial set of schools. First, we exclude 105 one-teacher schools because the government decided to include all of them in the OLPC program. Second, we exclude the 320 schools evaluated in Cristia et al. (2017) because the government decided that the control schools in this sample would also participate in the OLPC program once their study was completed in 2011.[5] This yields the 531 schools in our study.

III Data and Empirical Strategy

III.1 Data

We estimate the long-term impacts of the OLPC program on academic performance and school progression using comprehensive administrative and survey data. To track treatment compliance and school-level grade progression, we utilize an annual school census in which principals report information to the Peruvian Ministry of Education. These databases contain school-level informa-

[5] See Figure A.1 for more details. As the sample in Cristia et al. (2017) was selected at the randomization strata level, it remained internally valid. This also applies to the 531 schools in our study as, by the end of 2009, more than 93 percent of treated schools had been covered with a one-to-one ratio of OLPC XO laptops per student (Table A.1).

tion on enrollment, grade progression, teachers, resources, infrastructure, and technological inputs such as the number of computers and internet access. We analyze census data from 2007 (i.e., two years before the implementation of the OLPC program) until 2019.

To measure academic performance, we use national standardized examinations conducted by the Peruvian Ministry of Education, which evaluate students in mathematics and reading skills. These evaluations were implemented across different academic years and grade levels. At the primary level, students in second grade were assessed annually between 2007 and 2016, while those in fourth grade were evaluated in 2016 and 2018. At the secondary level, eighth grade students were assessed in 2015, 2016, 2018, and 2019. Fourth and eighth-grade examinations were matched, at the individual level, with the second-grade examinations. Thus, we evaluate fourth and eighth-grade academic performance among students who took the second-grade exam in the 531 experimental primary schools.

To assess students' primary and secondary school progression, as well as their application and enrollment to tertiary education, we leverage administrative enrollment data from the SIAGIE system. Launched in 2012 and administered by the Peruvian Ministry of Education, the SIAGIE system compiles the enrollment status of the full population of students at the primary, secondary, and tertiary levels, encompassing both public and private educational institutions. Specifically, for each year between 2012 and 2019, we observe every student's attended school, grade, passing status, and, when applicable, the student's application and enrollment status in tertiary education institu-

tions.[6] Since students are tracked annually across schools, we can identify those who attended one of the 531 schools in our sample.[7] When selecting students for analysis, we include those who attended a treatment or control school for at least one year. Since 98 percent of the students in our sample remain in the same primary school, this criterion is essentially equivalent to including students who have completed their entire primary education in our experimental sample.

Finally, in November 2013, we administered surveys to principals, teachers, and students (attending 5th and 6th grades) in 70 treatment and 70 control schools, randomly selected from our sample of 531 schools.[8] We collected information on access and use of XO laptops and other devices, internet connectivity, teachers' technical training, and digital competencies. We also evaluated students' mathematics and reading performance as well as a broad range of other skills, such as digital and cognitive skills (including Raven's progressive matrices, a verbal fluency test, and a coding test).[9] These data, obtained four years after the OLPC program implementation, help us explore potential mechanisms.

[6] In primary school, children repeat a grade if they fail both Spanish language and mathematics, and do not pass the recovery program offered during summer vacations (with the exception of 1st grade where promotion is automatic). In secondary school, students repeat a grade if they fail four or more subjects and do not pass the recovery program. In both primary and secondary schools, teachers decide whether to promote a student to the next grade based on their assessments of competencies in the national curriculum (MINEDU, 2005). The national standardized examinations are not used by teachers in the decision to promote students to the next grade since the results from these examinations are only available to teachers in the following academic year by which time the promotion decision has already been made.

[7] We do not use SIAGIE data for 2020/2021 because the Ministry of Education adopted universal progression during the COVID-19 pandemic.

[8] Due to budgetary constraints, we sampled schools from 5 regions. Nonetheless, the sample remains internally valid as the selection was conducted at the randomization strata level.

[9] The Raven's Progressive Matrices measure nonverbal abstract reasoning: respondents are presented with a series of progressively more difficult exercises that require choosing the figure that completes a pattern. The verbal fluency test measures language/vocabulary: students are instructed to write as many words as they can that began with a certain letter in three minutes (Ruff et al., 1997). The coding test measures processing speed and working memory: 10 pairs of one-digit numbers and graphical symbols were shown to students, who then completed as many corresponding symbols as possible in three minutes.

III.2 Empirical Strategy

We estimate the average treatment effect of the OLPC program with the following regression model:

$$Y_{itsr} = \alpha + \beta \cdot OLPC_{itsr} + \mu_{rt} + \varepsilon_{itsr} \quad (1)$$

where Y_{itsr} represents the outcome of student i from cohort t, who attended primary school s in randomization strata r. $OLPC_{itsr}$ is an indicator that takes the value of 1 if school s was randomly assigned to participate in the OLPC program, and 0 otherwise. We define cohorts based on the year in which students attended second grade because our primary measure for academic performance is the second grade national examination. Following Bruhn and McKenzie (2008), we include randomization strata-by-cohort fixed effects (μ_{rt}) to improve precision.

Given that the treatment was randomly assigned at the school level, we cluster estimated standard errors at that level. Moreover, with so many indicators and samples, we also report q-values which are analogous to p-values when accounting for multiple hypothesis testing (Benjamini et al., 2006; Anderson, 2008). The q-values denote the lowest critical level at which a null hypothesis is rejected when controlling for the false discovery rate.

III.3 Baseline Balance

Table 1 shows baseline balance using data from the 2007 and 2008 school census and the 2007 and 2008 national second grade examinations. Panel A shows that access to computers and internet was minimal, with both treatment and control schools having between 1 and 2 computers per 100 students. Panel B shows balance on other school-level inputs. While about 90 percent of schools had electricity, less than 60 percent had access to piped water. In terms of pedagogical

infrastructure, a third of schools had a library and almost none had a science lab. The average student-teacher ratio was around 21, the share of students who transferred from other schools was negligible, and 17 percent of students at school entry were overage. Panel C shows that second grade students were balanced in terms of mathematics and reading performance in the 2007 and 2008 national examinations.[10] Panel D shows balance in the fraction of students that advanced to the next grade.

III.4 Compliance

We examine compliance with the OLPC program in Figure 1, which shows the number of XO laptops per student for treatment and control schools over time. From 2009 on, within a year of starting the OLPC program, treated schools were close to saturated with one XO laptop per student. In contrast, control schools received almost no XO laptops through 2010. Starting in 2011, control schools began receiving some XO laptops, eventually reaching a ratio of about 0.4 laptops per student in 2019.[11] We also observe that the ratio in treatment schools began declining in 2014 as some laptops were lost or broke down. Nevertheless, the difference in the intensity of treatment between treatment and control schools remains large and significant throughout our period of analysis.[12]

We also explore whether the OLPC program triggered changes in other technology-related inputs or school characteristics. Table A.1 shows that while internet connectivity grew from virtually zero in 2009 to over 18 percent of schools with internet access by 2019, there were few significant differences between treatment and control schools in any of the years. Table A.3 shows that there

[10] Treatment and control schools were also balanced on *trends* in these outcomes (Table A.2).

[11] This reflected the government's desire to also provide other rural schools with educational technology.

[12] Although control schools were not less likely to have at least one XO laptop than treatment schools by 2013, the experimental variation in XO laptops per student persisted over time (Table A.1).

were no differences in access to desktops, other non-XO laptops, or on the presence of computer labs in the school across the treatment and control groups.[13] Table A.4 shows that the intervention did not generate differences in access to electricity, piped water, science lab, or library, or in the ratio of students per teacher, the share of students transferring from other schools, and overall school enrollment.

Our survey confirms the differential access to XO personal laptops between treatment and control schools for both students and teachers (Panel A of Table A.5). It also shows that the program affected access to XO laptops at home as some students were allowed to take the devices with them.[14] However, there were no effects on either access to non-XO computers at home or internet access at school or home. Thus, while the OLPC program generated significant and sustained access to personal XO laptops, it did not cause any significant impacts on other technology-related inputs or school characteristics that may have affected learning outcomes or grade progression.

IV Results

We examine the long-run effects of the OLPC program on (1) the academic performance and grade progression of schools over time by following successive cohorts in treatment and control schools; and (2) the trajectories of student performance and educational attainment by following students as they progress from primary school to university. We then explore potential mechanisms behind these long-run patterns using survey data.

[13] Note that desktops and non-XO laptops were much more likely to be used for administrative purposes than XO laptops, which were almost exclusively used for pedagogical purposes.

[14] Since the allocation of XO laptops within control schools was uncorrelated with academic performance, this rules out potential biases arising from only high performers benefiting from technology.

IV.1 Effects for Schools Over Time

Panel A of Figure 2 shows the effects on school-level academic performance in the eight years following treatment using data from the second-grade national examinations. There is no discernible pattern over time and none of the coefficients are significant. Pooling all the years together, we can rule out, with 95 percent confidence, effects larger than 0.05 standard deviations.[15]

Panel B of Figure 2 displays effects on grade progression, defined as the fraction of primary students that advanced to the next grade each year. All estimated coefficients are negative and, when pooling all years, results indicate a negative effect of 1.0 percentage point on grade progression (relative to the control group mean of 86.9%).[16]

We conclude that there is no evidence of positive impacts of exposure to the program on school-level educational outcomes over time. These estimates represent the long-term effects of the program on schools rather than students, insofar as treated students in all cohorts were exposed to the program for just two years before taking the second-grade examination.[17] They suggest that schools were not able to leverage technology to improve test scores in the early primary grades. The negative estimated impacts on grade progression over time suggest that the program may have triggered increases in grade repetition that affected student trajectories through the education system.[18]

[15] National examinations were only administered to schools with at least five students in second-grade. The fraction of the 531 schools with available data ranged from 59% to 71% between 2007 and 2013, but coverage fell to 39% by 2016. Appendix B analyzes attrition, showing that school participation in the exam was unrelated to treatment, key baseline characteristics of covered schools were balanced between treated and control groups over time, there were no compositional changes of schools over time, and that the results are robust to the exclusion of years with low coverage.

[16] Grade progression is computed by dividing the number of students promoted to the next grade at the end of the school year by the number of students enrolled at the beginning of the school year (and capped at 1). Table A.6 shows that the results are robust to alternative ways of computing the grade progression rate. Table A.7 shows that the negative effects are concentrated among students attending third and fourth grades.

[17] Table B.1 displays the estimates reported in Figure 2 and on the disaggregated reading and math performances.

[18] Appendix C explores school-level effect heterogeneity applying the machine learning-based approach of Chernozhukov et al. (2023). We find no evidence of heterogeneous effects.

IV.2 Effects on Student Educational Trajectories

Table 2 summarizes the effects of the OLPC program on academic performance and educational attainment for students. We link students who took the national second-grade exam in treatment and control schools to their scores on the fourth and eighth-grade examinations.[19] In addition, we follow the school progression of the full population of students who attended treatment and control schools using the SIAGIE data. We then evaluate effects pooling all cohorts (labeled with the year in which students attended second grade) with available data for each outcome.

Panel A shows results for academic performance.[20] Estimates for second, fourth and eighth-grade performance suggest no discernible effects. This is consistent with the null effects on academic performance among 5th and 6th graders evaluated in the 2013 survey (Panel B of Table A.5). After adjusting for multiple hypothesis testing, the q-values indicate no significant effects on academic performance. Following Kling et al. (2007), we compute an index of academic performance defined as the average of the standardized scores across all examinations taken by each student. This enables us to rule out, with 95 percent confidence, effects larger than 0.04 standard deviations on academic performance.

Panel B shows results for educational attainment. While we observe marginally significant negative effects on completing primary school on time and with up to one year delay (with effects of 2.1 and 1.7 percentage points respectively), there were no effects on completing primary education overall. We also observe a marginally significant negative estimate on the likelihood of applying

[19] Appendix B shows that matching rates across examinations reflect the population-wide on-time school progression rates within the focus schools and that attrition is balanced across experimental groups. It also shows that the responsiveness to the treatment is likely similar between those who were matched across examinations and those who were not as the effects on second-grade performance are equivalent between matched and unmatched individuals.

[20] Table A.8 presents academic performance impacts disaggregated by cohort.

to university on time. However, the impacts on secondary school completion or enrollment to university on time, although negative, are imprecisely estimated. When adjusting for multiple hypothesis testing, q-values indicate insignificant effects.[21] Finally, we compute the number of years of education that each student had satisfactorily completed by 2019, and find no significant effect on this summary measure.

Overall, we conclude that there were no long-term effects of the OLPC program on either academic performance or educational attainment.[22]

IV.3 Potential Mechanisms

We explore potential mechanisms behind the null long-term impacts using survey data collected in 2013, after four years of treatment. Surveys were administered to teachers and students in a random sub-sample of 70 treatment and 70 control schools, and are presented in Table 3. Panel A reports that teachers in treatment schools were more than twice as likely to report receiving training in the utilization of the XO laptops than teachers in the control group (with an effect of 35 percentage points over the control mean of 28 percent). These significant effects of increased training also apply to specific categories such as learning about basic XO functions, XO activities and software, and learning activities using the XO laptops. While total training days were higher among treated teachers, the differences are entirely driven by the extensive margin, with no significant differences

[21] Given that the SIAGIE started only in 2012, complete grade progression is not observed for cohorts that started school before 2012. Therefore, we compute on-time graduation based on the year in which students should have enrolled in first grade according to national rules. Reassuringly, Table A.9 shows consistent effects across different cohorts from the SIAGIE, and on time primary completion estimates are in line with the reduced primary grade progression from the school censuses (Figure 2). Another concern is that treatment might have altered the age at which parents enroll their children in first grade. Table A.10 documents that there were no effects on the fraction of overage students enrolled in first grade, suggesting that this possibility is not driving our results.

[22] Appendix C explores heterogeneous effects across predetermined variables. No heterogeneity is found based on gender, caregiver's educational attainment, baseline academic performance, or socio-economic status.

conditional on receiving training.[23]

Despite receiving training, there is no evidence of positive effects on teacher's digital skills. The effects on self-reported and XO-specific digital skills are not significant. The effects on general PC and internet skills are negative and either insignificant or marginally significant. Furthermore, in Panel C, we do not observe significant differences in teacher reports of computer use in the classroom between treatment and control schools. Teachers in treatment schools report using computers for only 0.8 hours per week more than teachers in control schools who use computers for 3.7 hours per week overall. These differences are even smaller in magnitude when looking at computer use in mathematics and reading/writing classes, although they are significant for reading classes where teachers in treatment schools report using computers for 0.4 hours more per week than the 1 hour per week in control schools. Still, even these differences are relatively small in magnitude and may help explain the null effects on academic outcomes.

Students in treatment schools were significantly more likely to use the XO laptops for entertainment, an increase of 14 percentage points. They also exhibit a 10 percentage-point increase in use for academic purposes, though this effect is not statistically significant (Panel D). Consistent with Cristia et al. (2017), we find large positive effects on computer skills. Panel E documents a highly significant increase of 0.41 standard deviations in XO-specific skills and a marginally significant increase of 0.17 in general PC skills while there is no effect on internet-related skills. However, we do not find strong evidence of effects on cognitive skills (Panel F). While there is a marginally significant effect of 0.19 standard deviations on verbal fluency, the effects on the Raven's Progressive Matrices and coding tests are small and insignificant. Following Kling et al. (2007), we compute a

[23] We also collected information on visits from IT specialists to teachers in the preceding 5 years. The differences between teachers in treatment and control schools are small and marginally significant, driven by differences in repair and maintenance rather than advice or training in the pedagogical use of XO laptops (Panel C of Table A.5).

summary index of cognitive skills and find no significant effects.

IV.4 Robustness

Effects for schools over time are equivalent when controlling for school-level baseline outcomes (Table A.11), or when estimating unweighted regressions with individual-level data (Table A.12). Effects on both, schools over time and student educational trajectories, are equivalent without controlling for randomization strata fixed effects (Table A.13 and Table A.14).

Our results report the impact of the OLPC program as implemented in rural Peru. That is, the effect on schools where students were provided personal XO laptops versus a counterfactual in which, while some computers were delivered, these were not distributed for personal use and, therefore, the OLPC program *per se* was not implemented. However, since the ratio of XO laptops per student was below 1 in some treatment schools and some laptops were distributed to the control group, this can also be interpreted as the intent-to-treat (ITT) estimate of providing one laptop for each child. We explore the treatment-on-the-treated (TOT) effects of this parameter by instrumenting the school-level ratio of XO laptops per student with treatment assignment. Results for both schools over time and student educational trajectories are shown in Table A.15 and Table A.16, being qualitatively similar to the main ITT effects.

V Conclusion

This paper presents results from a comprehensive, large-scale experimental evaluation of the One Laptop Per Child (OLPC) program in 531 rural primary schools, as implemented by the Peruvian government starting in 2009. We estimate null effects on schools' academic performance through 2016 and on students' academic performance when followed up until eighth grade. We

also examine the effects on students' grade progression and find small negative effects on the fraction of primary students that advanced to the next grade between 2009 and 2016. Consistent with these results, we find some suggestive evidence pointing to a small negative effect on the fraction of students who complete primary school on time, though there is no effect on eventually completing this education level. Turning to mechanisms, we find that despite increased access and use of laptops at home, and some evidence of improved digital skills for students, there was limited adoption of laptops for pedagogical purposes at schools and no effect on teachers' digital skills. These results suggest that providing computers to students without sufficient pedagogical support may have limited the effects on academic performance and may have led to negative effects on students' grade progression over time.

Our findings contrast with those of Lakdawala et al. (2023) who document that school-based internet access in Peruvian primary schools led to positive long-term effects on academic performance for schools over time. While both interventions sought to expand technology use in schools, they differed markedly in design and implementation. The OLPC program provided individual laptops loaded with e-books and educational applications to students and teachers within a context of low internet penetration, whereas the intervention studied by Lakdawala et al. (2023) improved school-based connectivity. It may be that the positive effects presented in Lakdawala et al. (2023) are due to the additional benefits of having internet access beyond just access to personal laptops. Or it may be that other factors, such as contextual differences or differences in empirical approaches, explain the contrasting findings. There is also evidence suggesting that access to personal laptops produces changes in student preferences regarding majors chosen in college (Yanguas, 2020a). However, in our setting, the fraction of students that enroll in tertiary education is only 6 percent, limiting our ability to investigate the effects on this margin.

With renewed interest in increasing access to computers and internet among governments in developing countries, it is important to extend the existing evidence on the short-term effects to longer-term evaluations. Though a large literature has documented that interventions in developing countries promoting the use of technology can produce positive effects on academic performance when implemented in after-school programs with additional instructional time, the evidence is much more limited for programs integrated into the standard school curriculum. At the same time, greater access to technological resources at schools and homes makes it crucial to understand how best to use these resources to improve educational outcomes. Looking forward, we expect future research to explore how recent advances in artificial intelligence may introduce opportunities to leverage technology in innovative ways to improve the delivery of educational services at low cost and large scale.

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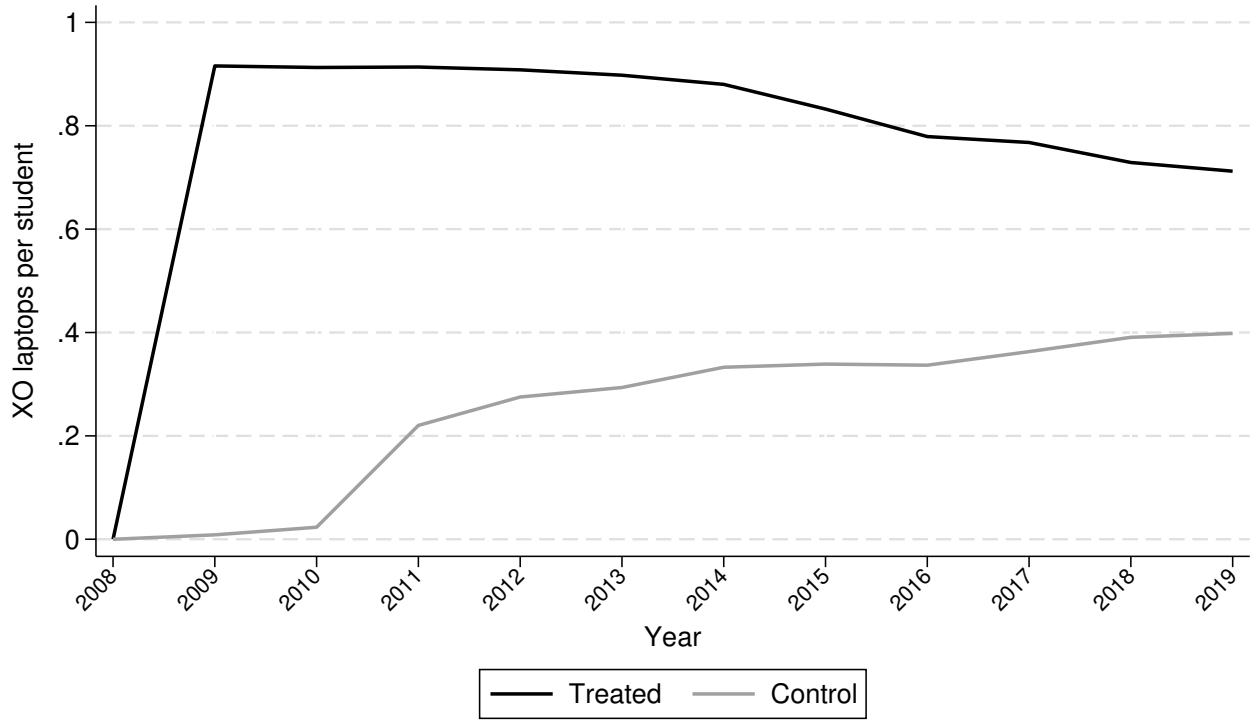
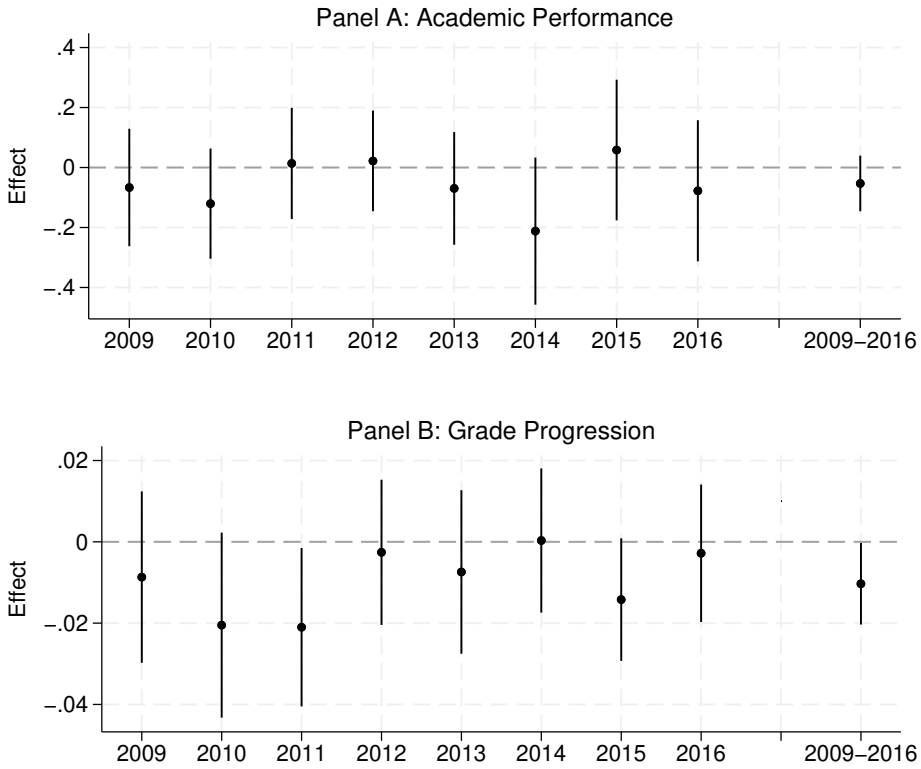
Figure 1: XO Laptops per Student over Time



Notes: This figure displays trends in terms of XO laptops per student at the school level. The sources are the Peruvian National Division of Technology in Education (2008-2011) and the school census (2011-2019). The first source reports XO deliveries to schools, and hence, it was only reported once. On the other hand, the census reports the yearly stock of usable/operational XO, but some schools fail to report in certain years. To have a complete series of XO per student for all schools, we have implemented the following steps. First, XO deliveries by the Peruvian National Division of Technology in Education are considered to remain in the school until the census reports an updated number. Second, for 2011, when both sources were available, information from the census was prioritized. Third, we performed an imputation over zero or missing values of XO laptops if they appear after a school already had a positive amount. This was done with a linear interpolation between the last and next positive values. If zero or missing values appear after the last positive value, that last positive value is used as a constant to complete the series. Finally, the school-level measure of XO laptops per student was capped at 1. This because, due to enrollment variation across years, some schools showed ratios of XO laptops per student beyond 1. As such, we capped the ratio to appropriately represent the number of effectively available laptops for individual use.

Figure 2: Effects for Schools over Time



Notes: Panel A shows estimated effects and 95 percent confidence intervals on an index of academic performance from school-level regressions that are weighted by the number of students who took the examinations in each school-year. To obtain the index, first, individual-level performance for reading and mathematics were standardized with zero mean and unit variance for the control group. Second, for each individual, performance in both subjects was averaged. Third, average performance was re-standardized with zero mean and unit variance for the control group to obtain the individual-level academic performance index. Fourth, the performance index was aggregated at the school-level mean. Panel B shows estimated effects and 95 percent confidence intervals on school-level grade progression (defined as the ratio of students promoted to the next grade with respect to those enrolled at the beginning of the school year in second to sixth grades - this ratio is capped at 1) using the yearly school census data. Estimates in Panel B are weighted by school (second - sixth grade) enrollment. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school level.

Table 1: Baseline Balance

	Treated Mean	Control Mean	Adjusted difference
	(1)	(2)	(3)
Panel A: Computers and connectivity			
Computers per student	0.021	0.013	0.004*
			(0.002)
School has internet	0.017	0.004	0.011
			(0.007)
Observations	296	235	
Panel B: Other school characteristics			
Electricity	0.922	0.902	0.011
			(0.024)
Piped water	0.598	0.574	0.002
			(0.041)
Library	0.382	0.306	0.071*
			(0.042)
Science lab	0.010	0.017	-0.009
			(0.010)
Students per teacher	20.886	21.393	0.402
			(0.438)
Fractions of transferred students	0.027	0.024	-0.002
			(0.003)
Fraction of overage students (first grade)	0.170	0.169	0.003
			(0.015)
Observations	296	235	
Panel C: Academic performance			
2007			
Second grade mathematics	-0.046	0.000	-0.055
			(0.093)
Second grade reading	-0.057	0.000	-0.058
			(0.091)
Observations	226	159	
2008			
Second grade mathematics	-0.063	0.000	-0.070
			(0.097)
Second grade reading	0.013	0.000	0.017
			(0.097)
Observations	230	167	
Panel D: School level grade progression			
Second grade	0.760	0.784	-0.020
			(0.013)
Third grade	0.786	0.798	-0.014
			(0.013)
Fourth grade	0.835	0.838	0.001
			(0.013)
Fifth grade	0.817	0.828	-0.006
			(0.012)
Sixth grade	0.849	0.869	-0.014
			(0.014)
Second - sixth grade	0.816	0.832	-0.013
			(0.009)
Observations	290	227	

Notes: This table presents baseline statistics and estimated differences between treatment and control schools. Columns 1 and 2 present means. Column 3 presents estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects. Panels A, B, and D present school-level regressions using the average between the 2007 and 2008 school censuses for continuous variables and the maximum between the 2007 and 2008 school censuses for dichotomous variables. Panel C presents school-level regressions from the 2007 and 2008 national second grade examinations where individual-level performance was first standardized with zero mean and unit variance for the control group and then aggregated at the school level mean. Estimates displayed in panel C are weighted by the number of students who took the examination in each school and estimates in panel D are weighted by the enrollment in each school-grade. ***p<0.01, **p<0.05, *p<0.1.

Table 2: Effects on Student Educational Trajectories

	Control mean	Effect	Observations	Cohorts	*p*-values	*q*-values
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Academic performance						
Second grade mathematics	0.000	-0.044	22,861	2009-2016	0.327	0.427
		(0.045)				
Second grade reading	0.000	-0.056	22,888	2009-2016	0.214	0.427
		(0.045)				
Fourth grade mathematics	0.000	-0.108	3,207	2014, 2016	0.136	0.427
		(0.072)				
Fourth grade reading	0.000	-0.133*	3,207	2014, 2016	0.069	0.427
		(0.073)				
Eighth grade mathematics	0.000	0.026	6,024	2009-2010, 2012-2013	0.568	0.494
		(0.045)				
Eighth grade reading	0.000	-0.010	6,025	2009-2010, 2012-2013	0.837	0.534
		(0.050)				
Index of academic performance	0.000	-0.046	22,898	2009-2016	0.313	
		(0.045)				
Panel B: Educational attainment						
Primary completion on time	0.695	-0.021*	28,516	2009-2015	0.055	0.427
		(0.011)				
Primary completion with up to one year of delay	0.862	-0.017*	24,939	2009-2014	0.052	0.427
		(0.009)				
Primary completion overall	0.954	-0.004	20,953	2009-2013	0.433	0.487
		(0.005)				
Secondary completion on time	0.518	-0.022	7,749	2009-2010	0.151	0.427
		(0.015)				
Secondary completion with up to one year of delay	0.655	-0.021	3,750	2009	0.268	0.427
		(0.019)				
Applied to university on time	0.167	-0.022*	3,750	2009	0.092	0.427
		(0.013)				
Enrolled to university on time	0.060	-0.010	3,750	2009	0.178	0.427
		(0.008)				
Completed years of education	8.205	-0.061	28,516	2009-2015	0.163	
		(0.044)				

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata by cohort fixed effects. Column 3 displays the number of individual-level observations in each pooled regression. Column 4 displays the cohorts included in each pooled regression where cohorts are labeled with the year in which students were enrolled in second grade. Column 5 shows the *p*-values and column 6 shows the adjusted *q*-values (where outcomes from both panels are all considered in one group). Mathematics and reading performance have been standardized at the individual level with zero mean and unit variance for the control group. At the bottom of panel A, we include an index of academic performance. This index was calculated in several steps. First, individual-level performance for mathematics and reading was standardized with zero mean and unit variance at the national sample for each grade and year. Second, both subjects were averaged and re-standardized with zero mean and unit variance. Third, for each student who took the ECE in multiple grades, we estimate an index of academic performance by averaging their score from all grades. Finally, we standardized this index with zero mean and unit variance for the control group by cohort. At the bottom of panel B, we include the number of satisfactorily completed years of (primary and secondary) education by 2019. The fourth-grade examinations were administered in years 2016 and 2018 (i.e., linked to cohorts who took the second-grade examinations in 2014 and 2016). The eight-grade examinations were administered in years 2015, 2016, 2018, and 2019 (i.e., linked to cohorts who took the second-grade examinations in 2009, 2010, 2012, and 2013). Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Table 3: Potential Mechanisms

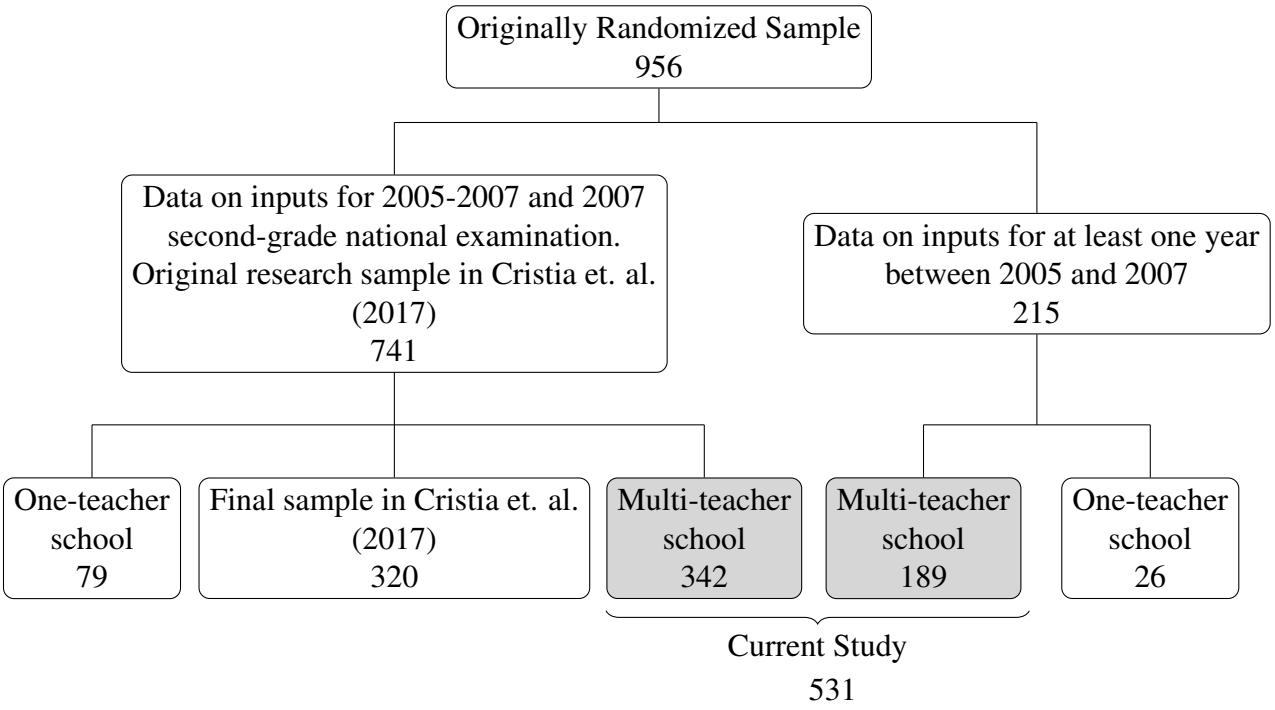
	Control mean	Effect	N	*p*-values	*q*-values
	(1)	(2)	(3)	(4)	(5)
Panel A: Teachers' digital training					
Received training in XO laptop utilization	0.280	0.350***	167	0.000	0.001
		(0.074)			
Basic XO functionalities and operation	0.268	0.270***	167	0.000	0.002
		(0.074)			
General activities and software of the XO	0.207	0.349***	167	0.000	0.001
		(0.071)			
Learning activities using the XO	0.134	0.175***	167	0.005	0.014
		(0.062)			
Total training days	1.313	1.135**	168	0.014	0.028
		(0.457)			
Total training days (conditional on receiving training)	4.542	-0.566	76	0.629	0.266
		(1.167)			
Panel B: Teachers' digital skills					
Self-reported digital skills	0.000	0.256	168	0.119	0.110
		(0.163)			
XO test	0.000	0.157	168	0.318	0.190
		(0.157)			
PC test	0.000	-0.255	168	0.159	0.120
		(0.180)			
Internet test	0.000	-0.317*	168	0.053	0.072
		(0.163)			
Panel C: Teachers' use of computers in the classroom					
Days Used last week	1.047	0.455***	168	0.002	0.006
		(0.140)			
Weekly hours using computers or laptops in class (typical week)					
Total	3.681	0.797	168	0.255	
		(0.698)			
Mathematics	0.723	0.254	168	0.164	0.120
		(0.181)			
Reading and Writing	0.952	0.398**	167	0.043	0.065
		(0.195)			
Panel D: Students' use of computers in the school (previous week)					
Days computer was used in school (last week)	1.378	0.459***	2,109	0.004	0.011
		(0.155)			
Used for entertainment	0.518	0.139**	2,128	0.027	0.045
		(0.062)			
Used for academic purposes	0.566	0.101	2,125	0.124	0.110
		(0.065)			
Panel E: Students' digital skills					
XO test	0.000	0.405***	2,128	0.000	0.001
		(0.090)			
PC test	0.000	0.170*	2,128	0.064	0.075
		(0.091)			
Internet test	0.000	0.078	2,128	0.395	0.222
		(0.091)			
Panel F: Students' cognitive skills					
Cognitive skills index	0.000	0.136	2,134	0.148	
		(0.093)			
Raven's progressive matrices	0.000	0.046	2,128	0.572	0.251
		(0.082)			
Verbal Fluency	0.000	0.187*	2,130	0.070	0.076
		(0.102)			
Coding	0.000	0.034	2,105	0.691	0.271
		(0.086)			

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects. Column 3 displays the number of observations in each regression. Column 4 shows *p*-values and column 5 shows the adjusted *q*-values (where outcomes from all panels are all considered in one group). Computer utilization for entertainment includes drawing, playing, listening to music, and watching videos or movies. Computer utilization for academic purposes includes reading, writing, organizing information (e.g., conceptual frameworks), using the calculator, and doing homework. Data corresponds to the survey implemented by the team in the year 2013. Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Appendix

Appendix A: Supplemental Figures and Tables

Figure A.1: Study Sample



Notes: This figure schematizes the sample selection. The originally randomized sample included 956 primary schools that were public, rural, multigrade, had administrative data on inputs for at least one year between 2005 and 2007, and were in the poorest districts within each region. Cristia et al. (2017) further restricted their original research sample to schools with administrative data on inputs for the years 2005 to 2007 and that participated in the 2007 second-grade national examination (N=741). After this, they excluded 79 one-teacher schools. Finally, due to budget constraints, they focused on schools in the eight largest regions (in terms of schools from the original sample) that had achieved at least 80 percent of coverage in the treatment group by August 2009. This delivers their final sample of 320 schools. Nonetheless, the coverage restriction was ultimately not binding as, by the end of 2009, more than 93 percent of all treated schools had been covered with almost a one-to-one ratio of OLPC XO laptops per student. Consequently, full program take-up occurred in parallel for all treated schools (both within and beyond the sample of Cristia et al. (2017)) in a way that full saturation was achieved by the end of year 2009. As shown in the figure, for the current study, we exclude the following schools from the originally randomized sample: all 105 one-teacher schools and the 320 schools studied in Cristia et al. (2017). This delivers the sample of 531 schools analyzed in the current study.

Table A.1: Effects on School-Level XO Computers and Internet by Year

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2009-2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Has XO	0.924***	0.840***	0.008	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	0.159***
	(0.017)	(0.023)	(0.010)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)
Control mean	0.009	0.111	0.987	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.828
Observations	531	531	531	531	531	531	531	531	531	531	531	5,841
XO per student	0.908***	0.893***	0.703***	0.646***	0.611***	0.559***	0.506***	0.460***	0.426***	0.354***	0.345***	0.583***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)	(0.021)	(0.022)	(0.023)	(0.024)	(0.026)	(0.026)	(0.016)
Control mean	0.009	0.023	0.220	0.275	0.294	0.333	0.339	0.337	0.363	0.391	0.398	0.271
Observations	531	531	531	528	531	529	529	526	527	526	527	5,816
Has internet	0.008	-0.005	0.044*	0.010	0.049**	0.030	0.015	0.054	0.010	0.027	0.019	0.024
	(0.005)	(0.014)	(0.025)	(0.032)	(0.022)	(0.030)	(0.029)	(0.039)	(0.035)	(0.033)	(0.035)	(0.015)
Control mean	0.000	0.027	0.058	0.124	0.036	0.113	0.121	0.219	0.141	0.138	0.183	0.105
Observations	502	488	508	516	503	520	518	469	434	526	513	5,497

Notes: For each outcome, this table presents (a) the estimated coefficient and standard error on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group mean, and (c) the number of school-level observations. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. ***p<0.01, **p<0.05, *p<0.1

Table A.2: Balance on Trends in Baseline Academic Performance

	Second grade mathematics	Second grade reading
	(1)	(2)
Treated	-0.042	-0.057
	(0.090)	(0.087)
Post 2007	0.041	0.037
	(0.098)	(0.090)
Treated · Post 2007	-0.043	0.062
	(0.122)	(0.115)
Observations	774	780

Notes: The table shows estimated effects from school-year-level regressions where individual-level performance was first standardized with zero mean and unit variance for the control group and then aggregated at the school level mean. Results correspond to a difference-in-difference estimation for years 2007-2008 between treated and control schools. We show the estimated coefficients and standard errors on the treatment indicator (Treated), an indicator for year 2008 (Post 2007) and the interaction of both from OLS regressions that control for randomization strata fixed effects and are weighted by the number of students who took the examination in each school-year. The number of school-year observations are shown below the estimates. Estimated standard errors are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Table A.3: Effects on School-Level Desktops, Other Laptops, and Computer Lab by Year

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2009-2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Has desktop	0.049	0.026	0.003	-0.001	0.004	-0.036	0.010	0.023	0.003	-0.017	0.015	0.007
	(0.044)	(0.043)	(0.044)	(0.044)	(0.042)	(0.041)	(0.043)	(0.041)	(0.041)	(0.041)	(0.040)	(0.023)
Control mean	0.446	0.612	0.625	0.637	0.599	0.639	0.563	0.710	0.750	0.677	0.700	0.631
Observations	502	488	508	516	503	520	518	469	434	526	513	5,497
Desktops per student	0.002	0.019**	0.020	0.010	0.001	-0.015	0.004	-0.002	-0.038	-0.007	-0.028	-0.003
	(0.003)	(0.009)	(0.016)	(0.013)	(0.010)	(0.017)	(0.023)	(0.020)	(0.037)	(0.028)	(0.026)	(0.012)
Control mean	0.022	0.037	0.054	0.058	0.062	0.096	0.091	0.125	0.181	0.159	0.193	0.097
Observations	502	488	508	515	503	520	518	469	434	525	513	5,495
Has other laptops			-0.005	-0.027	-0.034*	-0.006	-0.008	-0.024	-0.017	-0.029	-0.036	-0.021
			(0.016)	(0.022)	(0.020)	(0.023)	(0.033)	(0.035)	(0.036)	(0.030)	(0.033)	(0.014)
Control mean			0.027	0.066	0.059	0.074	0.290	0.324	0.354	0.427	0.448	0.228
Observations			508	516	503	520	518	469	434	526	513	4,507
Other laptops per student			0.001	0.000	0.000	0.001	-0.009	-0.009	0.001	0.001	0.002	-0.001
			(0.006)	(0.006)	(0.004)	(0.002)	(0.009)	(0.007)	(0.007)	(0.008)	(0.010)	(0.003)
Control mean			0.005	0.006	0.003	0.002	0.033	0.040	0.037	0.052	0.058	0.026
Observations			508	515	503	520	518	469	434	525	513	4,505
Has Computer lab					0.026	0.034	0.021	-0.044	0.016	-0.016	-0.017	-0.003
					(0.030)	(0.035)	(0.035)	(0.032)	(0.035)	(0.027)	(0.029)	(0.016)
Control mean					0.128	0.170	0.170	0.162	0.183	0.102	0.128	0.143
Observations					531	531	531	531	531	531	531	5,841
Total computers per student	0.909***	0.911***	0.723***	0.656***	0.613***	0.545***	0.500***	0.447***	0.406***	0.348***	0.317***	0.580***
	(0.018)	(0.020)	(0.025)	(0.023)	(0.022)	(0.028)	(0.035)	(0.035)	(0.042)	(0.044)	(0.043)	(0.022)
Control mean	0.029	0.058	0.276	0.337	0.355	0.429	0.461	0.485	0.541	0.601	0.645	0.383
Observations	531	531	531	528	531	529	529	526	527	526	527	5,816

Notes: For each outcome, this table presents (a) the estimated coefficient and standard error on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group mean, and (c) the number of school-level observations. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Blank cells denote missing information for the measured characteristic. Total computers per student considers XO laptops, desktops, and other non-XO laptops. ***p<0.01, **p<0.05, *p<0.1

Table A.4: Effects on Other School Characteristics by Year

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2009-2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Electricity	-0.027	0.035	-0.001	0.012	-0.016	0.004	0.002	-0.001	-0.007		0.005	0.001
	(0.027)	(0.024)	(0.022)	(0.019)	(0.020)	(0.015)	(0.017)	(0.014)	(0.019)		(0.016)	(0.011)
Control mean	0.878	0.909	0.929	0.942	0.955	0.965	0.961	0.970	0.957		0.965	0.949
Observations	496	488	508	516	503	520	518	522	526		513	5,620
Piped water	-0.082*	-0.013	-0.050	0.033	-0.051	-0.007	-0.038	-0.044	-0.055	-0.001	-0.051	-0.033
	(0.045)	(0.044)	(0.043)	(0.043)	(0.042)	(0.042)	(0.040)	(0.039)	(0.042)	(0.044)	(0.044)	(0.028)
Control mean	0.549	0.612	0.589	0.571	0.604	0.583	0.667	0.704	0.654	0.517	0.396	0.586
Observations	502	488	508	516	503	520	518	522	526	526	513	5,642
Science lab	0.001	0.008	-0.003	0.003	0.005	-0.002	0.009	0.004	0.008	0.016	0.029	0.007
	(0.011)	(0.014)	(0.014)	(0.011)	(0.006)	(0.012)	(0.014)	(0.016)	(0.014)	(0.014)	(0.018)	(0.009)
Control mean	0.009	0.018	0.022	0.013	0.005	0.017	0.017	0.026	0.021	0.017	0.022	0.017
Observations	497	488	508	516	503	520	518	522	526	526	513	5,637
Library	0.091**	-0.038	0.088**	0.047	0.073*	0.061	0.008	0.017	-0.006	-0.004	-0.017	0.029
	(0.038)	(0.044)	(0.043)	(0.032)	(0.041)	(0.042)	(0.042)	(0.033)	(0.037)	(0.039)	(0.041)	(0.023)
Control mean	0.180	0.320	0.268	0.115	0.257	0.296	0.325	0.142	0.209	0.263	0.274	0.241
Observations	497	488	508	516	503	520	518	522	526	526	513	5,637
Students per teacher	0.009	-0.014	0.067	-1.042*	0.014	-0.428	0.230	0.438	0.296	-0.058	0.200	-0.028
	(0.479)	(0.474)	(0.461)	(0.613)	(0.431)	(0.415)	(0.422)	(0.355)	(0.615)	(0.334)	(0.329)	(0.300)
Control mean	19.849	18.757	15.954	15.755	13.676	13.174	12.293	11.164	14.016	10.531	10.121	14.123
Observations	531	531	531	528	531	529	529	526	501	526	526	5,789
Fraction of transferred students	0.001	-0.007	-0.009	0.002	0.001	0.003	0.000	-0.000	-0.006	-0.004	-0.004	-0.002
	(0.005)	(0.005)	(0.014)	(0.004)	(0.005)	(0.006)	(0.008)	(0.005)	(0.005)	(0.006)	(0.010)	(0.003)
Control mean	0.022	0.029	0.056	0.024	0.021	0.022	0.032	0.031	0.039	0.041	0.053	0.034
Observations	531	531	531	528	531	529	529	526	527	526	527	5,816
School enrollment	0.813	-0.125	-1.194	0.002	0.053	-0.183	-0.029	0.306	0.492	0.511	1.438	0.188
	(1.988)	(2.043)	(2.107)	(2.126)	(2.165)	(2.207)	(2.341)	(2.285)	(2.452)	(2.489)	(2.514)	(2.083)
Control mean	61.336	59.621	53.749	48.180	45.179	41.549	39.417	37.730	35.769	34.442	33.419	44.599
Observations	531	531	531	528	531	529	529	526	527	526	527	5,816

Notes: For each outcome, this table presents (a) the estimated coefficient and standard error on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group mean, and (c) the number of school-level observations. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Blank cells denote missing information for the measured characteristic. ***p<0.01, **p<0.05, *p<0.1

Table A.5: Effects on Technology Access, Academic Achievement, and IT Support

	Control Mean	Effect	N	Respondent
	(1)	(2)	(3)	(4)
Panel A: Technology access				
Computers				
Student has own XO laptop in school	0.291	0.448***	2,129	student
		(0.046)		
Teacher has own XO laptop in school	0.133	0.321***	167	teacher
		(0.069)		
Student takes the XO laptop home	0.019	0.194***	2,142	student
		(0.036)		
Student has non-XO laptop or computer at home	0.100	0.018	2,137	student
		(0.017)		
Internet				
School has internet	0.057	0.057	140	principal
		(0.047)		
Student has internet at home	0.026	-0.002	2,127	student
		(0.007)		
Panel B: Students' academic performance				
Mathematics	0.000	0.061	2,123	student
		(0.095)		
Reading	0.000	0.040	2,144	student
		(0.086)		
Panel C: IT support for teachers				
Received visit from IT specialist	0.096	0.102*	168	teacher
		(0.054)		
Training in computer or laptop utilization	0.060	-0.007	168	teacher
		(0.035)		
Advise on use (after being trained)	0.048	-0.021	168	teacher
		(0.029)		
IT support (repair or maintenance)	0.036	0.085**	168	teacher
		(0.040)		

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects. Column 3 displays the number of observations in each regression. Column 4 displays the respondent for each outcome analyzed. Data corresponds to the survey implemented by the team in the year 2013. Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Table A.6: Effects on Alternative Definitions of School-Level Grade Progression by Year

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Denominator is enrollment at the beginning of the academic year (ratio is capped at 1)									
Effect	-0.009	-0.020*	-0.021**	-0.003	-0.007	0.000	-0.014*	-0.003	-0.010**
	(0.011)	(0.012)	(0.010)	(0.009)	(0.010)	(0.009)	(0.008)	(0.009)	(0.005)
Control mean	0.859	0.825	0.857	0.853	0.865	0.893	0.920	0.912	0.869
Observations	530	531	531	528	531	529	529	525	4,234
Panel B: Denominator is enrollment at the beginning of the academic year (ratio is not capped)									
Effect	-0.021	-0.022*	-0.021**	-0.009	-0.006	0.003	-0.013	-0.006	-0.013**
	(0.018)	(0.012)	(0.010)	(0.011)	(0.011)	(0.010)	(0.009)	(0.010)	(0.006)
Control mean	0.889	0.828	0.857	0.865	0.866	0.898	0.927	0.918	0.877
Observations	530	531	531	528	531	529	529	525	4,234
Panel C: Denominator is enrollment at the beginning of the academic year (missing if ratio >1)									
Effect	0.001	-0.018	-0.023**	-0.000	-0.008	0.002	-0.010	-0.002	-0.008
	(0.011)	(0.012)	(0.010)	(0.009)	(0.010)	(0.009)	(0.008)	(0.008)	(0.005)
Control mean	0.832	0.820	0.856	0.848	0.862	0.884	0.913	0.904	0.860
Observations	465	520	519	504	514	484	485	488	3,979
Panel D: Denominator is students in the end-of-year report (Promoted + Failed + Dropped Out + Transferred)									
Effect	0.006	-0.026**	-0.019*	-0.006	-0.007	0.000	-0.012	-0.001	-0.008
	(0.011)	(0.011)	(0.010)	(0.008)	(0.010)	(0.009)	(0.008)	(0.009)	(0.005)
Control mean	0.851	0.820	0.862	0.853	0.863	0.880	0.906	0.897	0.862
Observations	530	531	531	528	531	529	529	525	4,234
Panel E: Denominator is the maximum between enrollment and end-of-year report									
Effect	0.002	-0.020*	-0.021**	-0.001	-0.009	-0.001	-0.011	-0.004	-0.008
	(0.012)	(0.012)	(0.010)	(0.009)	(0.010)	(0.009)	(0.008)	(0.009)	(0.005)
Control mean	0.827	0.807	0.848	0.836	0.850	0.876	0.903	0.894	0.850
Observations	530	531	531	528	531	529	529	525	4,234

Notes: This table shows estimated effects on grade progression using alternative definitions. In all panels, the numerator of the grade progression ratio is the number of students promoted to the next grade at the end of the academic year who attended second to sixth grades. The different panels present alternative denominators and censoring approaches. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group means, and (c) the number of observations. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school. Estimates are weighted by school (second - sixth grade) enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table A.7: Effects on School-Level Grade Progression by Grade and Year

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Second grade									
Effect	0.011	-0.013	-0.017	0.010	-0.013	0.009	0.001	0.022	0.000
	(0.016)	(0.017)	(0.015)	(0.017)	(0.018)	(0.016)	(0.016)	(0.016)	(0.007)
Control mean	0.795	0.751	0.805	0.778	0.808	0.842	0.877	0.854	0.807
Observations	526	531	529	517	520	516	512	501	4,152
Third grade									
Effect	-0.017	-0.043**	-0.034**	-0.012	-0.010	0.018	-0.025*	-0.020	-0.019***
	(0.015)	(0.018)	(0.017)	(0.016)	(0.017)	(0.017)	(0.014)	(0.015)	(0.007)
Control mean	0.827	0.795	0.810	0.818	0.830	0.848	0.902	0.890	0.834
Observations	530	528	529	524	522	510	513	502	4,158
Fourth grade									
Fourth grade									
Effect	-0.017	-0.029*	-0.032**	-0.014	-0.005	-0.010	-0.016	-0.015	-0.018***
	(0.015)	(0.017)	(0.015)	(0.014)	(0.018)	(0.014)	(0.013)	(0.011)	(0.006)
Control mean	0.871	0.839	0.877	0.871	0.869	0.900	0.914	0.926	0.879
Observations	530	531	528	521	524	521	513	509	4,177
Fifth grade									
Effect	-0.002	-0.008	-0.024	0.015	0.008	-0.008	-0.027*	-0.012	-0.007
	(0.017)	(0.018)	(0.015)	(0.017)	(0.017)	(0.015)	(0.014)	(0.015)	(0.008)
Control mean	0.849	0.828	0.863	0.848	0.852	0.899	0.924	0.913	0.868
Observations	526	529	526	517	520	516	516	504	4,154
Sixth grade									
Effect	-0.012	-0.012	0.006	0.007	-0.027**	0.006	0.004	0.001	-0.004
	(0.016)	(0.017)	(0.013)	(0.015)	(0.012)	(0.012)	(0.009)	(0.009)	(0.006)
Control mean	0.895	0.897	0.912	0.904	0.941	0.941	0.953	0.950	0.922
Observations	526	526	527	520	520	515	512	508	4,154
Second - sixth grade									
Effect	-0.009	-0.020*	-0.021**	-0.003	-0.007	0.000	-0.014*	-0.003	-0.010**
	(0.011)	(0.012)	(0.010)	(0.009)	(0.010)	(0.009)	(0.008)	(0.009)	(0.005)
Control mean	0.859	0.825	0.857	0.853	0.865	0.893	0.920	0.912	0.869
Observations	530	531	531	528	531	529	529	525	4,234

Notes: This table shows estimated effects on grade progression for each grade. In all panels, the numerator of the grade progression ratio is the number of students promoted to the next grade at the end of the academic year; while the denominator is the number of students enrolled in each grade at the beginning of the academic year. When the ratio exceeded unity, it was capped at 1. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group means, and (c) the number of observations. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school. Estimates are weighted by school enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table A.8: Effects on Individual-Level Academic Performance by Cohort

Cohort:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Second grade mathematics									
Effect	-0.053	-0.105	0.022	0.043	-0.079	-0.196*	0.079	-0.093	-0.044
	(0.093)	(0.092)	(0.086)	(0.079)	(0.087)	(0.107)	(0.109)	(0.103)	(0.045)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	3,314	3,221	3,161	3,308	2,872	2,427	2,368	2,190	22,861
Second grade reading									
Effect	-0.071	-0.123	0.015	-0.004	-0.050	-0.204*	0.029	-0.050	-0.056
	(0.088)	(0.076)	(0.083)	(0.075)	(0.086)	(0.115)	(0.101)	(0.108)	(0.045)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	3,312	3,228	3,176	3,307	2,876	2,428	2,370	2,191	22,888
Fourth grade mathematics									
Effect						-0.182		-0.040	-0.108
						(0.115)		(0.090)	(0.072)
Control mean						0.000		0.000	0.000
Observations						1,524		1,683	3,207
Fourth grade reading									
Effect						-0.218*		-0.056	-0.133*
						(0.116)		(0.084)	(0.073)
Control mean						0.000		0.000	0.000
Observations						1,525		1,682	3,207
Eighth grade mathematics									
Effect	0.066	-0.006		0.063	-0.019				0.026
	(0.093)	(0.071)		(0.059)	(0.067)				(0.045)
Control mean	0.000	0.000		0.000	0.000				0.000
Observations	1,281	1,352		1,769	1,622				6,024
Eighth grade reading									
Effect	-0.101	-0.042		0.102	-0.035				-0.010
	(0.080)	(0.075)		(0.064)	(0.067)				(0.050)
Control mean	0.000	0.000		0.000	0.000				0.000
Observations	1,281	1,353		1,768	1,623				6,025
Index of academic performance									
Effect	-0.043	-0.107	0.014	0.033	-0.062	-0.201**	0.058	-0.084	-0.046
	(0.086)	(0.079)	(0.088)	(0.072)	(0.080)	(0.101)	(0.109)	(0.091)	(0.045)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	3,316	3,229	3,176	3,311	2,876	2,428	2,370	2,192	22,898

Notes: This table shows estimated effects on primary education outcomes for each of the cohorts that were pooled in the estimations shown in Table 2. Cohorts (displayed in each column) indicate the year when students were enrolled in second grade. Mathematics and reading exams have been standardized with zero mean and unit variance for the control group. At the bottom we include an index of academic performance that averages the performance across all grades for which students took the national examination as detailed in the notes to Table 2. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school. ***p<0.01, **p<0.05, *p<0.1.

Table A.9: Effects on Individual-Level Educational Attainment by Cohort

Cohort:	2009	2010	2011	2012	2013	2014	2015	2009-2015
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Primary completion on time								
Effect	-0.005	-0.030*	-0.007	-0.042**	-0.020	-0.026	-0.011	-0.021*
	(0.018)	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)	(0.015)	(0.011)
Control mean	0.604	0.632	0.663	0.692	0.734	0.763	0.788	0.695
Observations	3,750	3,999	4,342	4,494	4,368	3,986	3,577	28,516
Primary completion with up to one year of delay								
Effect	-0.010	-0.033**	-0.014	-0.021	-0.015	-0.011		-0.017*
	(0.016)	(0.014)	(0.014)	(0.013)	(0.011)	(0.012)		(0.009)
Control mean	0.813	0.829	0.858	0.861	0.895	0.910		0.862
Observations	3,750	3,999	4,342	4,494	4,368	3,986		24,939
Primary completion overall								
Effect	-0.006	0.002	0.001	-0.007	-0.010			-0.004
	(0.006)	(0.008)	(0.008)	(0.009)	(0.009)			(0.005)
Control mean	0.969	0.954	0.953	0.951	0.943			0.954
Observations	3,750	3,999	4,342	4,494	4,368			20,953
Secondary completion on time								
Effect	-0.010	-0.034*						-0.022
	(0.019)	(0.018)						(0.015)
Control mean	0.496	0.539						0.518
Observations	3,750	3,999						7,749
Secondary completion with up to one year of delay								
Effect	-0.021							-0.021
	(0.019)							(0.019)
Control mean	0.655							0.655
Observations	3,750							3,750
Applied to university on time								
Effect	-0.022*							-0.022*
	(0.013)							(0.013)
Control mean	0.167							0.167
Observations	3,750							3,750
Enrolled to university on time								
Effect	-0.010							-0.010
	(0.008)							(0.008)
Control mean	0.060							0.060
Observations	3,750							3,750
Completed years of education								
Effect	-0.013	-0.068	-0.067	-0.132**	-0.056	-0.048	-0.028	-0.061
	(0.088)	(0.080)	(0.077)	(0.066)	(0.061)	(0.047)	(0.031)	(0.044)
Control mean	9.834	9.680	9.197	8.393	7.569	6.696	5.729	8.205
Observations	3,750	3,999	4,342	4,494	4,368	3,986	3,577	28,516

Notes: This table shows estimated effects on primary education outcomes for each of the cohorts that were pooled in the estimations shown in Table 2. Cohorts (displayed in each column) indicate the year when students were enrolled in second grade. At the bottom we include the number of satisfactorily completed years of primary and secondary education by 2019. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school. ***p<0.01, **p<0.05, *p<0.1.

Table A.10: Effects on Overage at Entry (First Grade)

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Fraction of overage students									
Effect	-0.001	0.020	0.025	0.017	0.007	0.017	-0.007	0.004	0.010
	(0.018)	(0.019)	(0.020)	(0.020)	(0.026)	(0.025)	(0.024)	(0.015)	(0.010)
Cont. Mean	0.174	0.156	0.139	0.135	0.194	0.233	0.107	0.050	0.149
Observations	530	529	522	513	513	511	498	500	4,116

Notes: This table shows estimated effects on overage enrollment in first grade by year. Overage is the fraction of first grade students enrolled at 7 years of age or more. The school census collected enrollment by age with a cutoff date of June 30th up to the year 2014. Starting in 2015, the census varied the cutoff date to March 31st. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school. ***p<0.01, **p<0.05, *p<0.1.

Table A.11: Effects for Schools over Time Controlling for Baseline Outcomes

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Second-grade mathematics performance									
Effect	-0.004	-0.067	0.011	0.002	-0.124	-0.206*	0.079	-0.140	-0.050
	(0.096)	(0.102)	(0.096)	(0.085)	(0.101)	(0.117)	(0.114)	(0.111)	(0.049)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	329	380	335	299	254	220	2,512
Panel B: Second-grade reading performance									
Effect	-0.030	-0.088	0.005	-0.039	-0.068	-0.225*	0.025	-0.101	-0.062
	(0.092)	(0.084)	(0.091)	(0.080)	(0.099)	(0.126)	(0.110)	(0.110)	(0.047)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	330	380	335	299	254	220	2,513
Panel C: Second-grade academic performance									
Effect	-0.024	-0.082	0.001	-0.016	-0.102	-0.229*	0.055	-0.131	-0.062
	(0.096)	(0.096)	(0.098)	(0.085)	(0.102)	(0.126)	(0.116)	(0.114)	(0.050)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	330	380	335	299	254	220	2,513
Panel D: Grade progression									
Effect	-0.006	-0.016	-0.019**	-0.002	-0.007	0.002	-0.013*	-0.002	-0.009*
	(0.011)	(0.011)	(0.010)	(0.009)	(0.010)	(0.009)	(0.008)	(0.008)	(0.005)
Control mean	0.859	0.825	0.857	0.853	0.865	0.893	0.920	0.912	0.869
Observations	530	531	531	528	531	529	529	525	4,234

Notes: Panels A and B show estimated effects from school-level regressions where individual-level performance was first standardized with zero mean and unit variance for the control group and then aggregated at the school level mean. Panel C shows estimated effects from school-level regressions where individual-level performance for both subjects was first standardized with zero mean and unit variance for the control group and then averaged, re-standardized, and aggregated at the school level mean (as detailed in the notes to Figure 2). Panel D shows estimated effects on grade progression (defined as the ratio of students promoted to the next grade with respect to those enrolled at the beginning of the school year in second to sixth grades - this ratio is capped at 1) using the yearly school census data. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for the baseline outcome (i.e., school-level mean for years 2007-2008) and randomization strata fixed effects, (b) the control group means, and (c) the number of school-level observations. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school level. Estimates displayed in panels A, B and C are weighted by the number of students who took the examinations. Estimates in panel D are weighted by school (second - sixth grade) enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table A.12: Effects for Schools over Time (Using Individual-Level Performance Data)

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Second-grade mathematics performance									
Effect	-0.053	-0.105	0.022	0.043	-0.079	-0.196*	0.079	-0.093	-0.044
	(0.093)	(0.092)	(0.086)	(0.079)	(0.087)	(0.107)	(0.109)	(0.103)	(0.045)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	3,314	3,221	3,161	3,308	2,872	2,427	2,368	2,190	22,861
Panel B: Second-grade reading performance									
Effect	-0.071	-0.123	0.015	-0.004	-0.050	-0.204*	0.029	-0.050	-0.056
	(0.088)	(0.076)	(0.083)	(0.075)	(0.086)	(0.115)	(0.101)	(0.108)	(0.045)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	3,312	3,228	3,176	3,307	2,876	2,428	2,370	2,191	22,888
Panel C: Second-grade academic performance									
Effect	-0.067	-0.120	0.014	0.022	-0.070	-0.212*	0.058	-0.078	-0.054
	(0.092)	(0.087)	(0.088)	(0.080)	(0.089)	(0.115)	(0.109)	(0.109)	(0.047)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	3,316	3,229	3,176	3,311	2,876	2,428	2,370	2,192	22,898
Panel D: Grade progression									
Effect	-0.009	-0.020*	-0.021**	-0.003	-0.007	0.000	-0.014*	-0.003	-0.010**
	(0.011)	(0.012)	(0.010)	(0.009)	(0.010)	(0.009)	(0.008)	(0.009)	(0.005)
Control mean	0.859	0.825	0.857	0.853	0.865	0.893	0.920	0.912	0.869
Observations	530	531	531	528	531	529	529	525	4,234

Notes: Panels A and B show estimated effects from individual-level regressions where individual-level performance was standardized with zero mean and unit variance for the control group. Panel C shows estimated effects from individual-level regressions where individual-level performance for both subjects was first standardized with zero mean and unit variance for the control group and then averaged and re-standardized (as detailed in the notes to Figure 2). Panel D shows estimated effects on grade progression (defined as the ratio of students promoted to the next grade with respect to those enrolled at the beginning of the school year in second to sixth grades - this ratio is capped at 1) using the yearly school census data. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group means, and (c) the number of individual-level observations (Panels A-C) and the number of school-level observations (Panel D). Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school level. Estimates in panel D are weighted by school (second - sixth grade) enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table A.13: Effects for Schools over Time without Strata Fixed Effects

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Second-grade mathematics performance									
Effect	-0.108	-0.119	0.002	-0.061	-0.127	-0.192*	-0.065	-0.213*	-0.104*
	(0.101)	(0.100)	(0.094)	(0.091)	(0.107)	(0.106)	(0.114)	(0.112)	(0.061)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	329	380	335	299	254	220	2,512
Panel B: Second-grade reading performance									
Effect	-0.096	-0.110	0.030	-0.070	-0.113	-0.207*	-0.062	-0.177	-0.095
	(0.099)	(0.093)	(0.098)	(0.089)	(0.110)	(0.108)	(0.111)	(0.121)	(0.066)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	330	380	335	299	254	220	2,513
Panel C: Second-grade academic performance									
Effect	-0.111	-0.124	0.011	-0.071	-0.129	-0.212*	-0.069	-0.210*	-0.108
	(0.104)	(0.099)	(0.100)	(0.093)	(0.113)	(0.110)	(0.117)	(0.120)	(0.067)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	330	380	335	299	254	220	2,513
Panel D: Grade progression									
Effect	-0.012	-0.022*	-0.021**	-0.003	-0.010	-0.006	-0.019**	-0.007	-0.013**
	(0.011)	(0.012)	(0.011)	(0.011)	(0.011)	(0.010)	(0.009)	(0.010)	(0.006)
Control mean	0.859	0.825	0.857	0.853	0.865	0.893	0.920	0.912	0.869
Observations	530	531	531	528	531	529	529	525	4,234

Notes: Panels A and B show estimated effects from school-level regressions where individual-level performance was first standardized with zero mean and unit variance for the control group and then aggregated at the school level mean. Panel C shows estimated effects from school-level regressions where individual-level performance for both subjects was first standardized with zero mean and unit variance for the control group and then averaged, re-standardized, and aggregated at the school level mean (as detailed in the notes to Figure 2). Panel D shows estimated effects on grade progression (defined as the ratio of students promoted to the next grade with respect to those enrolled at the beginning of the school year in second to sixth grades - this ratio is capped at 1) using the yearly school census data. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that do not control for randomization strata fixed effects, (b) the control group means, and (c) the number of school-level observations. Pooled regressions control for year fixed effects. Estimated standard errors are clustered at the primary school level. Estimates displayed in panels A, B and C are weighted by the number of students who took the examinations. Estimates in panel D are weighted by school (second - sixth grade) enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table A.14: Effects on Student Educational Trajectories without Strata Fixed Effects

	Control mean	Effect	Observations	Cohorts	*p*-values	*q*-values
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Academic performance						
Second grade mathematics performance	0.000	-0.104*	22,861	2009-2016	0.087	0.263
		(0.061)				
Second grade reading performance	0.000	-0.095	22,888	2009-2016	0.154	0.277
		(0.066)				
Fourth grade mathematics performance	0.000	-0.094	3,207	2014, 2016	0.333	0.287
		(0.097)				
Fourth grade reading performance	0.000	-0.083	3,207	2014, 2016	0.393	0.287
		(0.098)				
Eighth grade mathematics performance	0.000	0.026	6,024	2009-2010, 2012-2013	0.670	0.388
		(0.060)				
Eighth grade reading performance	0.000	0.007	6,025	2009-2010, 2012-2013	0.925	0.492
		(0.070)				
Index of academic performance	0.000	-0.095	22,898	2009-2016	0.160	
		(0.067)				
Panel B: Educational attainment						
Primary completion on time	0.695	-0.031**	28,516	2009-2015	0.037	0.263
		(0.015)				
Primary completion with up to one year of delay	0.862	-0.027**	24,939	2009-2014	0.016	0.263
		(0.011)				
Primary completion overall	0.962	-0.011	20,953	2009-2013	0.111	0.263
		(0.007)				
Secondary completion on time	0.518	-0.036*	7,749	2009-2010	0.072	0.263
		(0.020)				
Secondary completion with up to one year of delay	0.655	-0.028	3,750	2009	0.228	0.287
		(0.023)				
Applied to university on time	0.167	-0.029**	3,750	2009	0.050	0.263
		(0.015)				
Enrolled to university on time	0.060	-0.013	3,750	2009	0.120	0.263
		(0.008)				
Completed years of education	8.205	-0.120**	28,516	2009-2015	0.040	
		(0.058)				

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for cohort fixed effects but do not control for randomization strata fixed effects. Column 3 displays the number of individual-level observations in each pooled regression. Column 4 displays the cohorts included in each pooled regression where cohorts are labeled with the year in which students were enrolled in second-grade. Column 5 shows *p*-values and column 6 shows the adjusted *q*-values (where outcomes from both panels are all considered in one group). Mathematics and reading performance have been standardized at the individual level with zero mean and unit variance for the control group. At the bottom of panel A, we include an index of academic performance that averages the performance across all grades for which students took the national examination as detailed in the notes to Table 2. At the bottom of panel B, we include the number of satisfactorily completed years of primary and secondary education by 2019. Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Table A.15: Effects for Schools over Time - IV

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Second-grade mathematics performance									
Effect	-0.059	-0.124	0.032	0.051	-0.127	-0.338*	0.154	-0.230	-0.068
	(0.111)	(0.118)	(0.131)	(0.131)	(0.151)	(0.200)	(0.231)	(0.281)	(0.072)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	329	380	335	299	254	220	2,512
Panel B: Second-grade reading performance									
Effect	-0.078	-0.146	0.021	-0.020	-0.080	-0.352	0.057	-0.125	-0.084
	(0.105)	(0.098)	(0.126)	(0.124)	(0.150)	(0.215)	(0.213)	(0.292)	(0.071)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	330	380	335	299	254	220	2,513
Panel C: Second-grade academic performance									
Effect	-0.074	-0.143	0.019	0.017	-0.112	-0.366*	0.113	-0.192	-0.082
	(0.110)	(0.111)	(0.134)	(0.133)	(0.155)	(0.216)	(0.231)	(0.296)	(0.075)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	330	380	335	299	254	220	2,513
Panel D: Grade progression									
Effect	-0.010	-0.023*	-0.029**	-0.004	-0.012	0.001	-0.027*	-0.006	-0.015**
	(0.012)	(0.013)	(0.014)	(0.014)	(0.016)	(0.015)	(0.015)	(0.019)	(0.007)
Control mean	0.859	0.825	0.857	0.853	0.865	0.893	0.920	0.912	0.869
Observations	530	531	531	528	531	529	529	525	4,234

Notes: Panels A and B show estimated effects from school-level regressions where individual-level performance was first standardized with zero mean and unit variance for the control group and then aggregated at the school level mean. Panel C shows estimated effects from school-level regressions where individual-level performance for both subjects was first standardized with zero mean and unit variance for the control group and then averaged, re-standardized, and aggregated at the school level mean (as detailed in the notes to Figure 2). Panel D shows estimated effects on grade progression (defined as the ratio of students promoted to the next grade with respect to those enrolled at the beginning of the school year in second to sixth grades - this ratio is capped at 1) using the yearly school census data. Each panel shows (a) the estimated coefficients and standard errors on the ratio of XO laptops per student from IV regression models that instrument this ratio with the treatment indicator, (b) the control group means, and (c) the number of school-level observations. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school level. Estimates displayed in panels A, B and C are weighted by the number of students who took the examinations. Estimates in panel D are weighted by school (second - sixth grade) enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table A.16: Effects on Student Educational Trajectories - IV

	Control mean	Effect	Observations	Cohorts	*p*-values	*q*-values
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Academic performance						
Second grade mathematics	0.000	-0.069	22,861	2009-2016	0.327	0.427
		(0.071)				
Second grade reading	0.000	-0.087	22,888	2009-2016	0.214	0.427
		(0.070)				
Fourth grade mathematics	0.000	-0.221	3,207	2014, 2016	0.135	0.427
		(0.147)				
Fourth grade reading	0.000	-0.273*	3,207	2014, 2016	0.070	0.427
		(0.150)				
Eighth grade mathematics	0.000	0.042	6,024	2009-2010, 2012-2013	0.569	0.490
		(0.074)				
Eighth grade reading	0.000	-0.017	6,025	2009-2010, 2012-2013	0.837	0.534
		(0.082)				
Index of academic performance	0.000	-0.074	22,898	2009-2016	0.313	
		(0.073)				
Panel B: Educational attainment						
Primary completion on time	0.695	-0.035*	28,516	2009-2015	0.057	0.427
		(0.018)				
Primary completion with up to one year of delay	0.862	-0.029*	24,939	2009-2014	0.053	0.427
		(0.015)				
Primary completion overall	0.954	-0.007	20,953	2009-2013	0.433	0.490
		(0.008)				
Secondary completion on time	0.518	-0.032	7,749	2009-2010	0.152	0.427
		(0.023)				
Secondary completion with up to one year of delay	0.655	-0.033	3,750	2009	0.269	0.427
		(0.030)				
Applied to university on time	0.167	-0.035*	3,750	2009	0.092	0.427
		(0.021)				
Enrolled to university on time	0.060	-0.016	3,750	2009	0.177	0.427
		(0.012)				
Completed years of education	8.205	-0.104	28,516	2009-2015	0.164	
		(0.075)				

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the ratio of XO laptops per student from IV regression models that instrument this ratio with the treatment indicator. Regressions control for randomization strata by cohort fixed effects. For second and fourth grade performance, the average of XO per student of the first 2 and 4 years, respectively, was used. For the index of academic performance, we used the average XO per student of all grades up to the highest grade used in the index for that student. For all other estimates, the average of XO per student during the 6 years of primary school was used. Column 3 displays the number of individual-level observations in each pooled regression. Column 4 displays the cohorts included in each pooled regression where cohorts are labeled with the year in which students were enrolled in second-grade. Column 5 shows *p*-values. Column 6 shows the adjusted *q*-values (where all outcomes analyzed are considered as one group). Mathematics and reading performance have been standardized at the individual level with zero mean and unit variance for the control group. The bottom of panel A considers an index of academic performance that averages the performance of all national examinations taken by each student as detailed in the notes to Table 2. At the bottom of panel B, we include the number of satisfactorily completed years of primary and secondary education by 2019. Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Appendix B: Attrition Analysis

Effects for schools over time: academic performance

Our investigation of effects on academic performance for schools over time relies on the second-grade national examination. This examination is applied to all schools with at least five students enrolled in second grade. Because of this, not every school in our sample was covered across all years. Therefore, it becomes imperative to show that school-level attrition across years is not driving our results.

In Table B.1 we show our main results of the effects for schools over time. Panels A-C show that out of the 531 schools in the sample, the year with the highest coverage was 2012 (with 380 schools covered) and the year with the lowest coverage was 2016 (with 220 schools covered). Accordingly, we test for whether the treatment was correlated with the likelihood of being included in the second-grade national examination in each year. Panel A of Table B.2 shows that the OLPC treatment was uncorrelated with this likelihood.

Conditional on being included in the examination, the average number of test takers per school varied between 8 and 10. At the intensive margin, Panel B of Table B.2 shows that the OLPC treatment did not affect the number of test takers.

To rule out potential compositional changes over time across the included schools, we perform baseline balance tests for some key characteristics reported in Table 1 considering only the set of schools covered in the examination within each year. Results in Table B.3 show stable baseline balance between the treated and control schools that were included in the examination each year. In addition to the stable balance, the baseline control group means of the included schools in each year are largely stable. This shows that not only balance was stable, but also the overall baseline composition of the sample of schools observed over time.

It is also worth noting that, up to year 2013, the coverage rate of our experimental schools oscillated around 60-70 percent. However, starting in 2014, coverage rates started to decrease significantly (Panel A of Table B.2). Given this, we test for whether the effects on academic performance are robust to the exclusion of years 2014 onward in which the coverage was significantly lower. Table B.4 shows that the effects on academic performance remain qualitatively unchanged after excluding either years 2014-2016 or 2015-2016.

The evidence presented suggests that attrition of schools with respect to the second grade national examinations is unlikely to be driving our estimates of the effects on academic performance for schools over time.

Effects for schools over time: grade progression

Panel D of Table B.1 displays our main results on grade progression. For this outcome, we rely on the annual school census that aims to cover the entire population of schools nationwide. Therefore, for this outcome we do not face attrition concerns. Indeed, the year with the lowest coverage was 2016 in which 525 out of the 531 focus schools were covered.

Effects on student educational trajectories: academic performance

To study individual-level academic performance over time, we rely on national examinations implemented in second, fourth and eight grades. Fourth-grade examinations were implemented in years 2016 and 2018. The Ministry of Education matched these examinations, at the individual level, with the second-grade examinations that corresponded to regular grade progression. That is, those who took the fourth-grade examination in year *t* were matched to the second-grade examination database of year *t-2*. Therefore, these correspond to cohorts that took the second-grade examination in years 2014 and 2016, respectively.

Eighth-grade examinations were implemented in years 2015, 2016, 2018, and 2019. The Ministry of Education matched these examinations, at the individual level, with the second-grade examinations that corresponded to regular grade progression. That is, those who took the eighth-grade examination in year *t* were matched to the second-grade examination database of year *t-6*. Therefore, these correspond to cohorts that took the second-grade examination in years 2009, 2010, 2012, and 2013, respectively.

Consequently, the estimated effects that we present on fourth and eight grade academic performance are conditional on regular school progression. Table B.5 shows the matching rates across examinations by second-grade cohorts. Overall, 69 percent of students who took the second-grade examination were matched to the fourth-grade examination. This matching rate closely mimics the proportion of students who completed primary school on time (equivalent to 69.5 percent as reported in Panel B of Table 2)

Table B.5 also shows that, overall, 48.4 percent of students who took the second-grade examination were matched to the eighth-grade examination. This matching rate closely mimics the proportion of students who completed secondary school on time (equivalent to 51.8 percent as reported in Panel B of Table 2). Therefore, the matching rates across examinations reflect the population-wide on-time school progression rates within the focus schools and are unlikely to be an artifact of the matching procedures applied by the Ministry of Education.

We then proceed to test if the treatment triggered differential attrition rates across examinations

over time. Table B.5 shows that the intervention was orthogonal to the likelihood of attrition across national examinations.

Finally, we examine if the responsiveness to the treatment is likely similar between those who were matched across examinations and those who were not. Table B.6 shows estimated effects on second-grade academic performance separately for those who were matched with future examinations and those who were not. The estimates show that the effects on second-grade performance are equivalent between matched and unmatched individuals.

The evidence presented suggests that individual-level attrition across national examinations over time is unlikely to be driving our estimated effects on academic performance for students.

Effects on student educational trajectories: educational attainment

The estimated effects on educational attainment reported in Panel B of Table 2 rely on population-wide administrative data compiled in the SIAGIE system. As detailed in Section III.1 of the paper, we observe every student's attended school, grade, passing status, and, when applicable, the student's application and enrollment status in tertiary education institutions. As such, for this set of outcomes, we do not face attrition concerns. Nonetheless, given the time-frame of our evaluation, we are unable to observe the full spectrum of outcomes for all cohorts as many are still too young. For this reason, longer-term outcomes such as applications and enrollment to university are only observed for the 2009 cohort and, consequently, sample sizes are smaller.

Table B.1: Effects for Schools over Time

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2009-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Second-grade mathematics performance									
Effect	-0.053	-0.105	0.022	0.043	-0.079	-0.196*	0.079	-0.093	-0.044
	(0.100)	(0.099)	(0.092)	(0.084)	(0.093)	(0.115)	(0.119)	(0.112)	(0.049)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	329	380	335	299	254	220	2,512
Panel B: Second-grade reading performance									
Effect	-0.071	-0.123	0.015	-0.004	-0.050	-0.204	0.029	-0.050	-0.056
	(0.094)	(0.082)	(0.089)	(0.080)	(0.093)	(0.124)	(0.110)	(0.118)	(0.048)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	330	380	335	299	254	220	2,513
Panel C: Second-grade academic performance									
Effect	-0.067	-0.120	0.014	0.022	-0.070	-0.212*	0.058	-0.078	-0.054
	(0.099)	(0.093)	(0.094)	(0.085)	(0.095)	(0.124)	(0.119)	(0.119)	(0.051)
Control mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	360	335	330	380	335	299	254	220	2,513
Panel D: Grade progression									
Effect	-0.009	-0.020*	-0.021**	-0.003	-0.007	0.000	-0.014*	-0.003	-0.010**
	(0.011)	(0.012)	(0.010)	(0.009)	(0.010)	(0.009)	(0.008)	(0.009)	(0.005)
Control mean	0.859	0.825	0.857	0.853	0.865	0.893	0.920	0.912	0.869
Observations	530	531	531	528	531	529	529	525	4,234

Notes: Panels A and B show estimated effects from school-level regressions where individual-level performance was first standardized with zero mean and unit variance for the control group and then aggregated at the school level mean. Panel C shows estimated effects from school-level regressions where individual-level performance for both subjects was first standardized with zero mean and unit variance for the control group and then averaged, re-standardized, and aggregated at the school level mean (as detailed in the notes to Figure 2). Panel D shows estimated effects on grade progression (defined as the ratio of students promoted to the next grade with respect to those enrolled at the beginning of the school year in second to sixth grades - this ratio is capped at 1) using the yearly school census data. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group means, and (c) the number of school-level observations. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school level. Estimates displayed in panels A, B and C are weighted by the number of students who took the examinations. Estimates in panel D are weighted by school (second - sixth grade) enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table B.2: School-Level Coverage in the Second-Grade National Examination

Year:	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: School included in the second-grade national examination										
Adjusted difference	0.029	0.017	0.053	0.027	0.013	0.000	-0.045	0.016	0.032	0.008
	(0.031)	(0.035)	(0.038)	(0.040)	(0.042)	(0.038)	(0.038)	(0.040)	(0.041)	(0.036)
Control mean	0.677	0.711	0.613	0.587	0.604	0.706	0.647	0.545	0.455	0.387
Observations	531	531	531	531	531	531	531	531	531	531
Panel B: Number of test takers (conditional on being included in the second-grade national examination)										
Adjusted difference	-0.049	0.225	-0.535	-0.125	-0.484	-0.151	0.473	-0.152	-0.553	0.302
	(0.493)	(0.410)	(0.532)	(0.577)	(0.584)	(0.520)	(0.599)	(0.633)	(0.791)	(1.015)
Control mean	10.057	9.174	9.611	9.761	9.641	8.669	8.184	8.172	9.355	9.901
Observations	385	397	360	335	330	380	335	299	254	220

Notes: This table shows estimated effects on whether the school was covered in the second grade national examinations and on the number of test takers (among schools included in the examinations). Years (displayed in each column) indicate the year of the second grade national examination. Each panel presents (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group mean, and (c) the number of school-level observations. ***p<0.01, **p<0.05, *p<0.1.

Table B.3: Baseline Balance Among Schools Covered in the Second-Grade National Examination by Year

Year:	2009	2010	2011	2012	2013	2014	2015	2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Computers per student								
Adjusted difference	0.006*	0.007*	0.003	0.004	0.006*	0.001	0.006	0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)
Control mean	0.013	0.012	0.014	0.013	0.012	0.013	0.012	0.013
Observations	360	335	330	380	335	299	254	220
Electricity								
Adjusted difference	0.042	0.028	0.030	0.033	0.027	0.015	0.006	0.000
	(0.032)	(0.035)	(0.033)	(0.032)	(0.034)	(0.036)	(0.038)	(0.043)
Control mean	0.816	0.801	0.827	0.816	0.822	0.820	0.827	0.819
Observations	360	335	330	380	335	299	254	220
Piped water								
Adjusted difference	0.001	0.007	0.003	0.003	0.025	-0.010	-0.051	-0.073
	(0.044)	(0.045)	(0.046)	(0.041)	(0.044)	(0.045)	(0.053)	(0.059)
Control mean	0.490	0.500	0.468	0.467	0.480	0.512	0.519	0.522
Observations	360	335	330	380	335	299	254	220
Enrollment (first - sixth grade)								
Adjusted difference	-0.558	1.772	2.282	1.990	1.840	1.834	1.295	0.676
	(2.491)	(2.586)	(2.589)	(2.305)	(2.561)	(2.840)	(3.311)	(3.978)
Control mean	68.705	70.188	70.461	68.726	71.908	74.766	78.603	81.582
Observations	360	335	330	380	335	299	254	220
Second-grade mathematics performance								
Adjusted difference	-0.032	-0.102	-0.069	-0.036	-0.034	0.011	-0.086	0.021
	(0.079)	(0.088)	(0.087)	(0.080)	(0.091)	(0.098)	(0.112)	(0.115)
Control mean	-0.049	0.059	0.057	0.045	0.023	0.003	0.059	-0.006
Observations	345	315	308	348	305	277	235	207
Second-grade reading performance								
Adjusted difference	-0.005	-0.040	-0.036	0.010	0.016	-0.025	-0.047	0.079
	(0.082)	(0.089)	(0.088)	(0.081)	(0.090)	(0.100)	(0.109)	(0.112)
Control mean	-0.028	0.054	0.050	0.041	0.045	0.016	0.059	-0.017
Observations	346	316	308	349	306	278	236	208
Grade progression (second - sixth grade)								
Adjusted difference	-0.021*	-0.009	-0.009	-0.010	-0.007	-0.009	-0.002	0.001
	(0.011)	(0.012)	(0.012)	(0.010)	(0.011)	(0.012)	(0.014)	(0.014)
Control mean	0.836	0.836	0.833	0.838	0.831	0.836	0.831	0.837
Observations	360	335	330	380	335	299	254	220

Notes: This table presents baseline statistics and estimated differences between treatment and control schools for the set of schools covered in the second grade national examinations every year. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata fixed effects, (b) the control group means, and (c) the number of observations. Results for second-grade mathematics and reading performance are estimated with school-level regressions where individual-level performance on the 2007 and 2008 evaluations were first standardized with zero mean and unit variance for the control group for each year and then aggregated at the school-year level mean. Then the school-level average between 2007 and 2008 was computed. The other outcomes present school-level regressions using the average between the 2007 and 2008 school censuses for continuous variables and the maximum between the 2007 and 2008 school censuses for dichotomous variables. Estimates for second-grade mathematics and reading are weighted by the number of students who took the examination. Estimates for school grade progression are weighted by school (second - sixth grade) enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table B.4: Effects on Academic Performance for Schools over Time - Alternative Pooling Periods

	Pooled school-year-level		
	2009-2013	2009-2014	2009-2016
	(1)	(2)	(3)
Panel A: Second-grade mathematics performance			
Effect	-0.033	-0.054	-0.044
	(0.051)	(0.051)	(0.049)
Control mean	0.000	0.000	0.000
Observations	1,739	2,038	2,512
Panel B: Second-grade reading performance			
Effect	-0.047	-0.066	-0.056
	(0.049)	(0.050)	(0.048)
Control mean	0.000	0.000	0.000
Observations	1,740	2,039	2,513
Panel C: Second-grade academic performance			
Effect	-0.044	-0.065	-0.054
	(0.052)	(0.053)	(0.051)
Control mean	0.000	0.000	0.000
Observations	1,740	2,039	2,513

Notes: Panels A and B show estimated effects from school-level regressions where individual-level performance was first standardized with zero mean and unit variance for the control group and then aggregated at the school level mean. Panel C shows estimated effects from school-level regressions where individual-level performance for both subjects was first standardized with zero mean and unit variance for the control group and then averaged, re-standardized, and aggregated at the school level mean (as detailed in the notes to Figure 2). Panel D shows estimated effects on grade progression (defined as the ratio of students promoted to the next grade with respect to those enrolled at the beginning of the school year in second to sixth grades - this ratio is capped at 1) using the yearly school census data. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator from OLS regressions that control for randomization strata by year fixed effects, (b) the control group means, and (c) the number of school-year observations. Estimated standard errors are clustered at the primary school level. Estimates displayed in panels A and B are weighted by the number of students who took the examinations. Estimates in panel C are weighted by school (second - sixth grade) enrollment. ***p<0.01, **p<0.05, *p<0.1.

Table B.5: Attrition Across National Examinations by Cohort

Cohort:	2009	2010	2012	2013	2014	2016	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Matched with fourth-grade mathematics							
Adjusted difference					0.014	-0.022	-0.003
					(0.038)	(0.032)	(0.027)
Control mean					0.606	0.787	0.690
Observations					2,427	2,190	4,617
Matched with fourth-grade reading							
Adjusted difference					0.014	-0.020	-0.001
					(0.038)	(0.032)	(0.027)
Control mean					0.606	0.786	0.689
Observations					2,428	2,191	4,619
Matched with eighth-grade mathematics							
Adjusted difference	0.008	-0.038	-0.032	-0.011			-0.018
	(0.024)	(0.024)	(0.024)	(0.023)			(0.016)
Control mean	0.380	0.442	0.553	0.565			0.484
Observations	3,314	3,221	3,308	2,872			12,715
Matched with eighth-grade reading							
Adjusted difference	0.008	-0.039	-0.032	-0.013			-0.019
	(0.025)	(0.024)	(0.024)	(0.022)			(0.016)
Control mean	0.380	0.442	0.552	0.566			0.484
Observations	3,312	3,228	3,307	2,876			12,723

Notes: This table shows estimated effects on individual-level matching rates across national examinations by cohort. The national second-grade examination is taken as the base to compute the individual-level match indicator with fourth and eight-grade national exams. Cohorts (displayed in each column) indicate the year when students were enrolled in second-grade. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Table B.6: Effects on Second-Grade Academic Performance by Matching Status

	Matched with eight-grade examination					Matched with fourth-grade examination		
Cohort:	2009	2010	2012	2013	2009-2013	2014	2016	2014-2016
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Second-grade mathematics performance								
Effect for matched	-0.071	-0.081	0.079	-0.081	-0.035	-0.243*	-0.038	-0.137
	(0.106)	(0.101)	(0.092)	(0.095)	(0.055)	(0.129)	(0.101)	(0.089)
	1,281	1,351	1,768	1,620	6,020	1,524	1,683	3,207
Effect for unmatched	-0.045	-0.104	0.029	-0.068	-0.048	-0.122	-0.230	-0.172*
	(0.098)	(0.103)	(0.085)	(0.092)	(0.053)	(0.113)	(0.142)	(0.091)
	2,033	1,870	1,540	1,252	6,695	903	507	1,410
p-value	[0.754]	[0.800]	[0.548]	[0.866]	[0.779]	[0.354]	[0.114]	[0.705]
Panel B: Second-grade reading performance								
Effect for matched	-0.100	-0.069	0.061	-0.001	-0.023	-0.208	-0.030	-0.117
	(0.101)	(0.088)	(0.083)	(0.090)	(0.052)	(0.136)	(0.105)	(0.092)
	1,280	1,353	1,767	1,623	6,023	1,525	1,682	3,207
Effect for unmatched	-0.055	-0.135	-0.052	-0.100	-0.085	-0.206*	-0.076	-0.169*
	(0.093)	(0.084)	(0.090)	(0.101)	(0.052)	(0.119)	(0.145)	(0.093)
	2,032	1,875	1,540	1,253	6,700	903	509	1,412
p-value	[0.593]	[0.452]	[0.194]	[0.246]	[0.179]	[0.991]	[0.694]	[0.552]

Notes: This table shows student-level effects on second-grade examination outcomes by their matching status with fourth and eight-grade examinations. Cohorts (displayed in each column) indicate the year when students were enrolled in second-grade for the cohorts that were also tested in fourth or eight-grade. Each panel shows (a) the estimated coefficients and standard errors on the treatment indicator differentiated by whether the student also took the fourth-grade or eight-grade examination from OLS regressions that control for randomization strata fixed effects (along with the number of student-level observations in each category), and (b) the *p*-value of the null for the equality of the estimated effects by matching status in brackets. Mathematics and reading exams have been standardized with zero mean and unit variance for the control group.. Regressions for individual years control for randomization strata fixed effects. Pooled regressions control for randomization strata by year fixed effects. Estimated standard errors are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Appendix C: Heterogeneity Analysis

Effects for schools over time

We explore the possibility of effect heterogeneity at the school level applying the machine learning-based approach (GATES analysis) proposed by Chernozhukov et al. (2023). We apply this framework to the school level academic performance and grade progression based on the 2009-2016 school averages. The covariates used for this heterogeneity analysis are based on the baseline characteristics from Table 1. For both outcomes, we use the 2007-2008 average of computers per student from Panel A, all variables from Panel B, and the second to sixth grade school enrollment. Additionally, for the academic performance we use the 2007-2008 average academic performance based on the variables from panel C, and for grade progression we use the second to sixth grade progression from panel D. [24]

The results are shown in Figure C.1 and Figure C.2. Overall, our findings indicate no significant heterogeneity regarding effects for schools over time.

Effects on student educational trajectories

For the effects on individual-level educational trajectories, we explore some few sources of heterogeneity based on the limited availability of predetermined characteristics at this level. Table C.1 evaluates heterogeneity by gender. Overall, we do not find evidence of heterogeneous effects by gender.

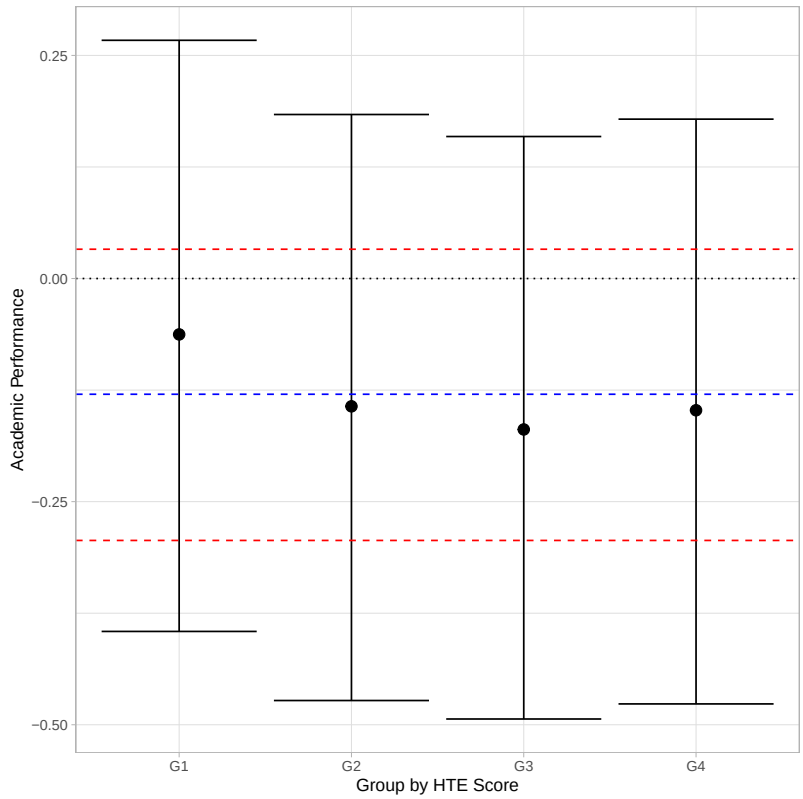
We then take advantage of a subset of cohorts for which the national examinations captured information on the caregiver's educational attainment. Panel A of Table C.2 reports this analysis which documents differential effects on academic performance for students whose caregivers had educational attainment below vs above completed primary school. Overall, we find no differential effects on academic performance. We also exploit the fact that the SIAGIE administrative data captured caregiver's educational attainment for all evaluated cohorts to explore heterogeneity on educational attainment. Panel B of Table C.2 documents no heterogeneous effects on this front.

While we do not possess measures of individual-level baseline academic performance (i.e., before exposure to the program) for the evaluated cohorts, we perform an analysis of heterogeneous effects by baseline school-level academic performance. For this, we use the average school-level performance in the second-grade national examinations of years 2007 and 2008. Table C.3 reports the findings suggesting no overall heterogeneity on this front.

[24] We exclude internet from panel A as a covariate in order for the algorithm to run properly. However, given the low access to internet, there was likely not much heterogeneity to be exploited through that covariate

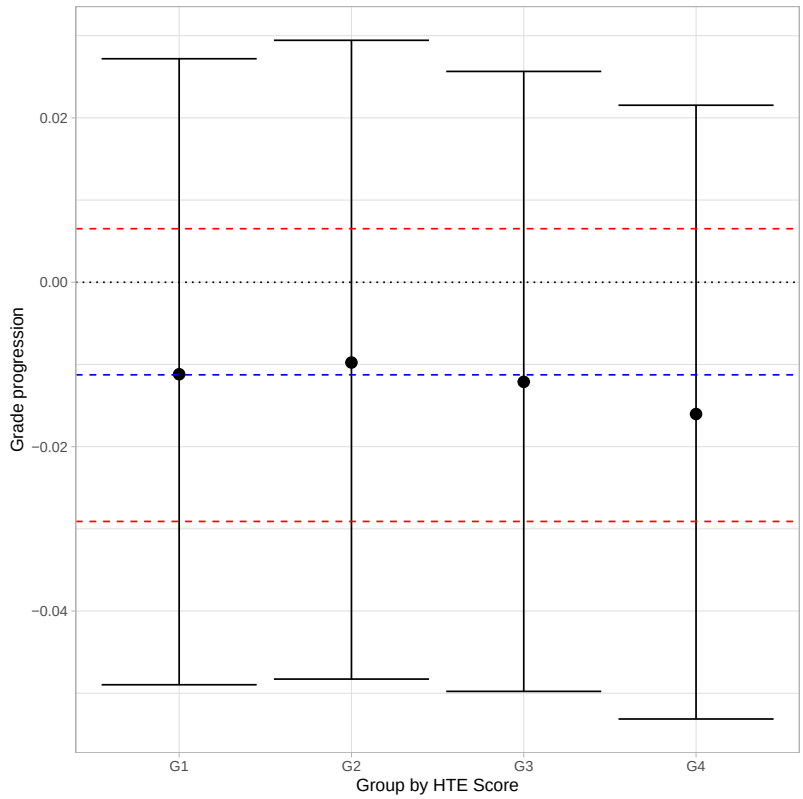
Finally, we exploit the data from our 2013 survey to explore potential effect heterogeneity by socio-economic status. To do so, we use data from the student questionnaire to build a socio-economic index defined as the equally weighted average of the presence of household assets and services (TV, radio, gas or electric stove, electric iron, cellphone, wheelbarrow, electricity, piped water, sewer, fixed line phone, internet, non-XO computer or laptop, video games). Table C.4 presents the findings from this analysis suggesting not discernible heterogeneous effects.

Figure C.1: Effects for Schools over Time on Academic Performance by Machine Learning Heterogeneity



Notes: Estimates correspond to a GATES analysis based on Chernozhukov et al. (2023) for school level academic performance based on the 2009-2016 average. The covariates used for this heterogeneity analysis are based on the baseline characteristics from Table 1. We use the 2007-2008 average of computers per student from Panel A, all variables from Panel B, the 2007-2008 average academic performance based on the variables from panel C, and the second to sixth grade school enrollment. Point estimates and 95% adjusted confidence intervals uniform across groups based on 1000 random splits in half

Figure C.2: Effects for Schools over Time on Grade Progression by Machine Learning Heterogeneity



Notes: Estimates correspond to a GATES analysis based on Chernozhukov et al. (2023) for school level grade progression based on the 2009-2016 average. The covariates used for this heterogeneity analysis are based on the baseline characteristics from Table 1. We use the 2007-2008 average of computers per student from Panel A, all variables from Panel B, the second to sixth grade progression from panel D, and the second to sixth grade school enrollment. Point estimates and 95% adjusted confidence intervals uniform across groups based on 1000 random splits in half

Table C.1: Effects on Student Educational Trajectories by Gender

	Control mean	Males	Females	p-value (2) = (3)	N	Cohorts
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Academic performance						
Second grade mathematics	0.000	-0.041	-0.047	0.825	22,861	2009-2016
		(0.048)	(0.047)			
Second grade reading	0.000	-0.051	-0.061	0.740	22,888	2009-2016
		(0.083)	(0.048)			
Fourth grade mathematics	0.000	-0.069	-0.141*	0.338	3,207	2014, 2016
		(0.082)	(0.083)			
Fourth grade reading	0.000	-0.132	-0.134	0.984	3,207	2014, 2016
		(0.050)	(0.082)			
Eighth grade mathematics	0.000	0.059	-0.004	0.194	6,024	2009-2010, 2012-2013
		(0.057)	(0.050)			
Eighth grade reading	0.000	0.042	-0.064	0.044	6,025	2009-2010, 2012-2013
		(0.047)	(0.057)			
Index of academic performance	0.000	-0.034	-0.058	0.362	22,898	2009-2016
		(0.047)	(0.047)			
Panel B: Educational attainment						
Primary completion on time	0.695	-0.023*	-0.018	0.660	28,516	2009-2015
		(0.011)	(0.013)			
Primary completion with up to one year of delay	0.862	-0.023**	-0.012	0.275	24,939	2009-2014
		(0.006)	(0.011)			
Primary completion overall	0.954	-0.004	-0.004	1.000	20,953	2009-2013
		(0.020)	(0.006)			
Secondary completion on time	0.518	-0.016	-0.029	0.593	7,749	2009-2010
		(0.026)	(0.020)			
Secondary completion with up to one year of delay	0.655	-0.015	-0.027	0.731	3,750	2009
		(0.018)	(0.026)			
Applied to university on time	0.167	-0.004	-0.044**	0.088	3,750	2009
		(0.012)	(0.018)			
Enrolled to university on time	0.060	-0.007	-0.015	0.593	3,750	2009
		(0.010)	(0.012)			
Completed years of education	8.205	-0.062	-0.060	0.968	28,516	2009-2015
		(0.049)	(0.052)			

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the treatment indicator for males from OLS regressions that control for randomization strata by cohort fixed effects. Column 3 displays estimated coefficients and standard errors on the treatment indicator for females from OLS regressions that control for randomization strata by cohort fixed effects. Column 4 displays the p-values for the null of equality of effects between males and females. Column 5 displays the number of individual-level observations in each pooled regression. Column 6 displays the cohorts included in each pooled regression where cohorts are labeled with the year in which students were enrolled in second grade. At the bottom of panel A, we include an index of academic performance that averages the performance across all grades for which students took the national examination as detailed in the notes to Table 2. At the bottom of panel B, we include the number of satisfactorily completed years of primary and secondary education by 2019. Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Table C.2: Effects on Student Educational Trajectories by Caregiver's Educational Attainment

	Control mean	Incomplete Primary or less	Complete Primary or more	*p*-value (2) = (3)	N	Cohorts
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Academic performance						
Second grade mathematics	0.000	-0.067	-0.018	0.305	12,100	2012-2016
		(0.066)	(0.065)			
Second grade reading	0.000	-0.065	-0.021	0.347	12,101	2012-2016
		(0.065)	(0.131)			
Fourth grade mathematics	0.000	-0.348***	-0.142	0.050	1,654	2014
		(0.131)	(0.116)			
Fourth grade reading	0.000	-0.374***	-0.159	0.031	1,655	2014
		(0.116)	(0.067)			
Eighth grade mathematics	0.000	0.100	-0.051	0.025	4,159	2009-2010, 2013
		(0.067)	(0.065)			
Eighth grade reading	0.000	0.047	-0.085	0.052	4,161	2009-2010, 2013
		(0.065)	(0.061)			
Index of academic performance	0.000	-0.050	-0.032	0.668	14,168	2012-2016
		(0.061)	(0.054)			
Panel B: Educational attainment						
Primary completion on time	0.705	-0.036**	-0.014	0.104	27,993	2009-2015
		(0.015)	(0.012)			
Primary completion with up to one year of delay	0.876	-0.032***	-0.013	0.119	24,426	2009-2014
		(0.012)	(0.006)			
Primary completion overall	0.972	-0.010	-0.007	0.641	20,481	2009-2013
		(0.006)	(0.021)			
Secondary completion on time	0.536	-0.022	-0.029*	0.742	7,519	2009-2010
		(0.021)	(0.027)			
Secondary completion with up to one year of delay	0.680	-0.035	-0.016	0.546	3,618	2009
		(0.027)	(0.016)			
Applied to university on time	0.172	-0.025	-0.016	0.701	3,618	2009
		(0.016)	(0.009)			
Enrolled to university on time	0.060	0.000	-0.013	0.350	3,618	2009
		(0.009)	(0.011)			
Completed years of education	8.306	-0.114**	-0.064*	0.274	27,993	2009-2015
		(0.050)	(0.037)			

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the treatment indicator for student's with caregivers who had not completed primary education from OLS regressions that control for randomization strata by cohort fixed effects. Column 3 displays estimated coefficients and standard errors on the treatment indicator for student's with caregivers who have completed primary education from OLS regressions that control for randomization strata by cohort fixed effects. Column 4 displays the *p*-values for the null of equality of effects between columns (2) and (3). Column 5 displays the number of individual-level observations in each pooled regression. Column 6 displays the cohorts included in each pooled regression where cohorts are labeled with the year in which students were enrolled in second grade. At the bottom of panel A, we include an index of academic performance that averages the performance across all grades for which students took the national examination as detailed in the notes to Table 2. At the bottom of panel B, we include the number of satisfactorily completed years of primary and secondary education by 2019. As information on caregiver's educational attainment was not available for the 2009-2011 second-grade national examinations, effects on second-grade academic performance reported in Panel A are restricted for cohorts 2012-2016. In addition, caregiver's educational attainment was not captured in year 2018. This corresponds to the year in which the 2016 cohort wrote the fourth-grade exam and in which the 2012 cohort wrote the eight-grade exam. Therefore, these cohorts are not included in the analysis for these outcomes. Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Table C.3: Effects on Student Educational Trajectories by School-Level Baseline Academic Performance

	Control mean	Above median	Below median	p-value (2) = (3)	N	Cohorts
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Academic performance						
Second grade mathematics	0.000	-0.077	-0.034	0.667	21,355	2009-2016
		(0.060)	(0.060)			
Second grade reading	0.000	-0.079	-0.042	0.707	21,381	2009-2016
		(0.094)	(0.060)			
Fourth grade mathematics	0.000	-0.367***	0.051	0.003	2,972	2014, 2016
		(0.090)	(0.094)			
Fourth grade reading	0.000	-0.388***	0.021	0.004	2,972	2014, 2016
		(0.070)	(0.090)			
Eighth grade mathematics	0.000	0.061	-0.002	0.523	5,609	2009-2010, 2012-2013
		(0.072)	(0.070)			
Eighth grade reading	0.000	-0.035	-0.023	0.910	5,611	2009-2010, 2012-2013
		(0.060)	(0.072)			
Index of academic performance	0.000	-0.087	-0.023	0.513	21,391	2009-2016
		(0.070)	(0.060)			
Panel B: Educational attainment						
Primary completion on time	0.690	-0.001	-0.028*	0.215	24,621	2009-2015
		(0.014)	(0.015)			
Primary completion with up to one year of delay	0.859	-0.011	-0.021	0.597	21,459	2009-2014
		(0.009)	(0.014)			
Primary completion overall	0.951	-0.007	-0.002	0.652	18,005	2009-2013
		(0.023)	(0.009)			
Secondary completion on time	0.517	-0.020	-0.019	0.959	6,639	2009-2010
		(0.031)	(0.023)			
Secondary completion with up to one year of delay	0.657	-0.029	0.009	0.383	3,212	2009
		(0.020)	(0.031)			
Applied to university on time	0.162	-0.031	-0.004	0.364	3,212	2009
		(0.013)	(0.020)			
Enrolled to university on time	0.059	-0.009	-0.013	0.867	3,212	2009
		(0.013)	(0.013)			
Completed years of education	8.175	-0.047	-0.047	1.000	24,621	2009-2015
		(0.060)	(0.068)			

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the treatment indicator for individuals who studied in schools that were above the median of the average second-grade national academic achievement for 2007 and 2008 from OLS regressions that control for randomization strata by cohort fixed effects. Column 3 displays estimated coefficients and standard errors on the treatment indicator for individuals who studied in schools that were below the median of the average second-grade national academic achievement for 2007 and 2008 from OLS regressions that control for randomization strata by cohort fixed effects. Column 4 displays the p-values for the null of equality of effects between those above and below the median baseline level of academic achievement. Column 5 displays the number of individual-level observations in each pooled regression. Column 6 displays the cohorts included in each pooled regression where cohorts are labeled with the year in which students were enrolled in second grade. At the bottom of panel A, we include an index of academic performance that averages the performance across all grades for which students took the national examination as detailed in the notes to Table 2. At the bottom of panel B, we include the number of satisfactorily completed years of primary and secondary education by 2019. Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.

Table C.4: Effects on Students by Socio-Economic Status

	Control mean	Below median SES	Above median SES	p-value (2) = (3)	N
	(1)	(2)	(3)	(4)	(5)
Panel A: Technology Access					
Student has own XO laptop in school	0.291	0.492***	0.419***	0.157	2,129
		(0.057)	(0.050)		
Student takes the XO laptop home	0.019	0.185***	0.198***	0.689	2,142
		(0.040)	(0.039)		
Student has non-XO laptop or computer at home	0.100	0.010	0.015	0.851	2,137
		(0.013)	(0.023)		
Student has internet at home	0.026	-0.003	-0.004	0.929	2,127
		(0.004)	(0.010)		
Panel B: Students' use of computers in the school (previous week)					
Used for entertainment	0.518	0.234***	0.079	0.012	2,128
		(0.073)	(0.065)		
Used for academic purposes	0.566	0.160*	0.063	0.140	2,125
		(0.082)	(0.065)		
Panel C: Students' digital skills					
XO test	0.000	0.454***	0.371***	0.464	2,103
		(0.121)	(0.094)		
PC test	0.000	0.300**	0.083	0.022	2,103
		(0.115)	(0.090)		
Internet test	0.000	0.162	0.026	0.123	2,103
		(0.106)	(0.094)		
Panel D: Students' cognitive skills					
Cognitive skills index	0.000	0.142	0.120	0.852	2,107
		(0.110)	(0.107)		
Raven's progressive matrices	0.000	0.005	0.060	0.595	2,101
		(0.099)	(0.091)		
Verbal Fluency	0.000	0.241*	0.158	0.540	2,106
		(0.129)	(0.117)		
Coding	0.000	0.036	0.025	0.904	2,085
		(0.107)	(0.091)		
Panel E: Students' academic achievement					
Mathematics	0.000	0.107	0.009	0.399	2,092
		(0.126)	(0.096)		
Reading	0.000	0.013	0.029	0.887	2,125
		(0.105)	(0.094)		

Notes: Column 1 displays control group means. Column 2 displays estimated coefficients and standard errors on the treatment indicator for student with below median socio-economic status (SES) from OLS regressions that control for randomization strata fixed effects. Column 3 displays estimated coefficients and standard errors on the treatment indicator for student with above median SES from OLS regressions that control for randomization strata by cohort fixed effects. Column 4 displays the p-values for the null of equality of effects between columns (2) and (3). Column 5 displays the number of observations in each regression. Socio-economic status was calculated with an equally weighted average index of household assets and services (TV, radio, gas or electric stove, electric iron, cellphone, wheelbarrow, electricity, piped water, sewer, fixed line phone, internet, non-XO computer or laptop, video games). In this index, we excluded assets associated with agricultural work (i.e., wood stove, plow, lamp, rake, or axe) as they might be correlated negatively with SES. However, results are consistent when including them in the SES index. Data corresponds to the survey implemented by the team in the year 2013. Estimated standard errors, reported in parentheses, are clustered at the primary school level. ***p<0.01, **p<0.05, *p<0.1.