The Impacts of Interactive Smartboards on Learning Achievement in Senegalese Primary Schools

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Abstract

Though much progress has been made, the current level of educational achievement in many developing countries remains low. One proposed solution for improving the quality of education is the use of technology. However, the empirical evidence regarding the success of technology interventions, including interactive smartboards, at improving student outcomes is mixed. Project Sankoré creates a digital classroom through the introduction of simple interactive whiteboard equipment consisting of an interactive whiteboard, a computer, a data projector, and digital resources. We evaluate the impacts of the Sankoré equipment in grades 1 and 2 of primary school in Senegal. The primary research hypothesis is to test whether the introduction of the project Sankoré kits have an impact on student learning as measured by test scores in French, mathematics, and education for life sciences and for life in society (ESVS). We further investigate heterogeneous treatment effects of the project by the gender of the student, by grade, and by the location of the school. The results suggest large positive impacts of the Sankoré project which are concentrated in urban schools.

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1. Introduction

Education is an important determinant of health, earnings, and overall well-being. Developing country governments, NGOs, and the international community have recognized the importance of education in economic development. The Millennium Development Goal (MDG) of achieving universal primary education by 2015 (United Nations, 2015a) is but one indication of the importance given to education in the development process. According to the United Nations (2015a), in 2015, net enrolment in primary education in developing regions reached 91% (compared to 83% in 2000). Sub-Saharan Africa's primary school net enrollment rate improved significantly over this period; from only 52% in 1990 to 80% in 2015 (United Nations, 2015a). However, in 2015, more than half of those children not enrolled in school worldwide lived in sub-Saharan Africa (33 million of the 57 million estimated primary school-aged children not in school) (United Nations, 2015a).

Though much progress has been made, the current level of educational achievement in many developing countries, and specifically in Sub-Saharan Africa, remains low. The Sustainable Development Goals, announced in September 2015 as a follow-up to the MDGs, include the goal of ensuring quality education (United Nations, 2015b). Increasing school enrolment is insufficient for improving education outcomes if, once in school, quality education is unavailable. This may be due to, amongst other issues, high teacher absenteeism, large class sizes, lack of teacher training, and/or few education resources such as textbooks, desks, etc. One proposed solution for improving the quality of education in developing countries is the use of information and communications technologies (ICTs). Indeed, the majority of ongoing World Bank education projects include an ICT component (World Bank, 2016).

Different types of ICTs have been proposed as possible ways of improving education outcomes in both developed and developing countries. For example, computers or tablets may be used to allow for personalized individual learning and to enable students to learn even if a teacher is absent or lacks training (Osin, 1998). Interactive smartboards have also been suggested as a way of increasing student and teacher motivation (Beauchamp & Parkinson, 2005). They may also enhance the benefits of other ICTs, such as, computers and projectors, by adding interactivity (Hall & Higgins, 2005). However, Türel and Johnson (2012) note that the true success of interactive smartboards depends on whether they are appropriately integrated into classrooms.

The empirical evidence regarding the success of technology interventions, including interactive smartboards, at improving student outcomes is mixed and those investigating the effectiveness of interactive smartboards are largely concentrated in developed countries (Higgins et. al., 2007). Several explanations have been put forward to explain the lack of positive results of such interventions including a mismatch between the intervention and the curricular objectives or student needs and limited training for teachers in the use of the new technology (Berlinski & Busso, 2015).

One recent evaluation of the use of interactive whiteboards was undertaken in Costa Rica (considered an upper-middle income economy by the World Bank). A randomized control trial was implemented to evaluate the impacts of four alternative pedagogical treatments (compared to the status-quo) in seventh grade Costa Rican classrooms on mathematics results (Berlinksi & Busso, 2015). The four treatments introduced were (1) a new curriculum, (2) the same new curriculum and an interactive whiteboard, (3) the new curriculum and a computer lab, and (4) the new curriculum and a laptop for every child in the class. The authors find a negative impact on mathematics results from all four interventions compared to the status quo. Students in the interactive whiteboard group learned 15.5% of a standard deviation less than those in the control group. The authors also find no differential impacts of the interventions between boys and girls.

Berlinksi and Busso (2015) propose two possible explanations for the negative impacts of the interventions that they find. One possibility is that, in the short-run, there are costs to using a new technology and a new curriculum as teachers learn how to use it and how to modify their teaching in response. Therefore, in the short-run, the impact of the intervention may be negative while, in the long-run, as teachers experiment and learn to use the new technology, there may be positive treatment effects. Another possible explanation is that some teachers are better than others at incorporating more active student participation in the classroom. The interventions lead teachers to experiment with more active classes even when some of them were not equipped to deal with the demands of such a classroom. In the long run, teachers will learn whether they are well suited for the intervention and, in response, will choose whether or not to implement it in their classrooms.

Cristia et. al. (2017) is one of the few studies to investigate the impact of an ICT intervention in a developing country. The authors evaluate the impact of the One Laptop per Child program in rural Peru and find no evidence of impacts on enrollment or math and language test scores. The authors do, however, find positive impacts on cognitive skills.

Project Sankoré is a collaborative effort between France and a number of African countries aiming at improving learning by creating a digital classroom through the introduction of simple interactive whiteboard equipment. In Senegal the project was implemented in two phases. The first phase was implemented between 2011 and 2013. The Sankoré equipment distributed during both phases of the project were identical and is pictured in Figure 1. During both phases of the project, the kits distributed to primary schools were intended to be used in grades 1 and 2.

The infrastructure for the second phase was distributed in 2014 with teaching with the whiteboards beginning in 2015. In Senegal, project Sankoré is implemented in the first and second year of primary school (*cours d'initiation* (CI) and *cours préparatoire* (CP)). These grades were selected because of young children's ability to adapt quickly to using technology and because Senegal is currently introducing technology in pre-school. Therefore, the introduction of project Sankoré in grades 1 and 2 ensures continuity in the use of technology in a learning environment.

In schools with more than one classroom in grade 1 and/or 2, beneficiary classrooms were selected by the school principal, in collaboration with the department education inspector and the teachers of these classrooms were trained on the use of the Sankoré kits. The teachers who participated in this training were chosen on the basis of their availability for the training and their prior experience using computers.

Figure 1: Project Sankoré Equipment

Source: Diagne (2016)

The Sankoré project also constitutes part of the Senegalese government's efforts to modernize the education system, to develop 21st century skills, and to improve the quality of the provision of education. Project Sankoré is being implemented in nine of the 14[2] *Inspections d'Académie* (similar to the regional

[2]When the Sankoré project evaluation was being designed, 14 *Inspections d'Académie* existed in Senegal. Reforms have since taken place and there are now 16 *Inspections d'Académie*.

level) in Senegal with the aim of achieving national coverage. However, before expanding the project throughout the country, and determining whether to expand the project to others countries, it is necessary to evaluate its effectiveness.

The main evaluation strategy proposed relied on the initial project implementation plan. In particular, the project team requested 1,200 kits (consisting of an interactive whiteboard, a computer, a data projector, and digital resources) from the French government. The department education offices (a department is roughly equivalent to a district) were asked to send priority lists of eligible schools to the regional level (*Inspections d'Académie*), based on the idea that 1,200 schools would be selected to receive the kits. The academies verified whether the schools were eligible, that is, whether they satisfied the required security and electricity requirements, and then merged the lists from the departments in their jurisdiction into one priority list and forwarded these lists to the Ministry of Education. The Ministry was then to allocate the 1,200 kits to the top priority schools in each sub-department[3]. The ranking of schools on the priority lists was based on the quality of the selection criteria (safety, accessibility, and access to electricity) at the school. For example, ceteris paribus, schools with more reliable access to electricity were ranked higher than those with less reliable access to electricity.

Given this planned implementation strategy, the research team believed that a regression discontinuity (RD) design would enable the identification of the causal impacts of the program on learning outcomes. Specifically, the regression discontinuity design assumes that the schools listed just below and just above the cutoffs for receiving the kits on each of the lists of schools supplied by the academy inspectorates were similar prior to the implementation of the program. Therefore, differences in the changes observed over time in the learning outcomes between the schools that did receive the kits and those that did not around the cutoff in each sub-department, identify the impacts of the program. This identification strategy implies comparing the changes in learning outcomes (test scores) of students in Sankoré classes in Sankoré schools near the cutoff with the changes in learning outcomes of students in non-Sankoré classes of the same grades in these same schools and with the learning outcomes of students in the same grades in non-Sankoré schools near the cutoff. Unfortunately, results presented in the baseline report (Ksoll, Mbaye, and Ssenkubuge, 2015) show that the assumptions necessary for the use of the RD technique do not hold in the baseline data. We, therefore, proceed with identifying the impact of the Sankoré project using the second proposed research design which relies on a parallel trends assumption, between the schools that were treated and those that were not, and uses a difference-in-differences estimation strategy. Results reported in the baseline report support the parallel trends assumption and, therefore, the use of the difference-in-differences technique.

The article is structured as follows. Section 2 describes in detail the project Sankoré intervention. Section 3 provides an overview of the context of the intervention by describing the education system in Senegal as well as the evaluation sites. Section 4 provides a visualization of the timeline of the project and of the evaluation while section 5 details the evaluation design, methodology, and implementation. Section 6 presents the results of the quantitative analysis using the difference-in-difference identification strategy and section 7 concludes with policy recommendations based on the findings.

2. Intervention

The Sankoré-Senegal project originated at the *Rencontre sur la solidarité numérique au service de l'éducation et du développement* (digital solidarity for education and development meeting) in Bamako, Mali on January 27th, 2009. The meeting outlined the Sankoré "Digital Education for All in Africa" program which was endorsed by the representatives of French speaking countries of Africa, including Senegal.

[3]However, only 750 whiteboards were received and a significant number of them were destined for other purposes (370 were allocated to schools, 200 to UNESCO BREDA, 150 to licensed establishments, 11 to the French Alliances, and the rest to non-governmental organizations (NGOs)).

The Sankoré project is based on the concept of a "digital classroom" and equips the classroom selected with an interactive whiteboard connected to a computer with a projector. The Sankoré project also allows the teacher and the learners to manipulate digital interactive educational resources through the Sankoré portal which is an interactive digital resource base of teaching and learning resources. Through interactive software and the tactile screen, the teacher and the learners both have access to text, moving images, and sound.

Project Sankoré is an initiative which constitutes part of the partnership agreements between Africa and France. The project lays the foundation for the digital classroom using simple interactive whiteboard equipment which makes pedagogic practice more learner centered. Of the 750 whiteboards that were received for implementation, 370 were allocated to schools, 200 to UNESCO BREDA, 150 to licensed establishments, 11 to the French Alliances, and the rest to non-governmental organizations. In most cases, schools received two Sankoré kits for use in grade 1 and grade 2 classes. Teachers involved in the implementation of the project were trained as were some technicians in order to support installation and repairing of equipment when required. The kits were distributed to the schools during the middle of 2014 and teaching with the whiteboards began in January/February 2015.

Several differences between urban and rural locations may contribute to differential impacts of the program between these types of schools. Firstly, in terms of stakeholder buy in, it is possible that both teachers, parents, and students outside of urban areas are less aware of the potential benefits of technology and, therefore, stakeholder buy in may be lower in these settings. Furthermore, if teachers and technicians are less comfortable with technology in such locations, the training they were provided may have been inadequate (while possibly being sufficient for teachers and technicians in urban locations). Finally, as mentioned previously, reliable electricity may be more unlikely outside of urban areas in Senegal.

Given the project Sankoré kits were intended only to be used by grades 1 and 2 classes in Senegal, we anticipate that the intervention should translate into improved learning after one to two years of implementation. The results may not be immediate because it may take some time for both teachers and students to familiarize themselves with the new technology. However, evaluating the impact of the project after more than two years is also not ideal. As the intervention does not currently continue into higher grades at the primary school level (or to other levels of education), we may expect any positive impacts of the project to decrease over time as the students progress through primary school and return to a teaching environment without the use of interactive whiteboards. However, this would not be the case if the project were expanded to all grades in primary school.

3. Context

Senegal is considered a low income country (according to the World Bank) with an estimated population of 15.13 million and a GDP growth rate of 6.5% in 2015 (World Bank, 2016). Senegal has had four presidents since its independence in 1960 and is one of the most politically stable countries in Africa (World Bank, 2013).

Poverty levels are high in Senegal and, in 2010, the poverty headcount ratio at national poverty lines was 46.7% of the population. The poverty gap between rural and urban areas is large; in 2011, 57% of the population were below the poverty line in rural areas compared to 26% in urban Dakar. There is a strong correlation between education levels and poverty. In 2011, poverty was more prevalent among the 54% of people living in a household whose head had no formal education and this pattern was unchanged from 2005. However, poverty levels decreased from 43% to 34% during the same period in households whose household head had primary education. Approximately 83% of the poor live in households with an uneducated head and this has remained constant over the past 10 years (World Bank, 2013).

The Senegalese constitution recognises education as a right and primary education is free and compulsory. There are four levels of instruction in the formal education system in Senegal: Pre-school, elementary school, secondary school (comprising academic teaching and public technical and vocational training), and higher education. Public education remains the dominant provision of education at these levels but there is also provision by private/independent schools. Pre-school is available for children from three to five years old and has three levels: *petite section* (children aged 3), *moyenne section* (children aged 4) and *grande section* (children aged 5). The duration of elementary schooling is six years and is targeted to children from seven to 12 years old, divided into six levels of schooling: Reception (*cours d'initiation*, CI), first year (*cours préparatoire*, CP), second year (*cours élémentaire première année*, CE1), third year (*cours élémentaire deuxième année*, CE2), fourth year (*cours moyen première année*, CM1), and fifth year (*cours moyen deuxième année*, CM2). For ease of exposition, in this report, we refer to CI as grade 1, CP as grade 2, CE1 as grade 3, and CE2 as grade 4. The school year in Senegal begins in October and ends in late June.

At the central level, the Ministry of Education ensures the realization of educational policy in Senegal. At the regional level, the Academic Inspections (AI) are responsible for the implementation of educational policy. Academic Inspections manage, at the department level, the Education and Training Inspectorates (IEF) who are also responsible for educational policy implementation. In each region, there are between two and four departments with one IEF per department led by an education inspector. Schools are then overseen by the IEF of their department.

Data from the Ministry of Education (*République du Sénégal, Ministère de l'Education nationale, La Direction de la Planification et de la Réforme de l'Education*, 2013), based on the 2013 census indicates that the average teacher-student ratio is 33 students per teacher. From 2000 to 2013, the enrolment rate at the elementary level (grades 1 and 2) increased by 67.2 to 93%, the girl-boy parity index increased from 0.87 to 1.1, and the primary school completion rate from 38.6 to 65.9%. However, the dropout rate is 9.8% at the elementary level. Relative to the rest of Sub-Saharan Africa, Senegal's investment in education is high; Senegal's expenditure on education as a percentage of total government expenditure was 25.74 in 2013 compared to the Sub-Saharan African average of 16.62 (World Bank, 2017), .

However, Senegal still faces challenges in the education sector leading to poor education outcomes. The government is attempting to address the inefficiencies in the sector through a constructivist approach to education which focuses on individual children's learning needs. Education is now compulsory for children aged 6-10 years and efforts are being made to minimize wastage in the education sector and to support early childhood development.

The World Bank (2013) notes that the quality of Senegal's telecoms is lagging behind that of the region and that costs remain higher than in other countries. Although there is a mobile penetration rate of approximately 67%, Senegal does not experience efficiencies and cost-saving opportunities because of the underutilization of ICTs and a poor regulatory and competitive environment (World Bank, 2013). ICTs are also rare in the education sector.

In 2012, statistical data on access to electricity in Senegal revealed important rural-urban differences (*Agence sénégalaise d'électrification rurale*, 2012). While in urban areas, the electrification rate (ratio of the number of households with access to electricity to the total number of households) was 90%, it was 24% in rural areas. Thus, with a national electrification rate of 54%, Senegal was doing well within Sub-Saharan Africa with an average rate of 32%. However, Senegal has not seen much progress in rural areas with only 29% of households having access to electricity in 2014. A recent assessment completed in 2014 shows that 14 out of the 42 Senegalese departments (33.3%) had electricity access rates of less than 10% and 17 departments out of 42 (40.5%) had a rate between 10% and 30% (General Population and Housing Census, 2013). There are 8,984 primary schools in Senegal with only 32% having access to electricity.

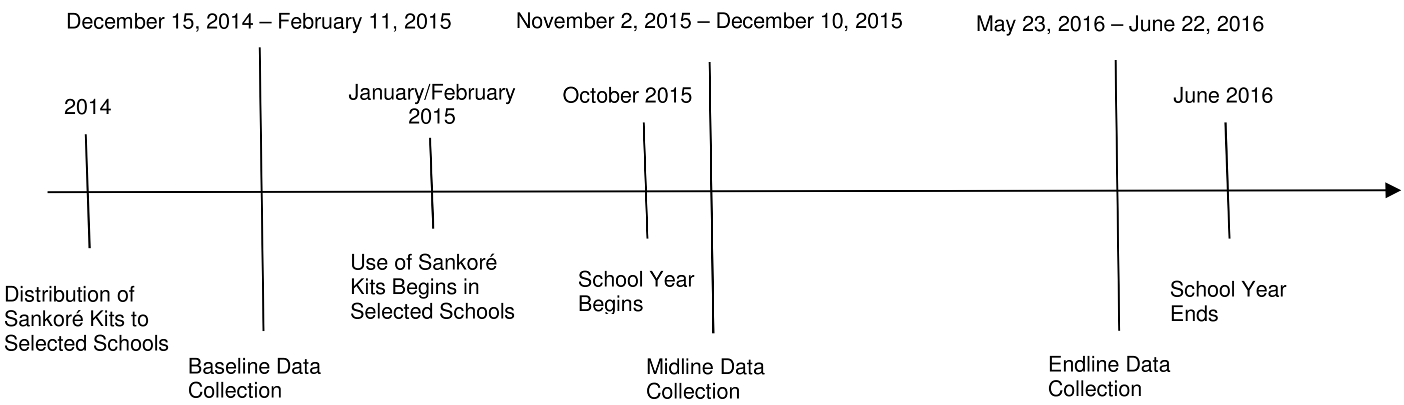
The study sites (schools) were chosen based on the planned rollout of project Sankoré. In Senegal, the project was implemented in two phases. The first phase was implemented between 2011 and 2013. The infrastructure for the second phase was distributed in 2014 with teaching with the use of the whiteboards beginning in 2015. The first stage of the sampling was conducted at the *Inspections d'Académie* (Academic Inspectorates) level with 9 of the, then, 14 IAs being involved in the rollout of the project. The representativeness of these IAs for Senegal as a whole is, unfortunately, outside the scope of this study as no data was collected for this population.

Within the 9 IAs who were to participate in the second phase of project Sankoré, the initial sampling for the study was conducted based on the RD evaluation design. The RD design uses only schools around the cutoff. The cutoffs are at the *Inspection de l'éducation et de la formation* (Education and Training Inspectorate; roughly equivalent to a District Education Office) level. IEFs with less than 3 schools on either side of the cutoff were dropped, which reduced the number of IAs the survey would take place in from 9 to 5 and the number of IEFs from 51 to 11. Schools in the study sample (near the cutoffs) must meet some basic infrastructure requirements in terms of electricity and security which automatically excludes the least endowed schools in Senegal.

In order to ascertain the external validity of the study, it is crucial to understand that the project was put in place throughout most of the country and in both rural and urban areas. The survey schools are representative of primary schools in five districts of Senegal (Dakar, Diourbel, Fatick, Kaolack, and Thiès) with access to electricity and sufficient infrastructure to keep the Sankoré kits secure. The kits were intended to be used in grades 1 and 2. Therefore, the evaluation cannot draw conclusions on the implementation of smartboards in either higher grades or at the pre-school level.

4. Timeline

The Sankoré program implementation and the evaluation implementation timeline are depicted below:



5. Evaluation: Design, methods and implementation

The research proposal was approved by the institutional review board at the University of Ottawa, Canada. The evaluation contributed an element of transparency to the selection of schools to benefit from the Sankoré intervention by asking officials to rank the eligible schools according to priority. Furthermore, the research does not alter the number of schools eligible for selection into the program. The selected school principals were informed of the study and their consent for participation was sought. Consent was also sought from the teachers and students participating in the impact evaluation. Anonymity of research subjects was maintained at all times.

Two possible evaluation techniques were proposed in the pre-analysis plan to investigate the impact of the interactive whiteboards on learning outcomes; a regression discontinuity design and a difference-in-differences analysis. It was noted that the validity of these methods needed to be verified after the collection of the baseline data. The baseline report (Ksoll, Mbaye, and Ssenkubuge, 2015) showed that the results from the baseline data invalidate the use of the RD technique. As such, the results presented here follow the second strategy proposed in the pre-analysis plan; that is, the difference-in-differences technique.

The difference-in-difference evaluation strategy compares changes in the outcomes of interest, test scores, before and after the intervention between students who benefited from the Sankoré intervention and others who did not. In order to use this estimation technique, we, therefore, need data from before and after the implementation of the intervention and for students who participated in the program and for a control group of students who did not. Unfortunately, we were unable to complete the baseline data collection prior to the implementation of project Sankoré. However, we do not anticipate the project to have had a large impact on learning in the first month of its use, enabling us to use data from this period as baseline pre-treatment data. Our post-treatment data comes from the endline survey conducted in May and June 2016. We collected data for students in grades 1 and 2 who were in classrooms assigned to use the Sankoré interactive whiteboards in treatment schools. These students form our treatment group. Since our endline survey was conducted approximately 1.5 years after the implementation of project Sankoré, we have two cohorts of children who were exposed to the Sankoré kits in each Sankoré school for each of grades 1 and 2. In addition to testing and interviewing these children, in those schools with more than one grade 1 or 2 classroom, we also collected data from those students in the other non-Sankoré classrooms in grades 1 and 2 in treatment schools. Students who were in grade 1 (2) during the baseline survey were in grade 2 (3) at the time of the endline survey, if they successfully completed grade 1(2).

Furthermore, we collected data for students in grade 3 during the baseline and in grades 3 and 4 during the endline in treatment schools who were also not in classrooms equipped with the Sankoré kits. Finally, we collected data for students in grades 1, 2, 3, 4 (students in grade 4 were only interviewed during the endline survey) in non-Sankoré schools that were located near the cutoff for having been chosen to receive the Sankoré kits according to the Ministry priority list. The students from these schools form the control group in the analysis.

Firstly, we use the assignment of the kits at the school-level to create our treatment and control groups. As such, we estimate an intention-to-treat estimator as not all of the students in grades 1 and 2 had access to the new technology. This strategy overcomes biases that may arise if, within grades, the kits are not distributed randomly to classrooms but based on teacher and/or student characteristics. Next, we instrument being in a classroom that received a Sankoré kit by being in a Sankoré school after the implementation of the intervention. This allows us to identify the average treatment effect on the treated under the assumption that there are no spillover effects of the program to non-Sankoré classes in Sankoré schools. In addition to studying the average treatment effect, we investigate heterogeneous treatment effects by gender of the child and by rural/urban location of the school.

The primary (uninstrumented) difference-in-differences technique is implemented by estimating the following regression:

$$y_{ist} = \beta_0 + \beta_1 Sankoré_s + \beta_2 post_t + \beta_3 Sankoré_s * post_t + X_{is}\gamma_1 + \mu_s + \varepsilon_{ist} \quad (1)$$

where y_{ist} is our outcome measure of interest for student i in school s at time t, $Sankoré_s$ is an indicator for whether the school s is a treatment school, $post_t$ is an indicator for whether the observation was collected during the endline survey, after the kits had been in use for approximately 1.5 years, as opposed to during the baseline survey, X_{is} are student characteristics including baseline test scores, gender, age, and levels of parental education. Moreover, X_{is} includes *Inspection de l'éducation et de la formation* fixed effects (since that is the level at which the treatment and control schools were selected). The outcome measures, y_{ist}, are the French, mathematics, and ESVS test scores. We implement the regressions separately by subject, using Z-scores for math, French and ESVS, where Z-scores are defined separately by grade. The coefficient of interest estimating the intention-to-treat effect of project Sankoré is β_3.

Given the majority of students change grades between our baseline and endline data collections, the difference-in-difference estimation strategy does not necessarily compare the results of the same students before and after the introduction of the kits but compares the changes in outcomes of students assigned to grades 1 and 2 before and after the implementation of the program (in the primary results). Some students remain in the sample of students in grades 1 and 2, and, therefore, are included in both the baseline and endline in the difference-in-difference estimation strategy, while others do not (those who began grade 1 in 2016 and those who progressed to grade 3 in 2016.

In the instrumented regression, the variable $Sankoré_s * post_t$ is no longer defined at the school–level but indicates whether or not the student was in a Sankoré classroom after the program's implementation. We instrument for being in a Sankoré classroom after the implementation of the program with the variable as defined at the school level ($Sankoré_s * post_t$).

In these two evaluation strategies, we did not explicitly include the grade 3 students. However, at the time of the endline survey, the majority of the students in grade 2 during the baseline were in grade 3 at the endline. Hence, they are included in an analysis and allow us to test whether any impacts of the Sankoré program persist after the students stop being exposed to the program. Moreover, data from those students in grade 3 at baseline allow us to test the parallel trends assumption necessary for the use of the difference-in-differences technique. The parallel trends assumption assumes that in the absence of the treatment, the treatment group would have experienced the same changes in the outcomes of interest as the control group. The assumption is that in the absence of the program the transition from grades 1 and 2 to grade 3 would have been the same in Sankoré schools as it is was in non-Sankoré schools. This allows for baseline differences in all grades between Sankoré and non-Sankoré schools as long as these differences are constant throughout all grades and do not, for example, increase with each additional year of schooling.

The results of the test of this assumption were presented in the baseline report (Ksoll, Mbaye, and Ssenkubuge, 2015). This was done by comparing whether baseline test results of students in grades 1 and 2 in Sankoré schools differed significantly from those of students in grades 1 and 2 in non-Sankoré schools (compared to students in grade 3) prior to the implementation of the program. The following regression specification was estimated:

$$y_{ist} = \beta_0 + \beta_1 Sankoré_s + \beta_2 grade1\&2_{it} + \beta_3 Sankoré_s * grade1\&2_{it} + IEF_{is}\gamma_1 + \mu_s + \varepsilon_{ist}$$

where y_{ist} is our outcome measure of interest for student i in school s at time t, $Sankoré_s$ is an indicator for whether the school s is a treatment school, $grade1\&2_{it}$ is an indicator variable for whether student i is in either grade 1 or 2 (as opposed to grade 3) in year t, and IEF_{is} are *Inspection de l'éducation et de la formation* fixed effects.The error term consists of μ_s, a common school-level error component capturing common local school characteristics, and ε_{ist}, which captures unobserved individual or idiosyncratic shocks. The error term is clustered at the school level. The coefficient of interest is β_3. An estimated value of this coefficient statistically significantly different from zero would indicate that the parallel trends assumption is unlikely to hold. In three separate regressions for French, mathematics, and ESVS, the estimated coefficient is not statistically significant at conventional levels, providing evidence that the parallel trends assumption is not violated for observations at schools in the vicinity of the cutoffs.

The sample size determination was based on the sample size calculations with random assignment. As McKenzie (2012) notes, if the autocorrelation in outcomes is 0.5 or higher (as we think is the case with education scores across two years), the difference-in-differences estimate has slightly more power than the simple post-test impact estimate of a randomized assignment. Results based on random assignment are likely to be conservative.

We assume a desired power of 0.8, an alpha of 0.05, a sample size of 30 students per class and 60 students per school (which is an underestimate given that many schools have more than one grade 1 and/or grade 2 class), an intra-cluster correlation (ICC) of 0.167 (which is the highest ICC of the 3 outcome variables we are looking at[4]). Further assuming that the correlation between baseline and endline outcomes is 0.6 and considering only one endline survey, with 115 schools, we can detect a minimum effect size of 0.21. When we include both classes together in one estimation, 114 schools are sufficient to detect an effect size of 0.2. Lastly, we gain some power due to the fact that we also sample students from classes that did not have the Sankoré kits installed. While this does not help with class-specific shocks, it does help with any school specific shocks that may have occurred between the baseline and the endline surveys.

The initial sample for the baseline data collection consisted of 173 schools. Using data from the baseline data collection, the parallel trends assumption necessary for the identification of the impacts of the project using the difference-in-differences strategy is plausible when the replacement schools are excluded[5] and when only schools within a certain bandwidth around the cutoffs are considered. This reduced the number of sampled schools in the midline and endline data collection to 122.

Primary data collection was completed in the 122 sampled schools. The number of schools by type of school (Sankoré or control group) by IEF is presented in table 1. Table 2 presents a description of the environment where the sampled schools are located. Of the 50 Sankoré schools, 26 are located in an urban area, five in a peri-urban area, and 19 in a rural area. The distribution of the 72 non-Sankoré schools is somewhat more peri-urban than the Sankoré schools with 32 urban schools, 13 peri-urban schools, and 27 rural schools. The number of schools, classrooms, and students involved in each stage of the data collection is described in tables 1-7.

Table 1: Schools in the baseline data collection by IA and IEF

IA	IEF	Number of schools
Dakar	Almadies	11
Dakar	Grand Dakar	13
Dakar	Parcelles Assainies	11
Diourbel	Bambey	19
Diourbel	Diourbel	16
Diourbel	Mbacke	20
Thies	Mbour 1	13
Thies	Thies Departement	10
Fatick	Fatick	24
Fatick	Foundiougne	24
Kaolack	Nioro	12
Total		173

[4]In terms of the main outcome measures we evaluate, the ICCs for the mathematics, ESVS, and French test scores are similar and vary between 0.12 and 0.167.

[5]Thirty-six schools on the original wait list did not meet the infrastructure requirements to receive the intervention (that is they lacked electricity). Therefore, 35 schools were added to the wait list to replace the schools who would not have been eligible. These are the replacement schools.

Table 2: Schools in the midline and endline data collection by IA and IEF

IA	IEF	Number of schools
Dakar	Almadies	9
Dakar	Grand Dakar	13
Dakar	Parcelles Assainies	10
Diourbel	Bambey	12
Diourbel	Diourbel	10
Diourbel	Mbacke	12
Thies	Mbour 1	10
Thies	Thies Departement	10
Fatick	Fatick	13
Fatick	Foundiougne	13
Kaolack	Nioro	10
Total		122

Within Sankoré schools, students were sampled from both classes with and without Sankoré kits whenever there was more than one classroom in a grade. In particular, 30 students were sampled from Sankoré classes and 20 students in non-Sankoré classes in Sankoré schools. In grade 3 (where only written tests were administered), 30 students per grade were sampled. In control schools, 30 students were sampled in each grade, with an equal proportion in each class (except schools of 4 classes, where there would be 8 and 7 students sampled per class). Tables 3 and 4 report the number of classrooms by grade in the schools in the sample during the baseline data collection (table 3) and the midline and endline data collection (table 4). The number of classes in the sampled schools did not change between the midline and endline surveys (as they both took place during the same academic year).

Table 3: Number of classes by grade during the baseline data collection

Number of Classrooms					
Grade	1	2	3	4	Total
CI	54	103	13	3	173
CP	49	115	6	3	173
Total	103	218	19	6	346

Some of the sampled students in the study change between the baseline and midline and endline surveys as students progress through primary school and change grades. The majority of students in grade 1 (CI) during the midline and endline surveys have just began primary school and, as such, were not in the sample during the baseline data collection. The exceptions are those students repeating grade 1. Moreover, between survey rounds some students transferred schools or dropped out (at least temporarily).

Table 4: Number of classes by grade during the midline and endline data collection

Number of Classrooms					
Grade	1	2	3	4	Total
CI	37	82	9	0	128
CP	30	76	11	2	119
CE1	39	82	9	3	133
CE2	43	86	9	2	140
Total	149	326	38	7	520

The students complete oral tests in grades 1 and 2 and complete written tests in grades 3 and 4. Students were also interviewed. The questionnaire focused on the child's demographic characteristics including their age, gender, primary language spoken at home, characteristics of their home, their parents, and their study habits. Descriptive statistics from the endline student questionnaire are presented in Appendix H. Teachers in sampled classrooms and school principals were also interviewed. The survey instruments, including tests, from all three rounds of data collection are included in Appendix C. The number of students sampled during the baseline data collection is presented by grade and type of school (Sankoré or non-Sankoré) in table 5. Tables 6 and 7 report the number of students having completed the tests (our main outcomes of interest) by grade and type of school.

Table 5: Number of students by grade during the baseline data collection

Number of Students			
Grade	Sankoré Schools	Non-Sankoré Schools	Total
CI	2,050	3,590	5,640
CP	2,062	3,587	5,649
Total	4,112	7,177	11,289

During the midline data collection, 4260 children in CI completed an oral test which lasted, on average, for 30 minutes. In CP, 4298 children were tested with each test taking an average of 35 minutes per child. In grade 3 (CE1), children completed written tests. Only those children in the sample who had completed an oral test during the baseline data collection were asked to take the test during the midline data collection and 3690 of these eligible children completed the test. Finally, 5665 children in CE2 who had completed a baseline written test also completed the midline written test. These statistics are presented in table 6 below.

During the endline data collection, in total, 8,369 children in CI completed an oral test which lasted, on average, for 30 minutes. In CP, 4342 children were tested with each test taking an average of 35 minutes per child. As for the midline survey, only those children in the sample in CE1 who had completed an oral test during the baseline data collection were asked to take the test during the endline data collection and 2924 of these eligible children completed the test. Finally, 5263 children in CE2 who had completed a baseline written test also completed the endline written test. These statistics are presented in table 7 below.

Table 6: Number of children tested during the midline data collection by type of school and grade

Grade	Sankoré School	Non-Sankoré School	Total
CI	2160	2100	4260
CP	1559	2739	4298
Total (oral)	3719	4839	8558
CE1	1992	1698	3690
CE2	2646	3019	5665
Total (written)	4638	4717	9355

Table 7: Number of children tested during the endline data collection by type of school and grade

Grade	Sankoré School	Non-Sankoré School	Total
CI	4367	4002	8369
CP	2268	2074	4342
Total (oral)	6635	6076	12711
CE1	1497	1427	2924
CE2	2349	2914	5263
Total (written)	3846	4341	8187

6. Impact analysis and results of the key evaluation questions

The first key research question of the evaluation is: What evidence is there that ICTs, specifically the Sankoré interactive whiteboard, improve learning outcomes? To what extent do students' test scores improve? In order to answer this question, we test whether the introduction of the project Sankoré kits have an impact on student learning as measured by test scores in French, mathematics, and education for life sciences and for life in society. We construct grade-specific z-scores, using the mean and standard deviation of the results of students in the control group schools, for the mathematics, French and ESVS test results as our primary outcomes of interest. All the results presented here were specified in the pre-analysis plan.

We collected data for students in grades 1 and 2 who were in classrooms assigned to use the Sankoré interactive whiteboards in treatment schools. These students form our treatment group. Since our endline survey was conducted approximately 1.5 years after the implementation of project Sankoré, we have two cohorts of children who were exposed to the Sankoré kits in each Sankoré school for each of grades 1 and 2. In addition to testing and interviewing these children, in those schools with more than one grade 1 or 2 classroom, we also collected data from those students in the other non-Sankoré classrooms in grades 1 and 2 in treatment schools. Furthermore, we collected data for students in grade 3 during the baseline and in grades 3 and 4 during the endline in treatment schools who were also not in classrooms equipped with the Sankoré kits. Finally, we collected data for students in grades 1, 2, 3, 4 (students in grade 4 were only interviewed during the endline survey) in non-Sankoré schools that were located near the cutoff for having been chosen to receive the Sankoré kits according to the Ministry priority list. The students from these school form the control group in the analysis. No data was imputed or excluded from the analysis.

Firstly, we use the assignment of the kits at the school-level to create our treatment and control groups. As such, we estimate an intention-to-treat estimator as not all of the students/classes in grades 1 and 2 had access to the new technology. This strategy overcomes biases that may arise if, within grades, the kits are not distributed randomly to classrooms but based on teacher and/or student characteristics. The primary (uninstrumented) difference-in-differences technique is implemented by estimating the following regression:

$$y_{ist} = \beta_0 + \beta_1 Sankoré_s + \beta_2 post_t + \beta_3 Sankoré_s * post_t + X_{is}\gamma_1 + \mu_s + \varepsilon_{ist}$$

where y_{ist} is our outcome measure of interest for student i in school s at time t, $Sankoré_s$ is an indicator for whether the school s is a treatment school, $post_t$ is an indicator for whether the observation was collected during the endline survey, after the kits had been in use for approximately 1.5 years, as opposed to during the baseline survey, X_{is} includes *Inspection de l'éducation et de la formation* fixed effects (since that is the level at which the treatment and control schools were selected). The coefficient of interest estimating the intention-to-treat effect of project Sankoré is β_3.

In order to demonstrate the plausibility of the hypotheses necessary for the use of the difference-in-differences estimation technique, two tables first presented in the baseline report (Ksoll, Mbaye, and Ssenkubuge, 2015), are included below. Table 8 provides evidence that the parallel trends assumption is not violated. The parallel trends assumption assumes that in the absence of the treatment, the treatment group would have experienced the same changes in the outcomes of interest as the control group. In this context, the parallel trend assumption specifies that the changes in test scores between grades 1 & 2 and grade 3 in treatment schools does not differ from the changes in test scores between grades 1 & 2 and grade 3 in control schools at baseline. The following regression specification was estimated:

$$y_{ist} = \beta_0 + \beta_1 Sankoré_s + \beta_2 grade1\&2_{it} + \beta_3 Sankoré_s * grade1\&2_{it} + IEF_{is}\gamma_1 + \mu_s + \varepsilon_{ist}$$

where y_{ist} is our outcome measure of interest for student i in school s at time t, $Sankoré_s$ is an indicator for whether the school s is a treatment school, $grade1\&2_{it}$ is an indicator variable for whether student i is in either grade 1 or 2 (as opposed to grade 3) in year t, and IEF_{is} are *Inspection de l'éducation et de la formation* fixed effects.The error term consists of μ_s, a common school-level error component capturing common local school characteristics, and ε_{ist}, which captures unobserved individual or idiosyncratic shocks. The error term is clustered at the school level. The coefficient of interest is β_3. An estimated value of this coefficient statistically significantly different from zero would indicate that the parallel trends assumption is unlikely to hold. In separate regressions for French, mathematics, ESVS, and an overall test score (z-scores), the estimated coefficient is not statistically significant at conventional levels, providing evidence that the parallel trends assumption is not violated.

Next, we use the assignment of the treatment at the school-level as an instrumental variable for assignment of the treatment at the classroom level (our estimation strategy for investigating average treatment effects). Using this technique, table 9 shows that, at baseline, the outcomes of the Sankoré classes in Sankoré schools do not differ relative to the non-Sankoré classes (at the same and higher level) and relative to the non-Sankoré schools. Using this technique, we, again, do not reject the parallel trends assumption.

Table 8: Parallel Trends Assumption

	(1)	(2)	(3)	(4)
	French	Math	ESVS	Total
Sankoré School	-0.078	-0.091	-0.184*	-0.353
	(0.104)	(0.103)	(0.111)	(0.305)
Grades 1 & 2	0.063	0.026	0.020	0.109
	(0.082)	(0.081)	(0.099)	(0.240)
Sankoré School * Grades 1 & 2	**0.044**	**0.016**	**0.172**	**0.233**
	(0.125)	**(0.119)**	**(0.141)**	**(0.363)**
Constant	0.523***	0.457***	0.629***	1.609***
	(0.175)	(0.148)	(0.174)	(0.467)
Observations	13,745	13,745	13,745	13,745
R-squared	0.070	0.061	0.083	0.081

Notes: Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9: IV Parallel Trends Assumption

	(1)	(2)	(3)	(4)
	French	Math	ESVS	Total
Sankoré School	-0.077	-0.091	-0.183*	-0.351
	(0.102)	(0.102)	(0.110)	(0.302)
Grades 1 & 2	0.077	0.008	0.028	0.113
	(0.077)	(0.078)	(0.098)	(0.232)
Sankoré School * Sankoré Grades 1 & 2	**0.079**	**0.026**	**0.296**	**0.402**
	(0.219)	**(0.207)**	**(0.244)**	**(0.631)**
Constant	0.524***	0.457***	0.633***	1.614***
	(0.173)	(0.147)	(0.169)	(0.457)
Observations	13,714	13,714	13,714	13,714
R-squared	0.071	0.061	0.084	0.083

Notes: Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
IV regressions. Sankoré Grades 1 & 2 instrumented by Sankoré school * Grades 1&2

Though our identification strategy does not rely on our treatment and comparison groups being identical at baseline (but on the parallel trends assumption), in tables 10-12, we show few statistically significant differences between treatment and control groups at baseline in test scores, household characteristics, and school characteristics. Test score differences are presented in table 10. The baseline data show that there are no statistically significant difference in test scores between Sankoré and non Sankoré schools in all three subjects. This is evident from the p-values from a two-sided test for the equality of means for each test score which are all above 0.10.

Table 10: Mean Baseline Test Scores by Treatment Status

	Sankoré	Non Sankoré	p-value
French Test Score	40.905	39.880	0.131
Math Test Score	35.523	35.610	0.846
ESVS Test Score	42.505	40.948	0.106

Notes: Test Scores out of 100.

Table 11 compares baseline asset ownership of students' households assigned to the treatment and control groups. In all asset categories except one, there is no statistically significant difference between households of children in Sankoré and non-Sankoré schools. The sole exception is in computer ownership where we find that children in Sankoré schools are 3% more likely to own a functional computer at home compared to those in non-Sankoré schools. This result is significant at the 10% level. When we investigate reported computer use outside of school, 7 percent of Sankoré students and 8 percent of non-Sankoré students use computers at baseline, with no statistically significant difference between the two. Based on the school-level characteristics (table 12), there does not seem to be strong evidence that, at baseline, schools are significantly different between treatment and control groups.

Table 11: Baseline Asset Ownership by Treatment Status

Household Asset Ownership	Sankoré	Non Sankoré	Overall	p-value	Urban	Peri Urban	Rural
	Mean	Mean	Mean	p-value	Mean	Mean	Mean
Refrigerator/Freezer	0.292	0.283	0.286	0.661	0.382	0.291	0.181
Television	0.653	0.601	0.621	0.134	0.606	0.651	0.478
Fan	0.466	0.449	0.455	0.626	0.529	0.520	0.301
Electric Iron	0.082	0.086	0.085	0.970	0.311	0.136	0.061
Phone	0.122	0.114	0.117	0.473	0.304	0.154	0.078
Vehicle/Truck/Tractor	0.133	0.126	0.129	0.926	0.303	0.200	0.090
Computer	0.199	0.169	0.181	0.052*	0.273	0.120	0.046

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table 12: Baseline School Characteristics by Treatment Status

	Mean of Control	Difference Treatment-Control	Difference Standard Error
Distance to Dakar (km)	101.3	8.217*	(4.189)
Distance to nearest Urban Center (km)	10.17	6.376**	(3.045)
City/Village Population	45791	9,368	(19,866)
Downtown/Post Office/or Health Center in Vicinity (Yes=1, 2=No)	1.063	-0.0471	(0.0479)
School has Electricity (Yes=1, 2=No)	1.540	-0.0309	(0.0888)
School has Tap Water (Yes=1, 2=No)	1.079	-0.0584	(0.0405)
Age of Oldest Facilities in School (years)	37.19	-3.390	(3.355)
Age of Newest Facilities in School (years)	6.556	2.117	(1.385)
Public Road/Highway in Vicinity (Yes=1, 2=No)	1.698	-0.0606	(0.0825)
Number of Teachers	14.14	0.0389	(0.700)
Number of Students	577.4	34.64	(50.35)
Number of Classrooms	11.33	-0.234	(0.532)
At Least One Multigrade Classroom (Yes=1, 2=No)	1.968	-0.00227	(0.0427)
Other Program Participation in Past 5 Years (Yes=1, 2=No)	1.651	-0.0944	(0.0896)
Number of Programs	1.500	-0.183	(0.324)
School Library (Yes=1, 2=No)	1.540	0.0568	(0.0897)
Number of French Books in Library	181.3	-54.24	(40.90)
Number of Mathematics Books in Library	89.27	-12.40	(31.81)
Number of School Desks	233.1	1.587	(15.60)
Average Length of School Desks (cm)	112.3	0.653	(2.352)
Number of Children per Desk	2.556	-0.0116	(0.101)
Average Age of School Desks (years)	13.43	2.029	(1.785)
Working Printer (Yes=1, 2=No)	1.698	-0.196**	(0.0922)
Working Copy Machine (Yes=1, 2=No)	1.825	-0.0635	(0.0759)
Working Scanner (Yes=1, 2=No)	1.841	0.00879	(0.0693)
Working Camera (Yes=1, 2=No)	2.000	-0.0266	(0.0255)
Number of Functional Desktops	1.825	1.056	(0.857)

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 13 presents the results of this difference-in-difference estimation using the students in grades 1 and 2 in non-Sankoré schools as the control group. Column 1 of the table presents the results for the French test z-score for students in grades 1 and 2 (controlling for grade). We find no statistically significant impact of the Sankoré kits on the French test scores for grades 1 and 2. Columns 2 and 3 replicates the difference-in-difference estimates separately for grade 1 (column 2) and grade 2 (column 3). Again, we find no statistically significant impact of the Sankoré program. Columns 4 through 6 replicate columns 1 through 3 using the math test z-score as the outcome of interest instead of the French test score. Here we find a statistically significant positive impact of the Sankoré kits on math learning. For grades 1 and 2 together (column 4), we find a statistically significant increase in math test scores of 0.186 standard deviations (relative to the control group) for those students in schools assigned to receive the Sankoré kits. This impact is statistically significant at the 10% level in grade 1 (0.208 – column 5) but not for grade 2 (0.151 – column 6). The final three columns of table 21 repeat the estimations for the ESVS test scores. As for the results from the French tests, we find no statistically significant impact of the Sankoré project.

Tables 14 through 19 investigate heterogeneity in the intention-to-treat estimates by gender (tables 14-16) and urban/rural status of the school (tables 17-19). Consistent with the results from table 13, we find no statistically significant impacts of the Sankoré project on French test scores for either girls or boys (table 14). Table 15 shows positive impacts of the Sankoré project on math test scores. We find a 0.219 standard deviation increase in math test scores for girls in grades 1 and 2 (column 1); 0.198 for girls in grade 1 (column 2) and 0.236 for girls in grade 2 (column 3). We also find a statistically significant (at the 10% level) 0.221 standard deviation increase in math test scores for boys in grade 1 (column 5). We find a statistically significant increase in ESVS test scores for girls in grades 1 and 2 (column 1, table 16), driven entirely by a statistically significant 0.256 standard deviation increase in girls test scores in grade 2 (column 3, table 16)). This is, perhaps, not surprising given students in grade 1 in Sankoré classrooms had only had access to the program for 2 to three months at the time of the endline data collection. Students in grade 2 who were assigned to a Sankoré classroom in both grades 1 and 2 would have had access to the program in grade 1 and the additional two to three months in grade 2. We find no impact of the Sankoré program on ESVS test scores of boys.

Tables 17-19 investigate heterogeneity in the intention-to-treat estimates by urban/rural status of the school by dividing the sample of schools into urban, peri-urban, and rural. We find that the overall effects shown in table 13 are driven entirely by large statistically significant positive impacts in urban schools. We find statistically significant positive impacts on all three test scores for both grades 1 and 2 ranging from a 0.353 standard deviation increase in French test scores for grades 1 and 2 to a 0.539 standard deviation increase in ESVS test scores in grade 1. There are several possible explanations for our differential impact findings by location. Firstly, electricity is likely more reliable in urban areas. Secondly, teachers and students may have been more familiar with technology similar to the Sankoré kits in urban areas before the introduction of the program. Another possibility is that teachers in urban areas are, in general, better trained and educated and, therefore, better able to integrate the kits into their teaching. Unfortunately, we do not have the data necessary to fully understand the exact reasons for these heterogeneous effects.

Table 13: Difference-in-difference estimates for test z-scores (grades 1 & 2)

	(1) French Test Grades 1 & 2	(2) French Test Grade 1	(3) French Test Grade 2	(4) Math Test Grades 1 & 2	(5) Math Test Grade 1	(6) Math Test Grade 2	(7) ESVS Test Grades 1 & 2	(8) ESVS Test Grade 1	(9) ESVS Test Grade 2
Sankoré	0.051	0.032	0.073	-0.048	-0.056	-0.032	0.031	0.018	0.052
	(0.093)	(0.106)	(0.102)	(0.080)	(0.091)	(0.091)	(0.097)	(0.114)	(0.101)
Post	-0.007	-0.016	0.006	-0.004	-0.008	0.004	-0.007	-0.010	0.002
	(0.068)	(0.086)	(0.077)	(0.068)	(0.079)	(0.079)	(0.080)	(0.087)	(0.090)
Sankoré*post	0.109	0.128	0.085	0.186**	0.208*	0.151	0.185	0.170	0.188
	(0.095)	(0.122)	(0.106)	(0.090)	(0.111)	(0.105)	(0.115)	(0.138)	(0.120)
Grade 2	0.007			0.006			0.031		
	(0.026)			(0.028)			(0.030)		
Constant	0.297***	0.177	0.418***	0.070	0.047	0.094	0.258***	0.208*	0.335***
	(0.106)	(0.121)	(0.117)	(0.097)	(0.113)	(0.095)	(0.090)	(0.110)	(0.089)
Observations	14,713	7,366	7,347	14,713	7,366	7,347	14,713	7,366	7,347
R^2	0.023	0.025	0.028	0.017	0.026	0.019	0.038	0.044	0.041

Note: Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 14: Difference-in-difference estimates for French test z-scores by gender (grades 1 & 2)

	(1) Girls Grades 1 & 2	(2) Girls Grade 1	(3) Girls Grade 2	(4) Boys Grades 1 & 2	(5) Boys Grade 1	(6) Boys Grade 2
Sankoré	0.025	0.014	0.034	0.083	0.053	0.123
	(0.097)	(0.110)	(0.110)	(0.095)	(0.115)	(0.101)
Post	-0.004	0.027	-0.030	-0.008	-0.066	0.052
	(0.074)	(0.096)	(0.085)	(0.070)	(0.088)	(0.080)
Sankoré*post	0.164	0.154	0.176	0.048	0.101	-0.017
	(0.103)	(0.131)	(0.120)	(0.096)	(0.127)	(0.110)
Grade 2	0.039			-0.026		
	(0.028)			(0.033)		
Constant	0.331***	0.194	0.505***	0.257**	0.156	0.322***
	(0.115)	(0.139)	(0.122)	(0.108)	(0.133)	(0.119)
Observations	7,675	3,839	3,836	7,038	3,527	3,511
R^2	0.029	0.028	0.036	0.021	0.027	0.024

Note: Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 15: Difference-in-difference estimates for math test z-scores by gender (grades 1 & 2)

	(1) Girls Grades 1 & 2	(2) Girls Grade 1	(3) Girls Grade 2	(4) Boys Grades 1 & 2	(5) Boys Grade 1	(6) Boys Grade 2
Sankoré	-0.049	-0.038	-0.060	-0.047	-0.077	-0.001
	(0.084)	(0.092)	(0.102)	(0.083)	(0.101)	(0.092)
Post	0.033	0.073	-0.006	-0.048	-0.104	0.014
	(0.072)	(0.084)	(0.087)	(0.072)	(0.090)	(0.083)
Sankoré*post	0.219**	0.198*	0.236*	0.153	0.221*	0.061
	(0.096)	(0.114)	(0.122)	(0.094)	(0.122)	(0.110)
Grade 2	0.044			-0.035		
	(0.031)			(0.031)		
Constant	0.039	-0.017	0.137	0.106	0.123	0.050
	(0.106)	(0.131)	(0.109)	(0.104)	(0.128)	(0.094)
Observations	7,675	3,839	3,836	7,038	3,527	3,511
R^2	0.022	0.034	0.023	0.017	0.027	0.018

Note: Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 16: Difference-in-difference estimates for ESVS test z-scores by gender (grades 1 & 2)

	(1)	(2)	(3)	(4)	(5)	(6)
	Girls	Girls	Girls	Boys	Boys	Boys
	Grades 1 & 2	Grade 1	Grade 2	Grades 1 & 2	Grade 1	Grade 2
Sankoré	0.035	0.048	0.020	0.026	-0.016	0.088
	(0.102)	(0.118)	(0.109)	(0.099)	(0.118)	(0.104)
Post	0.009	0.058	-0.035	-0.025	-0.089	0.045
	(0.081)	(0.093)	(0.096)	(0.086)	(0.092)	(0.096)
Sankoré*post	0.202*	0.148	0.256*	0.168	0.198	0.112
	(0.120)	(0.144)	(0.133)	(0.120)	(0.145)	(0.128)
Grade 2	0.074**			-0.015		
	(0.033)			(0.035)		
Constant	0.262***	0.205*	0.390***	0.255***	0.211*	0.275***
	(0.098)	(0.116)	(0.103)	(0.095)	(0.126)	(0.091)
Observations	7,675	3,839	3,836	7,038	3,527	3,511
R^2	0.042	0.051	0.043	0.036	0.044	0.040

Note: Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 17: Difference-in-difference estimates for French test z-scores by school location status (grades 1 & 2)

	1 Urban Grades 1 & 2	2 Urban Grade 1	3 Urban Grade 2	4 Peri-Urban Grades 1 & 2	5 Peri-Urban Grade 1	6 Peri-Urban Grade 2	7 Rural Grades 1 & 2	8 Rural Grade 1	9 Rural Grade 2
Sankoré	-0.284**	-0.325**	-0.259*	0.459**	0.358	0.614***	0.126	0.081	0.180
	(0.126)	(0.137)	(0.148)	(0.172)	(0.239)	(0.169)	(0.151)	(0.173)	(0.158)
Post	-0.158	-0.048	-0.271**	-0.059	-0.176	0.085	0.194**	0.091	0.307***
	(0.110)	(0.128)	(0.123)	(0.221)	(0.284)	(0.189)	(0.080)	(0.129)	(0.074)
Sankoré*post	0.353**	0.363**	0.359**	-0.195	-0.106	-0.309	0.001	0.060	-0.066
	(0.140)	(0.169)	(0.151)	(0.233)	(0.315)	(0.214)	(0.139)	(0.183)	(0.161)
Grade 2	-0.014			0.038			0.023		
	(0.040)			(0.059)			(0.042)		
Constant	0.448***	0.269*	0.613***	0.356	0.028	0.759***	-0.440***	-0.735***	-0.515***
	(0.135)	(0.140)	(0.163)	(0.213)	(0.222)	(0.203)	(0.120)	(0.064)	(0.123)
Observations	6,715	3,339	3,376	2,891	1,440	1,451	5,107	2,587	2,520
R^2	0.035	0.040	0.046	0.054	0.052	0.075	0.042	0.034	0.065

Note: Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 18: Difference-in-difference estimates for math test z-scores by school location status (grades 1 & 2)

	1 Urban Grades 1 & 2	2 Urban Grade 1	3 Urban Grade 2	4 Peri-Urban Grades 1 & 2	5 Peri-Urban Grade 1	6 Peri-Urban Grade 2	7 Rural Grades 1 & 2	8 Rural Grade 1	9 Rural Grade 2
Sankoré	-0.326***	-0.394***	-0.242*	0.361**	0.282	0.451***	0.004	0.060	-0.067
	(0.112)	(0.135)	(0.123)	(0.138)	(0.180)	(0.168)	(0.124)	(0.146)	(0.148)
Post	-0.138	-0.099	-0.165*	0.061	-0.112	0.237	0.158*	0.139	0.172
	(0.100)	(0.128)	(0.092)	(0.130)	(0.161)	(0.145)	(0.093)	(0.099)	(0.129)
Sankoré*post	0.404***	0.423**	0.359***	-0.149	0.029	-0.335	0.101	0.127	0.097
	(0.123)	(0.163)	(0.121)	(0.199)	(0.251)	(0.227)	(0.126)	(0.152)	(0.174)
Grade 2	-0.068*			0.073			0.060		
	(0.041)			(0.054)			(0.042)		
Constant	0.239**	0.167	0.234**	-0.013	0.009	0.060	-0.263**	-0.492***	-0.141
	(0.117)	(0.135)	(0.114)	(0.155)	(0.135)	(0.187)	(0.109)	(0.050)	(0.112)
Observations	6,715	3,339	3,376	2,891	1,440	1,451	5,107	2,587	2,520
R^2	0.038	0.042	0.050	0.044	0.054	0.046	0.052	0.051	0.060

Note: Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 19: Difference-in-difference estimates for ESVS test z-scores by school location status (grades 1 & 2)

	1	2	3	4	5	6	7	8	9
	Urban	Urban	Urban	Peri-Urban	Peri-Urban	Peri-Urban	Rural	Rural	Rural
	Grades 1 & 2	Grade 1	Grade 2	Grades 1 & 2	Grade 1	Grade 2	Grades 1 & 2	Grade 1	Grade 2
Sankoré	-0.397***	-0.463***	-0.331**	0.563***	0.550***	0.611***	0.170	0.108	0.242
	(0.138)	(0.153)	(0.153)	(0.170)	(0.203)	(0.192)	(0.139)	(0.177)	(0.147)
Post	-0.291**	-0.215*	-0.362***	0.154	0.079	0.268	0.247**	0.155	0.348***
	(0.118)	(0.120)	(0.131)	(0.176)	(0.228)	(0.167)	(0.093)	(0.134)	(0.094)
Sankoré*post	0.532***	0.539***	0.518***	-0.290	-0.347	-0.245	0.066	0.150	-0.031
	(0.157)	(0.169)	(0.167)	(0.228)	(0.273)	(0.246)	(0.159)	(0.221)	(0.169)
Grade 2	-0.051			0.091			0.101**		
	(0.042)			(0.065)			(0.051)		
Constant	0.517***	0.414***	0.567***	0.733***	0.515*	1.066***	-0.857***	-0.747***	-0.833***
	(0.117)	(0.120)	(0.127)	(0.166)	(0.263)	(0.051)	(0.109)	(0.067)	(0.110)
Observations	6,715	3,339	3,376	2,891	1,440	1,451	5,107	2,587	2,520
R^2	0.055	0.064	0.058	0.126	0.131	0.138	0.058	0.045	0.081

Note: Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Next, we instrument being in a classroom that received a Sankoré kit by being in a Sankoré school after the implementation of the intervention. This allows us to identify the average treatment effect on the treated under the assumption that there are no spillover effects of the program to non-Sankoré classes in Sankoré schools.

In the instrumented regression, the variable $Sankoré_s$* $post_t$ in equation (1) is no longer defined at the school–level but indicates whether or not the student was in a Sankoré classroom after the program's implementation. We instrument for being in a Sankoré classroom after the implementation of the program with the variable as defined at the school level ($Sankoré_s$* $post_t$). The variable $Sankoré_s$ is also defined at the classroom level and is instrumented in the estimation with the assignment of the treatment at the school level. The results are presented in table 20.

Consistent with the intent-to-treat estimated effects, we find positive and statistically significant impacts of the Sankoré kits on math test scores. As expected, the estimated average treatment effects are larger in magnitude than the ITT estimates. We find a statistically significant increase in math test scores in grades 1 and 2 together (column 4 – 0.300) and in both grades when estimated separately (0.257 for grade 1 – column 5 and 0.386 for grade 2 – column 6). While the ITT estimates for the ESVS test scores are not statistically significant (table 28), we do find a statistically significant ATT estimate for ESVS test scores in grade 2 of 0.570 standard deviations (column 9).

In these two evaluation strategies, we did not explicitly include the grade 3 or 4 students. However, at the time of the endline survey, the majority of the students in grade 2 during the baseline were in grade 3 at the endline. The Sankoré kits were not intended to be used in grade 3 classrooms (though as discussed previously some treatment schools did not strictly adhere to the implementation guidelines). In table 21, we present the results for grade 3 students. Those assigned to treatment schools may have been assigned to Sankoré classrooms in grade 2 but had been in grade 3 (without the use of the Sankoré kits) for two to three months at the time of the endline testing. Therefore, they allow us to investigate, in the short-run, whether the positive impacts of the Sankoré program in grade 2 persist after the students stop being exposed to the program. We find large statistically significant positive impacts of the Sankoré program for students in grade 3 at the endline data collection varying from a 0.264 standard deviation increase in French test scores to a 0.371 standard deviation increase in ESVS test scores. This suggests, at least in the short run, program impacts persist.

Table 20: Instrumental variable difference-in-difference estimates for test z-scores (grades 1 & 2)

	(1) French Test Grades 1 & 2	(2) French Test Grade 1	(3) French Test Grade 2	(4) Math Test Grades 1 & 2	(5) Math Test Grade 1	(6) Math Test Grade 2	(7) ESVS Test Grades 1 & 2	(8) ESVS Test Grade 1	(9) ESVS Test Grade 2
Sankoré classroom	0.083	0.046	0.137	-0.078	-0.084	-0.052	0.051	0.025	0.102
	(0.150)	(0.156)	(0.181)	(0.129)	(0.134)	(0.162)	(0.157)	(0.168)	(0.178)
Sankoré classroom*post	0.175	0.135	0.307	0.300**	0.257*	0.386*	0.298	0.188	0.570**
	(0.154)	(0.171)	(0.220)	(0.145)	(0.152)	(0.217)	(0.186)	(0.192)	(0.250)
Post	-0.019	-0.032	0.006	-0.014	-0.023	0.003	-0.023	-0.029	0.001
	(0.069)	(0.089)	(0.077)	(0.070)	(0.083)	(0.078)	(0.083)	(0.091)	(0.089)
Grade 2	0.060*			0.048			0.100***		
	(0.032)			(0.033)			(0.037)		
Constant	0.273**	0.177	0.432***	0.053	0.044	0.112	0.227**	0.207*	0.361***
	(0.107)	(0.118)	(0.123)	(0.099)	(0.112)	(0.103)	(0.092)	(0.109)	(0.094)
Observations	14,713	7,366	7,347	14,713	7,366	7,347	14,713	7,366	7,347
R^2	0.021	0.025	0.016	0.016	0.026	0.015	0.032	0.044	0.018

Note: Sankoré classroom instrumented using school-level treatment. Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 21: Difference-in-difference estimates for grade 3 students

	(1) French Test	(2) Math Test	(3) ESVS Test
Sankoré	-0.053	-0.077	-0.214**
	(0.092)	(0.091)	(0.093)
Post	0.006	-0.005	-0.012
	(0.079)	(0.081)	(0.082)
Sankoré*post	0.264**	0.277**	0.371***
	(0.115)	(0.125)	(0.121)
Constant	0.395***	0.384***	0.295*
	(0.147)	(0.120)	(0.175)
Observations	7,851	7,851	7,851
R^2	0.121	0.111	0.096

Note: Robust standard errors clustered at the school level in parentheses. Regressions include *Inspection de l'éducation et de la formation* fixed effects. *** p<0.01, ** p<0.05, * p<0.1

7. Conclusion

The findings of this study suggest large positive impacts of the Sankoré project which are concentrated in urban schools. Unfortunately, the unavailability of sufficient cost data prevent us from both evaluating the cost effectiveness of the project and from making a precise policy recommendation. However, our findings do clearly suggest that if the Sankoré project is to be extended, this should only be done in urban areas. Without additional changes to training, infrastructure, or other complementary learning inputs, the project is not likely to be successful in peri-urban or rural schools. This implies increasing disparities between rural and urban schools which should be considered by policy makers when determining project Sankoré's future in Senegal. Future research should include the collection of sufficient cost data for a complete cost-benefit analysis and should investigate the mechanisms causing the heterogeneity in results between urban and other schools.

A cost-benefit analysis of a continuous training program, specifically for teachers, after the initial training, may be useful. If Senegal is to adopt interactive whiteboards as an integral part of the education system, teacher education should include additional ICT integration. Finally, any continued implementation of project Sankoré should be carefully and continuously monitored.

Policy makers may also want to consider alternative ways of scaling up the project. Such alternatives should be rigorously evaluated before being implemented on a large scale. Given limited funding, providing interactive whiteboards to fewer schools, with all grades using them is one possibility. Another is maintaining two interactive whiteboards per school, as originally planned, but additionally implementing an effective system for caring for and repairing them in a timely manner.

References

Beauchamp, G. and Parkinson, J., 2005. Beyond the 'wow' factor: Developing interactivity with the interactive whiteboard. *School Science Review*, 86(316), pp.97-103.

Berlinski, S. and Busso, M., 2015. *Challenges in Educational Reform: An Experiment on Active Learning in Mathematics*. IDB Working Paper Series IDB-WP-561.

Cristia, J., Ibarrarán, P., Cueto, S., Santiago, A. and Severín, E., 2017. Technology and Child Development: Evidence from the One Laptop per Child Program. *American Economic Journal: Applied Economics, 9(3),* pp.295-320.

Diagne, B., 2016. Report on the Sankore midline restitution workshop held at the National Center for Education Resources (CNRE in French) in Dakar on April 27th, 2016.

Glaser, B.G. and Strauss, A.L., 1967. The discovery of Grounded Theory: Strategies for Qualitative Theory.

Goodrick, D., 2014. *Comparative Case Studies*. Methodological Briefs: Impact Evaluation 9, UNICEF Office of Research, Florence.

Hall, I. and Higgins, S., 2005. Primary school students' perceptions of interactive whiteboards. *Journal of Computer Assisted Learning*, 21(2), pp.102-117.

Higgins, S., Beauchamp, G. and Miller, D., 2007. Reviewing the literature on interactive whiteboards. *Learning, Media and Technology*, 32(3), pp.213-225.

Higgins, S., Falzon, C., Hall, I., Moseley, D., Smith, F., Smith, H. and Wall, K., 2005. *Embedding ICT in the literacy and numeracy strategies: final report*. Project Report. University of Newcastle upon Tyne, Newcastle.

Ksoll, C., Mbaye, S. and Ssenkubuge, I., 2015. *Project Sankoré: Evaluation Baseline Report*.

Mawoyo, M., 2015. *Report of the Sankore Impact Evaluation Midline Data Collection Quality Assurance Visit*.

McKenzie, D., 2012. Beyond baseline and follow-up: The case for more T in experiments. *Journal of Development Economics*, 99(2), pp.210-221.

Ndiaye, A., 2014. *Présentation du projet Sankoré Sénégal : bilan d'étape de la deuxième phase*. Impact evaluation workshop presentation, 4 August 2014 at République du Sénégal, Ministère de l'Education nationale, Dakar, Senegal.

Snilstveit, B., Stevenson, J., Menon, R., Phillips, D., Gallagher, E., Geleen, M., Jobse, H., Schmidt, T. and Jimenez, E. 2016. *The impact of education programmes on learning and school participation in low-and middle-income countries: a systematic review summary report*, 3ie Systematic Review Summary 7. London: International Initiative for Impact Evaluation (3ie).Open-Sankoré, 2016. Open-Sankoré : The Free Interactive Whiteboard Software. Viewed 2 February 2017, < http://open-sankore.org/en/about>.

Osín, L., 1998. Computers in Education in Developing Countries: Why and How?.

République du Sénégal, Ministère de l'Education nationale, 2014a. *Projet Sankoré Sénégal : bilan d'étape de la deuxième phase, juillet 2013-juin 2014*.

République du Sénégal, Ministère de l'Education nationale, 2014b. Projet Sankoré Sénégal : cadre logique.

République du Sénégal, Ministère de l'Education nationale, La Direction de la Planification et de la Réforme de l'Education, 2013. *DEPRE 2013*.

Trucano, M., 2014. *In search of the ideal educational technology device for developing countries*. Viewed 2 February 2017, <http://blogs.worldbank.org/edutech/ideal-educational-technology-device>.

Türel, Y. K. and Johnson, T. E., 2012. Teachers' Belief and Use of Interactive Whiteboards for Teaching and Learning. *Educational Technology & Society*, 15 (1), 381–394.

United Nations, 2015a. The Millennium Development Goals Report 2015. United Nations Publications.

United Nations, 2015b. Follow-up to the outcome of the Millennium Summit. A/69/L.85, United Nations General Assembly.

World Bank, 2013. Country Partnership Strategy (FY2013–2017) for the Republic of Senegal.

World Bank, 2016. *Education and Technology*. Viewed 2 February 2017, <http://www.worldbank.org/en/topic/edutech/overview#1>.

World Bank, 2017. World Development Indicators: Expenditure on education as % of total government expenditure (%) [Data file]. Retrieved from https://data.worldbank.org/indicator/SE.XPD.TOTL.GB.ZS.