The impacts of interactive smartboards on learning achievement in Senegalese primary schools

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Note to readers

This final impact evaluation grantee report has been submitted in partial fulfilment of the requirements of grant PW2.14 awarded under Policy Window 2. 3ie is making it available to the public in this final report version as it was received. There were a number of implementation challenges which makes it difficult to understand the large and significant results. The authors suggest that most of the positive impacts were driven by the urban schools but the qualitative studies did not provide any insight into the channels of impact nor on the key factors that might have driven the urban rural divide.

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Executive Summary

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; our population of interest. 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.

We expect the provision of Sankoré kits to motivate students and transform their learning experience. The transformed learning experience is expected to lead to improved overall performance in all subjects due to the combination of more effective instruction and sharpened learning abilities.

The research methodology uses a difference-in-difference evaluation strategy to investigate the intention-to-treat impacts of the project. We compare changes in student learning outcomes before and after the introduction of the Sankoré program in schools receiving the program to changes in these outcomes for students in comparison schools who did not receive the program (nor any additional intervention) during the same time period. 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 also use an instrumental variable identification strategy to estimate the average treatment effect on the treated of project Sankoré. We instrument being in a classroom that received a Sankoré kit by being in a Sankoré school after the implementation of the intervention. Participants (principals, teachers, and students) were aware whether they were in a treatment or a comparison school.

Though much of the qualitative evidence suggested difficulties in the implementation of the project, including in the training of teachers and technicians and in repairing broken material, our quantitative evidence suggests, on average, large positive impacts of the program on student learning, primarily for mathematics in urban schools. For grades 1 and 2 together, we find a statistically significant increase in math test scores of 0.186 standard deviations (relative to the comparison group). This increase is driven entirely by urban schools where the increase in math test scores for grades 1 & 2 is 0.404 standard deviations. Using our instrumental variable estimation strategy, we find positive and statistically significant impacts of the Sankoré kits on both math and ESVS test scores. As expected, the estimated average treatment effects are larger in magnitude than the ITT estimates. We find a statistically significant increase in ESVS test scores in grade 2

of 0.570 standard deviations and a 0.300 statistically significant increase in math test scores in grades 1 and 2. Moreover, these benefits persist into grade 3. We find large statistically significant positive intent-to-treat 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 and a 0.371 standard deviation increase in ESVS test scores.

These results suggest large positive impacts of the Sankoré project which are concentrated in urban schools. Unfortunately, the unavailability of sufficient cost data prevents 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.

The internal validity of the study rests on the assumption that in the absence of the Sankoré project, students exposed to the Sankoré equipment would have progressed as did the students in comparison group schools. Although this assumption is impossible to test, we do provide evidence from grade 3 students suggesting that it likely holds. The external validity of the study rests on the comparability of primary schools in Senegal to primary schools in other contexts. To the extent that without the project, many other developing countries have similar levels of primary school learning levels, schooling inputs, teacher training, teacher and student familiarity with technology, and school infrastructure, including access to and the pricing of electricity, we would expect to find similar positive impacts of the introduction of interactive whiteboards with digital content if the program is implemented in a similar manner to the Sankoré project evaluated here.

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Abbreviations and Acronyms

3ie	International Initiative for Impact Evaluation
CI	Grade 1 (*Cours d'initiation*)
CRDES	Economic and Social Development Research Centre (*Centre de Recherche pour le Développement Economique et Social)*
CP	Grade 2 (*Cours préparatoire*)
DD	Difference-in-differences
ESVS	Education in Science and Social Life (*Education à la science et à la vie sociale*)
FG	Focus Group
IA	Academic Inspectorates *(Inspections d'Académie)*
ICC	Intra-cluster correlation
ICT	Information and Communications Technology
IEF	Education and Training Inspectorate (*Inspection de l'éducation et de la formation*, roughly equivalent to a District Education Office)
IE	Impact Evaluation
MDG	Millennium Development Goal
MoE	Ministry of Education
NEPAD	New Partnership for Africa's Development
NGOs	Non-governmental Organizations
OER	Open Educational Resources
RD	Regression Discontinuity
SMART	Specific, Measurable, Achievable, Realistic and Time bound
TI	Teacher interview
UNESCO BREDA	The Documentation Centre of the Dakar Regional Office of The United Nations Educational, Scientific and Cultural Organization

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. In June 2011, the government of Senegal received the equipment for 345 digital classrooms. 279 of the 345 Sankoré kits were distributed to schools meeting safety, accessibility, and electricity requirements in five Academic Inspectorates *(Inspections d'Académie)* (Dakar (4 classrooms), Diourbel (52 classrooms), Kaolack (68 classrooms), Thiès (87 classrooms), and Fatick (54 classrooms), with 14 remaining kits unknown), 40 kits were distributed to administrative and training structures, and 26 were distributed to the Islamic Institute, Dakar. Regional and national training was implemented from June through December 2011. The installation of the kits took place between January and April 2012. The school selection criteria for receiving a Sankoré kit during the first phase of the project was identical to that of the second phase and is described in detail below. Moreover, 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[1] *Inspections d'Académie* (similar to the regional 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.

In consultation with the New Partnership for Africa's Development (NEPAD) agency, through its e-Africa e-schools initiative, the International Initiative for Impact Evaluation (3ie), contracted Neil Butcher and Associates (NBA) to evaluate the project in Senegal. 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[2]. 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

[1]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*.

[2]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)).

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.

Moreover, a qualitative component of the research design was implemented. A case study methodology was used with 20 case studies selected from the 122 schools that constitute the sample for the evaluation, comprising 14 schools receiving the Sankoré kits and six comparison schools.

The key research questions of the evaluation are:

1. What evidence is there that interactive whiteboards improve learning outcomes? To what extent do students' test scores improve?
2. How cost effective is this model of interactive whiteboards?
3. What evidence exists of improved access to and usage of interactive whiteboards in participating schools; by teachers and by students?
4. How can similar future projects be improved using lessons that have been learned from this project?

Given the literature cited previously, a priori the impact of the Sankoré kits on student test scores is ambiguous. Previously conducted studies have found either negative (Berlinksi & Busso, 2015) or negligible (Higgins et. al., 2005) impacts of similar interactive whiteboard interventions. The cost effectiveness of this project is also ambiguous. Firstly, because the impacts are ambiguous and secondly because such interventions can be quite costly. For example, Trucano (2014) notes the following five challenges to the effective implementation of technology interventions in developing countries: Affordability, accessibility, connectivity, electricity, and usability. Though most existing studies do not find positive impacts of interactive whiteboards on student achievement, they do find improved access and usage of computer technologies in participating schools by both students and teachers (see Higgins et. al. (2007) for a review). Therefore, one may expect similar positive impacts of the Sankoré intervention in Senegal. However, these studies were all conducted in developed countries. As suggested by Trucano (2014), electricity and usability may be important issues in primary schools in Senegal, leading, again, to ambiguous results regarding access and usage of computer technologies. Snilstveit et. al. (2016) present a systematic review of the findings of 16 different computer-assisted learning programs (laptops or computer labs but not interactive whiteboards) in 9 low- and middle-income countries and also find mixed results. Overall, no positive effects on language arts and composite test scores are observed while some studies did find some positive impacts on math achievement. The authors conclude that there is a lot of variation in the

impacts between programs. Our final research question will use both the quantitative and qualitative results to provide policy recommendations regarding the introduction of interactive whiteboards.

As previously mentioned, 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 report is structured as follows. Section 2 describes in detail the project Sankoré intervention and discusses the theory of change and the research hypotheses. 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 builds on the description of the intervention of section 2 and discusses the implementation of the program in practice. Section 7 presents the results of the quantitative analysis using the difference-in-difference identification strategy and section 8 discusses these findings. Section 9 concludes with policy recommendations based on the findings.

2. Intervention, theory of change and research hypotheses

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.

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.

Four training sessions were organized by the Cultural Services Department of the French Embassy in Senegal. During the first training session, 50 Ministry of Education officials and other participants (the number of other participants at this training session is not known to the research team) were

trained in the installation of the digital classrooms and in the transfer of ownership of the project. The second training focused on pedagogical aspects of the program and addressed the use of digital resources in the classroom and on the creation of these resources. During this training 12 Ministry of Education employees (six at the central level and six from regional offices) were trained. During the third training session, two Ministry of Education officials were trained on the Open-Sankoré multiplatform open-source portal. In total, 64 officials from the Basic Youth and Adult Education (*l'Education de Base des Jeunes et des Adultes*) Department of the Ministry of Education, both at the central and regional offices, were provided with training.

In addition, the Inter-Ministerial Delegation for Digital Education in Africa (*Délégation Interministérielle à l'Education Numérique en Afrique*) provided and funded the final training session training for the 9 Academic Inspectorates involved in the second phase of Project Sankoré. This training took place May 10-13, 2014 and 50 individuals from the Academic Inspectorates and from the central office of the Ministry of Education took part. Moreover, some of these individually had also received training for the Sankoré project in 2011 during the first phase of the project. In total, 114 officials from the Ministry of Education were provided with training during this phase of the project.

This team of trained officials supervised training sessions held in each Academic Inspectorate, in collaboration with the Directorate of General Administration and Equipment (*Direction de l'Administration Générale et de l'Equipement*) of the Ministry of Education. The duration of these training sessions was between two and five days.

The specific objectives of project Sankoré include:

- To provide resources for the effective use of interactive whiteboards, including project kits and open software.
- To provide initial and ongoing training on digital pedagogy and the development of open educational resources.
- To strengthen the capacity of technicians in the installation and maintenance of Sankoré kits.
- To create a national repository for open educational resources.
- To conduct research to learn from the implementation of Project Sankoré and improve the project.
- To orientate students on the use of interactive whiteboards.
- To sensitize the community on the importance of ICT in education.

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 (*education à la science et à la vie sociale*, ESVS). We construct z-scores for the mathematics, French, and ESVS test results as our primary outcomes of interest. We further investigate heterogeneous treatment effects of the project by gender of the student, by grade, and by school location.

Project Sankoré concept and evaluation documents do not explicitly specify the theory of change. However, the project goal and objectives, activities, outputs, outcomes and assumptions are specified in a project log frame. The research team developed the theory of change retrospectively as outlined below and summarized graphically in Figure 2.

The project goal is to improve learning outcomes through the use of interactive whiteboards. The expected result is that the success of initial schools will motivate other schools to introduce

interactive whiteboards and that donors will fund a roll out of the kits to more schools after realizing the positive impact of the project.

The theory is that project Sankoré will achieve this goal because the provision of Sankoré kits, the training of teachers and technicians, the development of learning materials, and the orientation of learners will motivate students and transform their learning experience. The transformed learning experience will not only improve the ICT-literacy and confidence of students, making them better suited to working in the knowledge economy, but it will also lead to improved overall performance in all subjects due to the combination of more effective instruction and sharpened learning abilities.

Moreover, evidence of improved performance within school and at school-leaving levels will motivate teachers and school management, as well as the parent-teacher associations, where they exist, to fully adopt the new technology and to allocate resources that will make digitally enabled instruction sustainable. Evidence that project Sankoré is having a positive impact will persuade the government to formally integrate this approach in education sector policy, allocate additional resources to the project, and ensure that the project is rolled out at all levels of education. The success of the project in improving learning outcomes will also attract funding from donors for the expansion of the project.

There are several underlying assumptions within the theory change framework outlined above. Firstly, successful project implementation requires both stakeholder buy in and sufficient funding. Secondly, effective project management and monitoring and evaluation are necessary. Thirdly, teachers and technicians must be adequately trained to use and maintain the Sankoré kits, respectively. Finally, adequate infrastructure, specifically reliable and affordable electricity, must be available. A rigorous impact evaluation that can attribute improvements in learning outcomes to the Sankoré project would demonstrate the effectiveness of the project and garner more funding for its expansion to the entire Senegalese education system.

The qualitative evidence from this evaluation suggests that several of these assumptions may not have held in Senegal during the implementation of project Sankoré. Specifically, there appears to have been insufficient training of both teachers and technicians. Moreover, both reliable and affordable electricity necessary for the successful implementation of the project were unavailable for several schools, particularly for those in peri-urban or rural locations.

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.

Figure 2: Theory of Change

Stakeholders	Inputs	Outputs	Outcomes Short-Term (1 – 4 years)	Outcomes Long-Term (5 years+)	Impact
Government and Development Partners	Funding of project	Project budgets		Cascade training as more and more schools get involved	Improved academic results, with possible differentials between urban and rural schools
	Development of monitoring and evaluation of project	Project theory of change, Log frame. Management plans	Effective management, monitoring and evaluation of Sankoré project		
School Management, Technicians and Teachers	Training for Teachers, School Management and Technicians	ICT literate School Teachers, Administrators, Technicians and Managers	Effective installation, maintenance and use of Sankoré kits	Increased use of digital equipment and resources in the schooling system	National development
	Production & Acquisition of Digital Learning Resources	National Open Educational Resources (OER) repository Digital resources	Efficient school administration		
	Computers & Connectivity	Networked classrooms	Entrants to post school institutions that are ICT enabled	Increased national competitiveness	High human development indices
Parents	Kits in schools Funding for more kits	Kitted classrooms	Ownership of project by community, therefore, protection against theft	Long term integration of e-education approach into national education sector policy and budget	Access to digital resources and services by the community
	Electricity to schools	Electrified schools			
Private Sector			Improved learning outcomes for more students; especially in urban schools	Mass market for ICT services Sustainable private public partnerships	
Assumption	• Stakeholders are mobilized • Stakeholders buy in & support are sought throughout project • Stakeholders are kept informed of critical aspects of implementation	• Kits given to schools with electricity • Content is developed • Teachers and technicians are trained • There are monitoring tools • Project is evaluated	• Project log frame is refined, with specific, measurable, achievable, realistic and time bound (SMART) indicators • Community ownership is strong • Teachers draw on resources from the OER repository • School leadership supports use of kits	• Teachers take up technology and use it for teaching • Kits are functional and there is technical support for trouble shooting • Students are motivated by the technology • Both students and teachers are more exposed to technology	• Funding is available for more kits • There is greater demand for use of the kits • Technology becomes entrenched in education sector	Rigorous evaluation can attribute impact to Sankoré

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*, 2016). 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 (*Agence sénégalaise d'électrification rurale*, 2016). A recent assessment completed in 2014 shows that the national electrification rate increased slightly to 57.5% in 2013 while the large rural-urban differences remained stable; 86.9% of urban households and 24.2% of rural households had access to electricity (*Agence Nationale de la Statistique et de la Démographie*, 2014). In 2013, of the 7,795 public primary schools in Senegal, only 23.2% had access to electricity (compared to 22.0% in 2012) (*Ministre de l'Education nationale*, 2013). There are important regional as well as rural-urban differences in access varying from a high of 87.4% of schools in Dakar having access to electricity to a low of 7% in the region of Kaffrine (*Ministre de l'Education nationale*, 2013). In 2013, 14.3% of rural schools had access to electricity while 69.0% of schools in urban areas had access (*Ministre de l'Education nationale*, 2013).

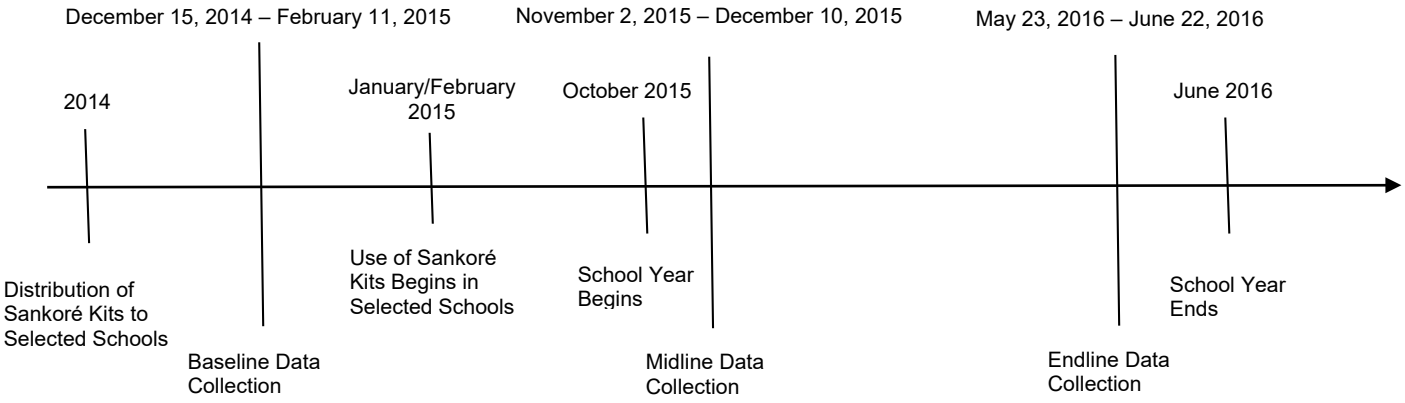
The study sites (schools) were chosen based on the planned rollout of project Sankoré. In Senegal, the project was implemented in two phases. The first phase was implemented between 2011 and 2013. The infrastructure for the second phase was distributed in 2014 with teaching with the use of the whiteboards 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[3]). Further assuming that the correlation between baseline and endline outcomes is 0.6 and considering only one endline survey, with 50 Sankoré schools and 72 non-Sankoré schools, we can detect a minimum effect size of 4.24 points (out of a possible 100) for mathematics, 3.95 points (out of a possible 100) for French, and 5.15 points (out of a possible 100) for ESVS when one regression is used to estimate the impacts of the program in grades 1 and 2. These effect sizes are equivalent to a change of 0.21 standard deviations for each subject. When separate regressions by grade are conducted, we can detect a minimum effect size of 4.35 points (out of a possible 100) for mathematics, 4.05 points (out of a possible 100) for French, and 5.28 points (out of a possible 100) for ESVS. These effect sizes are, again, equivalent to a change of 0.21 standard deviations for each subject. 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.

[3]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.

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[4] 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

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 per school 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).In these tables, the number of

[4]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.

classrooms are classified according to whether the school had 1, 2, 3, or 4 classrooms in that particular grade.

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

Table 3: Number of classrooms per school 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

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

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).

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.

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

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 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

All instruments for the study were developed by the survey firm *Centre de Recherche pour le Développement Economique et Social* (Economic and Social Development Research Centre, CRDES) and piloted. In order to ensure consistency of data collection and the validity and reliability of all data collected, enumerators were trained over six days before the baseline, midline, and endline data collections. The training involved going through all questionnaire items to ensure that enumerators understood these clearly and to make sure there were no errors in the questionnaire. The training also focused on the use of tablets and mobile phones for capturing the data and on the transmission of the captured data to the server at CRDES. After the training, all instruments were piloted in the field before the actual data collection took place. Any issues arising from the pilot were addressed by the survey team leader and the enumerators were informed of all changes that were made to the instruments.

During the field work, enumerators were organized into teams of three, with one supervisor in each team. The supervisor was responsible for the team, the equipment, and for sending the data collected to the server each day. At the end of each work day, the data manager at CRDES verified the data collected before the data collection for any particular school was confirmed as complete. All data collection was identical across treatment arms apart from additional questions in the teacher and principal questionnaires regarding the Sankoré kits which were included only in Sankoré schools.

Several quality control measures were in place throughout the evaluation to ensure data quality. Firstly, an external quality assurer was hired to liaise with CRDES regarding the protocol for the baseline data collection oversight activities. The assurer also verified the questionnaires, calculated interview contact rate statistics, verified the do-files for the baseline report analysis, and informed the project team of any issues. Secondly, during the midline survey, a project team member from NBA visited selected schools in different regions to monitor the data collection on site. A record of the visit (18-20 November 2015) was documented in the report “Report of the Sankore Impact Evaluation Midline Data Collection Quality Assurance Visit” (Mawoyo, 2015).

The implementation of the Sankoré project did not include any form of compensation to either the schools, teachers, or principals for using the Sankoré kits in the classrooms. The only compensation given as part of the evaluation of the Sankoré project were to the students in both Sankoré and control school who participated in the quantitative study. These students took either oral or written tests and were given sweets for their participation. Furthermore, the students who took the written test were given the pencils and erasers with which they took the tests to keep.

Alongside the quantitative data collection, several data collection methods were used for the qualitative analysis of the Sankoré project. A literature review was undertaken to situate the project within a broader body of knowledge on smartboard use in primary schools, specifically, in literacy, mathematics, and science. Documents from the Senegalese Ministry of Education were reviewed to gain a deeper

understanding of the rationale, conceptualization, and implementation of the project. Evaluation reports from the first phase of the Sankoré project in Senegal (2011-2013) were also reviewed.

The qualitative research adopted a case study methodology, where 20 case study schools were selected from the 173 schools that constituted the sample for the evaluation. The case study schools comprised 14 Sankoré and six comparison schools that were selected on the basis of high, low, and mid-scores in the baseline tests. Six of the 14 Sankoré schools are in urban areas, three are in peri-urban areas, and five are in rural areas. The 14 Sankoré schools provided an opportunity for the use of a comparative case study methodology (Goodrick, 2014). The qualitative study was aimed at enhancing the quantitative study, and provides explanations regarding the implementation of the whiteboard project which would otherwise not be visible through quantitative data alone.

Interviews were conducted with principals, teachers, district inspectors, and Ministry of Education officials who were members of the Sankoré technical committee. The interviews were intended to explore how the project was being implemented and perceptions of its effectiveness and impacts. Student focus groups were conducted with groups of 10 students in classes where the smartboards were being used in Sankoré schools and with grade 1 and 2 classes in comparison schools. The aim of the focus group discussions was to gather information regarding student learning experiences with their teachers. Lesson observations were undertaken in both Sankoré and comparison schools in order to explore pedagogy in the observed classes. Structured instruments were used for the interviews, focus groups, and classroom observations to ensure consistency of the data collection. Finally, qualitative surveys with principals and teachers were conducted as part of the quantitative evaluation. Table 8 provides an overview of the qualitative data that was collected for the evaluation during the different periods of data collection.

Table 8: Overview of qualitative data collection

Data Collection Method	Number During First Visit	Number During Second Visit	Number During Final Visit	Total for all 3 Visits
Classroom observations	27	36	20	83
Teacher interviews	29	39	28	96
Principal interviews	20	20	20	60
Student focus groups	29	38	23	90
District MoE Officials interviews	7	7	10	24
National MoE Officials interviews	1	11	4	16
Sankoré principal qualitative survey	58	48	50	156
Sankoré teacher qualitative survey	318	287	159	764

Data from interviews, student focus groups, and classroom observations was analyzed using thematic codes that were developed using the constant comparison method (Glaser and Strauss, 1967). These codes were informed by research questions and were used to systematically code all the data scripts, with

the unit of analysis being a meaningful section of discourse, which could be a phrase, a sentence, or several sentences in a response. The coded data was reviewed three times by the same researcher, with the reviews taking place one week apart, to ensure consistency and stability of coding. The interpretation of the coding was done using frequency counting in order to determine the prevalence of meanings associated with implementation and the impact of the evaluation. The systematic coding of data from all respondents allowed for triangulation and reduced bias through anecdotal use of data. The coding of data identified the school, the geographic location, the method of data collection, and the respondent. The following table illustrates an example of this coding and analysis.

Table 9: Example of qualitative data coding

Site Code and Event	Data	Code
S01UTI2a	A weakness of the program is that when students move from grade 2 to 3, they can no longer use the whiteboard, and this creates a “rupture” for the students.	xxchadist
S08RTI1a	A weakness of the project is that only a few classes have the whiteboards.	xxchadist
S11UTI1a	In this school, the whiteboard, is only for Grade 1 and it is not shared with other teachers.	xxchadist
S11UTI2b	It is a major weakness that Sankore is only in a few schools and grades.	xxchadist
S09UTI1	*The other students are really sad because they are not lucky enough to learn from the kit. That’s why they are always wondering what we are doing with the Sankore. They sometimes stand at the windows spying what we do. In fact, they are curious.*	xxchadist
S11UTI1b	The teacher complained that the whiteboard was only for his class and he could not share with other teachers.	xxchadist
S15PTI2b	The teacher indicated that a weakness to the project was that there was lack of continuity with the program beyond grade 1 and 2. She suggested that the kits be distributed to other grades.	xxchadist
S08RTI1b	The teacher indicated that the whiteboard is only for her grade and she does not share with other grades.	xxchadist
S15PTI2a	The teacher lamented the lack of continuity in the use of whiteboards as the students she had taught the previous year would no longer use the whiteboard, as they were in Grade 3.	xxchadist
IEF02-I1	A program challenge cited was the fact that the kit was only in two classrooms and not in all classrooms at a school.	xxchadist
IEF02-I2	*Furthermore, there are only fifteen Sankore schools in the entire department, they must generalize the project in all schools.*	xxchadist

In this example, the site code and event represent the school, the respondent, the data collection method, and the visit number. For example, S09UTI1 is school number 9 in an urban area (U), during teacher Interview (TI) visit 1 (1). The R after the school number denotes a rural school and the P a school in a peri-urban area. IEF is the district official for district 2 and the data was sourced from the first and second interviews. The text in italics in the data column shows verbatim statements which could be used as quotations in the report. So, in the data above, although the respondents convey it in different ways, they all

have the same concern about the limited distribution of kits and the concern is evident in schools in all geographic locations.

Several strategies were adopted in order to avoid bias in both the quantitative and qualitative research. Given the data collection took place in both treatment and control schools, both may be subject to survey effects. The data collection was designed in order to minimize these effects and any differences in these effects across treatment and control schools. Firstly, the fieldwork training was extensive and focused on comparability. Secondly, each field work team collected data in both Sankoré and non-Sankoré schools. This reduces the likelihood that interviewer effects are correlated with the program. Moreover, enumerators interviewed and tested students in both Sankoré and non-Sankoré students within Sankoré schools. Furthermore, all field work team members were local Senegalese, from throughout the country, experienced in data collection and the field work was overseen and managed by a local Senegalese researcher with extensive experience in data collection. This choice of field work team greatly reduced the possibility of any positionality effects.

Our primary outcomes of interest, test scores, should not be differentially subject to survey or Hawthorne effects at the student level. At the school level, Hawthorne effects may be characterized by teachers assigned to the Sankoré program believing that if their students succeed and perform well on the tests associated with the program evaluation, either they or others will get (more) ICT resources. During the data collection, both principals and teachers in both treatment and control schools were informed that the data collection was an evaluation of the Sankoré program. If this is indeed the case, it suggests the possibility that positive impacts of the program may dissipate, to some extent or completely, if the project is expanded further without evaluation, especially if the program is viewed as permanent by the teachers.

As the schools in the study are located across Senegal, we believe direct spillover effects between treatment and control schools are unlikely. Schools are generally quite far apart from one another and there is very little formal contact between schools. No regular meetings between teachers or principals of different schools are organized by either the Ministry of Education or any other organization. We investigate spillovers within schools directly by comparing the results of classes in grades 1 and 2 in Sankoré schools that did not receive the Sankoré kits to grades 1 and 2 classes in control schools. Finally, we are unaware of any other large-scale ICT program simultaneously put in place in primary schools in Senegal during the period of our evaluation which may have contaminated either the treatment or control group schools, or both. Thus, we are confident that any effects we find can be attributed to the Sankoré project we are evaluating.

We do not believe that John Henry effects play a major role at the student level. Such effects would have to be implausibly large in order to consistently change student behaviour, day in and day out for almost two years, to have a significant impact on their test scores. Moreover, given the treatment was at the class/school level and not the individual student level, it is unlikely to have modified the test taking behaviour of students. Furthermore, throughout the evaluation, the study was referred to as a study of ICT in Senegal, as opposed to a study of e-schools or the Sankoré program. Therefore, the control group students, teachers, and principals were unlikely to be aware they were part of a control group nor that the study they were involved in was an evaluation of the Sankoré program. This greatly reduces the likelihood of any John Henry effects.

6. Program or policy: Design, methods and implementation

The Sankoré project was conceptualized as part of a donor funded arrangement between the French government, and seven countries: Burkina Faso, Benin, Haiti, Mali, Madagascar, Mauritius, and Senegal. The project provides kits comprising a computer, a video projector and an interactive whiteboard with smart touch technology. The project also provides access to educational content to be used with a whiteboard

provided through Open-Sankoré, a multiplatform open-source portal that can also be used without constant access to the internet. The Open Sankoré portal is under the aegis of Webdoc SA, Switzerland, and *la délégation Interministérielle à l'Education Numérique en Afrique* (the inter-ministerial delegation for digital education in Africa), France. The team provides development, support, and communications for the portal (Open-Sankoré, 2016).

In Senegal, the project Sankoré oversight is through two bodies; a steering committee and a technical committee, led by the project coordinator who is one of the Minister of Education's advisors. The steering committee comprises the Minister of Education and national level directors. This committee sets guidelines for project implementation, including financial and technical aspects of implementation. In addition, it monitors implementation and ensures that an evaluation of the project takes place (Ndiaye, 2014). It was expected that this committee would meet twice a year for project oversight meetings (*République du Sénégal, Ministère de l'Education nationale*, 2014a).

The technical committee comprises representatives from the National Institute for Study and Action for Development in Education, the monitoring bureau (*Bureau de suivi*), the computer division of the Ministry of Education (*Cellule informatique du Ministère de l'Education Nationale*), the division for the promotion of information and communication technologies of the Ministry of Education (*Division de la promotion des technologies de l'information et de la communication du Ministère de l'Education Nationale*) as well as regional and district level representatives. This committee is responsible for the actual implementation of the project including supporting implementation activities at the local level, the production of digital resources to be used by teachers, and the monitoring and evaluation of implementation activities. It is expected to meet four times a year for project oversight meetings (Ministry of Education, 2014). In reality, this committee does not appear to have developed any digital resources. The resources from Open Sankoré which were provided with the distribution of the Sankoré kits are those used by teachers.

The project log frame (*République du Sénégal, Ministère de l'Education nationale*, 2014b) indicates that the project is underpinned by five components: 1) Community awareness, 2) equipping classes with digital components and content, 3) initial and continuing training of stakeholders on digital pedagogy and maintenance, 4) monitoring and evaluation, and 5) coordination. Below is a discussion of the goals of these five components and their current status.

The log frame specifies that by 2020, 14 awareness raising activities will have taken place in each district. As of yet, we are not aware of any awareness raising activities having taken place. Furthermore, some principals were not aware of the criteria that had been used to select their school as a treatment school. In addition, some principals indicated that parents had complained that their children were watching TV and not learning. The parents believed the whiteboard was a television, and, therefore, leisure, and not a learning tool. These two examples suggest the need for improvements for ensuring community awareness; at both the school and the household level.

Overall, the implementation of project Sankoré was challenging. Data coding of the qualitative data distinguished respondents according to the school's geographic area and it emerged that challenges did not vary by location but were quite rampant across the entire qualitative sample (20 schools of which 14 received the intervention and 6 were control schools). There appears to have been a disconnect between the intentions, inputs, outputs, and outcomes of the project. As described previously, the original intention of the project was the distribution of 1,200 kits to primary schools throughout Senegal. However, of those kits provided by the French government, only 370 were allocated to primary schools. This decision appears to have signaled a mission drift, with schools receiving fewer than planned. Although outside the scope of this study, it would be interesting to investigate whether the technical challenges experienced by schools were also experienced by the other organizations that received the Sankoré kits.

While in principle, the governance structures were well defined, in practice, implementation responsibilities seem to have been restricted to a few individuals at the Ministry. There was the perception among members of the technical committee that there was a group of people in charge who had put the technical committee together as a project requirement without assigning commensurate responsibility. The technical committee members who were interviewed expressed some frustration with their peripheral involvement. The following quotes summarize this sentiment:

> *… our involvement in the project is just superficial. We are not involved in the decision making or in the monitoring. From time to time they [those playing a role in implementation] summon us to a*

meeting for passing information …. there is a problem of synergy between the different actors of the project. Normally, the responsibility should be given to the department that can best serve the project. The technical support for instance should have been allocated to a department like ours (Interview, Technical Committee Member, 27.01.16).

I am not directly involved in project implementation. All that I know I got from the meeting we had a few months ago where there was a presentation of the baseline of Sankoré impact evaluation (Interview, Technical Committee Member, 3.02.16).

A district official confirmed the feeling that key stakeholders were being sidelined by highlighting that most of the activities that officials were involved in were for compliance purposes:

The Sankoré project does not give much visibility to the "focal points". As "focal points", we have always wished to have a sort of "meeting framework" for exchanges, to share and improve but it's not yet the case. For the Sankoré project, we only meet when there is a need to satisfy requirements, a report to provide, things like that. But in reality we do not have any "framework of engagement and sharing" which would allow the "focal points" to meet regularly (IEF04 I3).

Between the introduction of the Sankoré kits in the treatment schools (January 2015) and the endline data collection (June 2016), the kits were available in these schools for 13 months of schooling. The Sankoré project design intended for the Sankoré kits to be used in the first and second year of primary school in Sankoré schools. The assignment of the kits at the school-level, between Sankoré schools and control schools, was implemented as designed. Kits were delivered to all schools and most kits were connected when the field work team visited the school. However, according to results from the qualitative study, in schools with connection problems, some had persisted for many months without being repaired. Moreover, some kits were not being used for their assigned purpose (i.e., in grades 1 and 2). Table 10 reports the grades principals reported as using the whiteboards using data from the midline and endline principal qualitative surveys.

Table 10: Whiteboard usage by grade according to principals

Grade	% principals reporting usage by grade at midline data collection (n=48)	% principals reporting usage by grade at endline data collection (n= 49)
1	56.25%	53.1%
2	79.17%	79.6%
3	54.17%	55.1%
4	10.42%	20.4%
5	2.08%	0%
6	4.17%	4.17%

Although usage was most prevalent in grade 1 and 2 classrooms, significant usage was also reported in grades 3 and 4, with an increase in use by grade 4 classrooms during the endline data collection. This data was corroborated by teacher interviews. The teachers in some schools admitted that teachers in other grades besides grades 1 and 2 use the whiteboards. Nine of the lessons observed during all phases of the qualitative data collection in the 14 Sankoré schools were in grade 3 classes and two were in grade 4 classes. This phenomena can likely be explained by the frustration expressed by respondents (teachers and principals) regarding the availability of just two kits per schools. The practice of assigning kits to only two classes was deemed discriminatory and hurtful towards children, as students who don't have kits in their classrooms feel left out:

The other students are really sad because they are not lucky enough to learn from the kit. That's why they are always wondering what we are doing with the Sankoré. They sometimes stand at the windows spying what we do (S09U TI1).

One of the principals expressed it poignantly when he remarked that some students are very disappointed that they do not have a kit:

> "*it is very difficult to handle the frustration of a child*" (S17R PI1).

District officials expressed the desire to have kits in all classes at schools where there were two kits and at all schools where there were no kits. The limited number of kits and how they were distributed in schools was mentioned as a program challenge and, out of 25 groups of challenges, with a total of 544 codes, this was the sixth most cited challenge. Concerns about the number of kits was expressed by teachers, principals, students, and national and district education officials.

The lack of continuity in the use of the kit after grade 2 may be why the kits are sometimes being used in grades 3 and 4. Lack of continuity was mentioned four times by three teachers from different schools, who expressed the disappointment that when students move from grade 2 to 3, they no longer have the kit and this causes a 'rupture' for the students. One of the teachers indicated that she combines use of the whiteboard with the blackboard "*to prepare students for grade 3 when they would not have a smartboard*" (S16R TI3). Another teacher stressed that the discontinuation in the use of the whiteboard would lead to the loss of skills that students had acquired:

> *… when second grade students go to third grade and so on, they will forget how to manipulate the tool because of lack of continuation* (S15P TI3b).

The qualitative research also probed the extent of use of the whiteboard, by inquiring how frequently teachers used them. During the interviews and in the qualitative survey, teachers were asked how often they use the Sankoré kit each week. Lesson observations also provide an indication of the use of the kits. In addition, students were asked to indicate how often they worked on the interactive whiteboard with their teachers. Reported weekly usage by teachers, principals, and students during interviews concurred, providing support that the reporting of this aspect of use is reliable. Frequency of usage reported by teachers in the qualitative survey and in interviews is presented in the table below.

Table 11: Frequency of use of Sankoré kits according to teachers

Frequency of use of kits/week	Reported frequency of use in midline qualitative survey (n=39)	Reported frequency of use in endline qualitative survey (n=42)	Reported frequency of use during interviews (n=14 schools)
Once	12,8%	7,5%	0%
Twice	17,9%	10,0%	14,2%
Three times	17,9%	17,5%	42,8%
Four times	5,1%	2,5%	7,1%
Everyday	23,1%	15,0%	7,1%
Never	23,1%	47,5%	21,4%
Total	100%	100%	100%

Table 11 shows a high prevalence of non-usage of whiteboards. The decline in usage between the midline and endline is of particular concern. Lesson observations were used as another measure of evaluating frequency of use and the results are similar. During the first visit, the Sankoré kits were not being used for lessons in 40.6% of the 32 observed classrooms and during the second visit, 47% of the observed 32 lessons were not taught using Sankoré kit. During the third visit, the kits were not being used in 82% of the 28 observed lessons. There were several reasons why the kits were not being used when researchers

observed the lessons and these included technical challenges, such as, damage and calibration, as well as electricity challenges.

In five schools, the Sankoré kit was never used in any of the three visits. In four of these schools, technical challenges were cited as the reason for non-use. Of all challenges ascribed to the project (544 codes for challenges), technical challenges were the most cited, with 27.9% of the challenges codes assigned to them. All respondents were frustrated by the high degree of technical challenges experienced with the project. According to the principals, teachers, and students in four schools, from the time of installation, the interactive whiteboards had never worked in their schools. In one school, the whiteboard worked once and then stopped working. The teacher qualitative survey corroborated the case study results on the extent of faulty whiteboards, with 38.9% teachers reporting in the endline survey that faulty whiteboards were a challenge. Another 16.7% of respondents highlighted that their whiteboards were not working.

one lesson observation during the second visit, the teacher in one school spent 30 minutes fiddling with the interactive whiteboard to try and get it to work and failed. She then abandoned the whiteboard and resorted to using the blackboard after wasting much time. Some teachers highlighted that because of the technical challenges with the whiteboard, they always have to have a backup plan so that they do not waste valuable teaching time if the whiteboard does not work. This defeats the time saving quality of the whiteboard.

What is most overwhelming about these technical challenges is that neither the principals nor the teachers are trained to deal with them, so they have to rely on district offices to send technicians to repair the kits. This in itself is a problem because the technical capacity at the district level is inadequate or non-existent as highlighted by this district official:

> *… many of the hindrances are linked to material breakdown. Indeed, we have many times been warned about that and it raises another problem which is the lack of trained technical staff. The project has a focal point in each department, and there are two technicians in the region responsible for the maintenance of the kits and another focal point is supposed to coordinate everything at the regional level. Every time we meet a problem, he is immediately alerted. We were asked to designate a technician for each district, but these designated persons have not yet received training. Sometimes if the breakdown is complex, we are compelled to send the materials to the other region, Thies, because they are reported to be more competent at fixing the kits. Sometimes it also takes too long for schools to report a breakdown and coupled with the lack of technicians, repair takes a very long time to be effected* (IEF06 I1).

Based on this observation, it is not surprising that some interactive whiteboards had been dysfunctional for over a year even though the principals had reported them as faulty. The problem of broken kits was not limited to isolated or specific districts. It was rampant across many districts and it was a system level challenge.

The persistent breakdown of kits led a few people to question the quality of the computers and whiteboards, citing that they were too fragile and needed constant care which was unachievable because of the limited number of technicians supporting each region. Quality concerns may be justified, given the fact that the principal survey revealed that various components of the kit were broken, as highlighted in the following table.

Table 22: Components of Sankoré kit that were damaged according to principals

Sankore kit component	% Principals reporting damage of component at midline	% Principals reporting damage of component at endline
Computer	29,17%	32,0%
Sankoré software	0%	6,0%
Digital resources	6,25%	6,0%

Sankore kit component	% Principals reporting damage of component at midline	% Principals reporting damage of component at endline
Video projector	10,42%	28,0%
Stylus	16,67%	16,0%
Network cable	12,50%	22,0%
Interactive kit	2,08%	6,0%

Table 12 shows the deterioration of components of the kit from the midline data collection to the endline. During the midline, 35.4% of principals reported that their kits had no damage, but during the endline, only 26% of the principals reported that their Sankoré kits were not damaged, highlighting that more kits were broken than functional. Of those who reported damage, computer damage was the most prevalent, followed by the video projector and the network cable.

Not all of the technical challenges were complex and needed a technician. Two teachers shed light on this by explaining that when there are minor technical issues, they phone the technician who tells them what to do on the phone and this usually resolves the issue. This suggests that if the training of teachers focused on basic trouble shooting, some of the technical challenges could easily have been addressed.

Electricity challenges were another impediment to effective use of whiteboards. In order for schools to be selected to receive the Sankoré kits, they had to satisfy electricity and security requirements. However, even with these requirements and the delivery of the kits, other inputs, such as, universal installation of the kits, teacher training, an adequate number of trained technicians, and stable electricity, were lacking, and likely affected the utilization of the kits. Electricity challenges affected schools in all geographic areas.

During the first qualitative school visits, there was no electricity in three schools due to a power cut. Power was the fourth most cited challenge of all the project challenges highlighted (49 codes), with reports that power outages affected the effective use of the kit. A further challenge with the power outages was that the power cuts were unscheduled and so it was difficult to plan for them.

A limited number of features of the kits were observed in use in Sankoré classes during classroom observations while teachers were observed teaching math, ESVS, and French. In the 18 Sankoré lessons where the whiteboard was used during school visits, all teachers except one invited students to come and use the pointer or group objects. Only one teacher monopolized the whiteboard in all three observed lessons and did not invite the students to go to the board and work on it. High value was placed on the whiteboard's visualization capabilities. Of the 244 coded instances of the strengths of the Sankoré project, 14% (33 codes) were regarding visualization. Visual images are believed to assist with the concretization of concepts (8% representing 20 codes) and improving comprehension (11% representing 26 codes). The visuals on the whiteboard were also reported to be motivating for teachers (45% of the strengths codes, representing 111 codes on motivation). Another related benefit of the visuals was time saving (18% of the strengths codes, which is 43 codes). All teachers indicated that time was saved during preparation as all the content was on the kit and they did not have to spend that much time preparing lessons. In class, time was also saved because the teacher did not have to spend a lot of time drawing on the board to aid the students' understanding. The clear images from the kit made students understand more quickly which meant the teacher could do more exercises during the lesson. The power of the visualization and how it changed the pedagogy in class was captured succinctly by one of the principals:

> *They [students] find much interest in the usage of the smartboard because of the illustrative teaching. In terms of teaching, Sankoré helps to be closer to reality because of the images. Before the project, it was quite difficult to find good and clear pictures of certain animals; but now, we can even display a video of these animals and let the kids benefit from that. Even concepts such as geometrical figures are now very easy to be taught because the kit includes some illustration of them* (S18P PI2).

Table 13 summarizes the benefits of the interactive whiteboards by the stakeholders. In the focus group interviews, the students highlighted that the images were what they liked best about the Sankoré project. Teachers hinted as to why the whiteboard was used mainly for visualization when they highlighted that it was difficult for them to search for more resources as they did not have internet connectivity.

Table 13: Benefits of the interactive whiteboards

Code	Descriptor	Frequency	Principals	Teachers	MoE Official	IEF Inspector	Students	Lesson Observation
xstreconc	Concretises concepts	20	6	6	-	-	5	3
xxstrecompr	Improves comprehension	26	1	4	-	-	21	-
xxstrevisual	Visuals	34	6	10	-	-	15	3
xxstretime	Time saving	43	5	32	-	1	4	1
xxstremot	Motivates students and teachers	111	13	52	2	2	30	12

The Sankoré content was also cited as an area of weakness and there were complaints from six teachers from schools in urban, rural, and peri-urban locations. All the complaints from rural teachers were related to the difficulties associated with manipulating content because of limited internet connectivity; it was difficult to access the backup library and to update the content without connectivity. One of the teachers from an urban school pointed out that although the content was weak, she could update it because she had access to reliable internet. The teacher at a peri-urban school indicated that some of the content was not suitable for the grade 1 level. One teacher from a rural school pointed out that some localization was needed as some of the materials were not relevant to the Senegalese context and it would be beneficial if the materials contained some culturally relevant content.

> *I just expect that quality of the content be ameliorated. For instance, if we study history, the content should include some narrations or pictures of our national heroes. …. In so doing, kids would be attached to their culture. And maybe they would more and more appreciate to learn* (S16R TI1).

Teachers were trained to use the Open Sankoré resources by the *Centre Régional de Formation du Personnel de l'Education* (Regional Training Centre for Education Personnel) and the district inspectors. However, there were challenges with the training and training was the second most common challenge cited by respondents, with 23.8% of the 544 challenge codes pertaining to training. Several issues were raised in relation to training, including the coverage of the training, timing, quality, and adequacy. Regarding the coverage of the training, the endline teacher survey revealed that of the 185 teachers who were supposed to be teaching using a Sankoré kit only 24.3% had been trained. This suggests that many of the Sankoré teachers had not received any training. Principals, teachers, and IEF Inspectors commonly agreed that lack of training of all teachers was a real challenge, especially since the MoE moved teachers between schools during the year. If a trained teacher was moved from a Sankoré school, they were often replaced by an untrained teacher. At four Sankoré case study schools, the whiteboard was not being used in seven classrooms because the teachers were new and they had not been trained. Even within schools, principals pointed out that the training of only two teachers presented challenges when a Sankoré teacher was ill and no one else could take their class.

Respondents highlighted that the training did not take place before the initiation of the project. Teachers were trained long after project initiation – as long as seven months to a year after the project had started in the schools. Further, principals were trained after the project was initiated and yet they were supposed to

supervise teachers and report to the IEF. Some inspectors indicated that they had not yet been trained. The following quote highlights frustration with the timing of the training:

> *The training was late because teachers and principals should receive it at the same time. Unfortunately, principals were trained a year after the beginning of the implementation of Sankoré* (S17R PI3).

Regarding quality and adequacy of the training, those who were trained expressed unhappiness with the length and content of the training. Some of the teacher training for the Sankoré project was facilitated by the IEF inspectors and data from teacher interviews revealed that the training duration varied from two to five days, depending on the district. Teachers also expressed concern about the training, highlighting that some of the IEF inspectors were battling with mastering using the kits themselves. All respondents agreed that this training was inadequate and this is aptly captured in the quote below:

> *Personally, I think that the time [for training] was not enough because I still do not know how to fully access the content of the kit. I can't make a proper lesson plan as I was doing in the past with a paper so that I can follow a specific scheme to teach. Another thing also is that I don't have a person who can guide me, I mean the principal can't supervise my work adequately so that I can realize if I am in the right or wrong in doing this or that. Even the other colleagues, with whom I shared the training, can't actually help me if I am stuck* (S09U TI1).

After the initial two to five days of training, teachers did not receive any further ongoing training. When asked to evaluate the quality of the training in the midline and endline qualitative surveys, 66% and 55% of the teachers, respectively, indicated that the training was not satisfactory, with 34.7% teachers at midline and 61.3% at endline citing the short duration of training as the main reason for their perception.

A project assumption was that training two teachers per school was adequate. This model assumed that staffing was stable and that teachers would stay in their schools for long periods. However, this proved to be a flawed assumption, as the second visit to the schools revealed that there were eight new teachers in the classes which had been observed during the first visit. The new teachers had not been trained and were, therefore, unable to use the kit. Some teachers and principals stressed that it is important to train all teachers on how to use the Sankoré kit. Furthermore, ongoing training would ensure that any new teachers in the system who would not have been trained at the initial training would also get the opportunity to be trained during subsequent follow-up training.

Training was also to be directed to district education inspectors and principals to enable and facilitate their role of monitoring teachers and technicians. Principals were supposed to supervise teachers in schools and also required training, but, for some, their training was delayed and many did not feel confident in evaluating their teachers in the use of the smartboards. Moreover, some of the IEF inspectors, who were also supposed to monitor the project through teacher observation, had not been trained. Training took place as a once off event with no follow up or continuous training after the initial introductory training.

Both principals and inspectors were expected to monitor teachers in schools by observing them while teaching. The IEF inspectors were expected to collate monitoring data from schools and send it to the MoE who would then address any specified challenges. In reality, monitoring was weak at all levels and was not used to mitigate challenges. District officials reported that there were no monitoring tools and so no monitoring data was collected. However, some principals indicated that they had sent monitoring reports to the district office. The following quote reiterates the frustration with the lack of training by principals:

> *I definitely do not understand anything about Sankoré. They* [district officials] *told us that we were going to be trained but still it is not the case. They have just trained the teachers who were going to be using it. We principals, our training was planned a month ago and it would take three or four days. At the end, they informed us that it would not be possible because the means are not available. Then, the training was postponed to an unknown date. We are still waiting. What is mostly tough for me is that I am literally not able to evaluate what the teachers using Sankoré are doing because I don't know Sankoré at all* (S09U PI1).

During the baseline, in districts where training of principals had started, there were already concerns by principals that the training duration was not adequate. Like the teachers' training, the duration of the

principals' training varied from two days to three days, and not all principals had been trained. During the endline visit, some principals had still not been trained.

For district officials, some mentioned that they had not been trained on how to monitor; hence, they felt out of their depth. Among those who were trained, the concern was that only one inspector per district had been trained. However, more inspectors were needed to go to schools for effective monitoring. As with teachers, some district inspectors had also been transferred and those who had taken over from them were ill equipped to monitor the teachers as they had not been trained. Officials from two of the eight districts in the qualitative sample also indicated that they did not have enough vehicles to go for school visits. The officials attributed lack of monitoring to the fact that they had not been consulted during the choice of schools, as they would have chosen schools that were close to each other.

These challenges with the effective implementation of the Sankoré project were all identified in the implementation evaluation of the first phase of the project. A Sankoré project progress report (*République du Sénégal* , 2014a) cited lack of funding for kit repair, lack of training of teachers and inspectors, limited use of Sankoré resources by the teachers, and poor support of project implementation from the inspectors as challenges noted in the evaluation of the first phase of the project in 2013. Yet, these problems still abounded in 2016, three years later. This signals a weakness by government to use evidence for policy decision making, an area that has to be addressed should the Sankoré project continue and expand.

According to the qualitative data collected, where kits were being utilized, there were positive reports of improved student and teacher motivation. There were also reports of improved student learning outcomes. Such claims are investigated for a representative sample of students in section 7 of this report. The visual content of the Sankoré material was reported to be grabbing the students' attention, enabling them to focus and concentrate. The visuals also facilitated the concretization of concepts which aided student comprehension. There were even reports of improvements in test results, in schools where principals and teachers compared results of the students in the grades that were using Sankoré to those who were not. However, according to these teachers and principals, these gains were not sustained over time as there were constant interruptions in the use of the whiteboard, emanating from issues such as unscheduled power outages to permanent technical challenges. Once again, these are self-reports of teachers and principals and such claims are investigated further in the next section.

Despite the systemic challenges elaborated above, there was widespread recognition of the strengths of the program and its potential benefits. There were positive reports about the program's ability to motivate both teachers and students. Out of the 244 codes generated for program strengths, motivation constituted 45.5% of the codes, and this was noted across respondent groups. Table 14 highlights the major program strengths that were reported in interviews and observed during lesson observations (n=244).

Table 14: Perceived program strengths

Code	Descriptor	Frequency	Principals	Teachers	MoE Official	IEF Inspector	Students	Lesson Observations
xxstremot	Motivates teachers and students	111	13	52	2	2	30	12
xxstretime	Time saving	43	5	32	0	1	4	1
xxstrevisual	Visuals	34	6	10	0	0	15	3
xxstrecompr	Improves comprehension	26	1	4	0	0	21	0
xxstreconc	Concretises concepts	20	6	6	0	0	5	3

The motivational aspect of the whiteboards was related to several features – time saving, visuals, comprehension, and concept formation. Teachers reported that because content was available as part of

the kit, this reduced their preparation time significantly. In class, visualization enabled students to understand the concepts much faster and this also improved lesson pacing and ensured broader curriculum coverage, as described in the following quote:

> *… instead of losing lots of time in drawing figures on the black board, it enables me to save time. Moreover given that I am not an artist, the images that the kit generates are more beautiful to look at and are better aligned to everyday realities* (S11U TI3b).
>
> *It's easy for me to prepare my lesson and I don't take too much time to explain since students get it fast. The whiteboard is an innovative learning and teaching aid for me as a teacher. I feel more confident to do my lesson on the whiteboard and my students concentrate better* (S01U TI2a).

In focus group (FG) discussions, the students who praised the time saving qualities of the whiteboard attributed this to the fact that they did not need to spend some lesson time going to fetch water to clean the board, which also made them filthy:

> *… we prefer learning via the whiteboard because it's easier and we save time. We don't need to clean it using the sponge, to fetch water in the bucket and to write with chalk. Right now our whiteboard is not working well that's why we are tired all the time because we need to clean the board, to fetch water, and before going home our body is dirty* (S11U FG3a).

The visuals or images are what made teachers and students like the whiteboard as these concretized the concepts and enabled quick comprehension. There was a general perception among principals, IEF inspectors, students, teachers, and focus group participants that the students' performance on tests had improved because the whiteboard motivated them and made them focus more. Of the 102 codes on outcomes of the Sankoré project, 90% were about the fact that Sankoré had led to improvement in results. The distribution of these codes is highlighted in table 15 (n=102).

Table 15: Perceptions of improvement of student results

Code	Descriptor	Frequency	Principals	Teachers	MoE	IEF	FG
xxoutimprove	Improving student results	92	25	41		1	25

However, according to some, not having the kit after exposure to it seemed to have demotivated the students into regressing and not doing as well:

> *This year, we have not yet done the assessments. Last year, kids were achieving very high marks in the first semester while we were using the kit. During the second semester when the kit had broken down, they had a slight fall in their performances. Between the two classes of the same grade, the Sankoré class had a higher average than the non-Sankoré class last year in the first semester; in the second semester, it was the non-Sankoré class which had a higher average* (S16R TI2).

The program was not formally changed during the study period. The only deviations from study protocol were the lack of use of the Sankoré kits by some teachers and schools and the use of the kits in classes that were not assigned to use them (in classes other than grades 1 and 2) in Sankoré schools. Therefore, the results in section 7 should be interpreted as intent-to-treat estimators and not treatment effects of the Sankoré kits. The study protocol provided schools and teachers with considerable freedom in the use the kits. Specifically, there were no requirements regarding the use of the digital resources provided with the kits, the choice of school subjects for which the teachers should use the whiteboards, or how the whiteboards should be used. School principals and teachers in both Sankoré and control school were aware of participating in a study of ICT in Senegal but not specifically of an evaluation of the Sankoré program.

7. 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 16 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 17 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 16: 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 17: 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 18-20, 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 18. 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 18: 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 19 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 20), there does not seem to be strong evidence that, at baseline, schools are significantly different between treatment and control groups.

Table 19: 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 20: 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 21 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 22 through 27 investigate heterogeneity in the intention-to-treat estimates by gender (tables 22-24) and urban/rural status of the school (tables 25-27). Consistent with the results from table 21, we find no statistically significant impacts of the Sankoré project on French test scores for either girls or boys (table 22). Table 23 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 24), driven entirely by a statistically significant 0.256 standard deviation increase in girls test scores in grade 2 (column 3, table 24)). 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 25-27 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 21 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 21: 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 22: 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 23: 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 24: Difference-in-difference estimates for ESVS 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	0.035	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 25: 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 26: 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 27: Difference-in-difference estimates for ESVS 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	-0.397***	-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 28.

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 29, 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.

The results from this quantitative analysis are perhaps surprising given the overwhelming evidence from the qualitative study that the implementation of the Sankoré project had several limitations. This prompted a re-estimation of the quantitative analysis for the qualitative sub-sample (results available upon request). However, it is important to note that given the limited number of schools in the qualitative school sample, these results should be interpreted with caution. The analysis for the qualitative sub-sample shows no significant overall impact of the Sankoré project (consistent with the qualitative analysis findings). However, the analysis by school locations shows positive impacts of the program in rural schools for both ESVS and math test scores in grade 2, and for math in peri-urban schools in grade 1 (which differ from the quantitative analysis of the full sample where we find only positive statistically significant impacts in urban schools). As with the quantitative analysis (of the full sample), we find persistent positive effects for grade 3 students of the Sankoré kits on ESVS test scores (but not math and French as with the full sample) and the instrumental variable analysis shows a positive impact of the project on math test scores in the qualitative sub-sample. These findings suggest that, overall, the quantitative analysis for the qualitative sub-sample is consistent with the qualitative analysis (with the small sample size caveat) suggesting that the qualitative sub-sample is not representative of the full sample.

Table 28: 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 29: 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

There are several different types of costs associated with the Sankoré program. Firstly, there are the costs of the kits themselves. On average, one interactive whiteboard costs 1,950 USD. The other costs of the program can be organized by the bearer of the costs. The Ministry of Education bore the costs of teacher training, delivery of the kits, training of personnel in repairing the kits, and kit repair when necessary. The schools that received the kits were responsible for electricity payments associated with the use of the kits. Moreover, a requirement for schools to receive a Sankoré kit was that they have access to electricity and sufficient infrastructure to keep the Sankoré kits secure. If the project is to be expanded to schools without such requirements, additional costs associated with electricity provision and security may be required. Finally, principals, teachers, and students may have born psychological costs associated with the pedagogical change of the use of whiteboards.

Unfortunately, we have not been provided with the costs of the program from the Ministry of Education (see appendix I for correspondence between the evaluation team and the Ministry of Education) necessary for a cost-benefit analysis. However, even without this data, we are able to conclude that the implementation of the Sankoré program is extremely unlikely to be cost-effective outside of urban areas. We find very few positive and statistically significant impacts of the program in both peri-urban and rural areas. However, we are, unfortunately, unable to calculate a project rate of return for urban schools.

8. Discussion

The internal validity of the study rests on the assumption that in the absence of the Sankoré project, students exposed to the Sankoré equipment would have progressed as did the students in comparison group schools. Although this assumption is impossible to test, we do provide evidence from grade 3 students suggesting that it likely holds. Tables 16 and 17 show 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.

Though much of the qualitative evidence suggested difficulties in the implementation of the project, including in the training of teachers and technicians and in repairing broken material, our

quantitative evidence suggests, on average, large positive impacts of the program on student learning, primarily for mathematics in urban schools. Though these results may seem contradictory, it is quite likely that implementation issues were, on average, more severe outside of urban areas, explaining the heterogeneous findings.

The existing literature evaluating the impacts of the introduction of interactive whiteboards in primary schools is quite sparse, especially in developing countries. The findings are quite mixed with some studies finding negative impacts, others finding some positive impacts, and still others finding no impacts. The findings of this study add to those studies finding some positive impacts of such a project and are an important contribution to the literature. Our findings suggest that some student learning outcomes do improve with the introduction of an interactive whiteboard as predicted by the theory of change discussed in section 2.

The external validity of the study rests on the comparability of primary schools in Senegal to primary schools in other contexts and possibly, to other levels of education within Senegal. To the extent that without the project, many other developing countries have similar levels of primary school learning levels, schooling inputs, teacher training, teacher and student familiarity with technology, and school infrastructure, including access to and pricing of electricity, we would expect to find similar positive impacts of the introduction of interactive whiteboards with digital content if the program is implemented in a similar manner to the Sankoré project evaluation in Senegal.

If project Sankoré is to be scaled up within Senegal, to additional primary schools, to other levels of schooling including grades other than 1 and 2 in primary school, or to another setting, our qualitative and quantitative results suggest it is likely to be more successful in urban areas; likely, in part, due to implementation difficulties. Thus, attention should be paid to its implementation, including the duration of teacher training and the number of teachers trained to use the equipment, equipment repairs, access to electricity, and the costs of additional usage of electricity associated with the use of the kits. Furthermore, a scale-up of the project to additional urban primary schools would likely increase disparities between urban and rural schools and should be taken into consideration by policy makers.

The results of this study have yet to be presented to key stakeholders. However, results from the midline data collection were presented to stakeholders (teachers, principals, inspectors, members of the Ministry of Education) in Senegal in 2016. A workshop was organized by the Ministry of Education to discuss the status of the Sankoré project. The implementation issues raised in this report were already apparent during the midline data collection and were shared with stakeholders. These issues were in accordance with their experience with the project. These implementation issues should be investigated further in the design of both monitoring and evaluation plans. Further research should investigate the causes of the urban-rural differences in the impacts of the Sankoré program and should collect all relevant cost data in order to enable a full cost-benefit analysis of the program.

9. Specific findings for policy and practice

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.

The qualitative findings of the study suggest that there is a perception amongst policymakers within Senegal that the Sankoré kits should be distributed to more schools to create equality. However, the qualitative report recommends that this not be considered at present given the current state of implementation of the project. Moreover, the implementation issues raised here appear to be a perpetuation of the implementation practices of Phase 1 of the project. Significant improvements in implementation are required before the scaling up of the program, particularly outside of urban areas.

Policy makers may want to consider the following suggestions for improving the implementation of the project. All of these suggestions should be evaluated, including a full cost-benefit analysis, before a final decision regarding the future of the Sankoré project is made. Any modified Sankoré project should ensure that all teachers, principals, and IEF inspectors are properly trained. Training should include some basic trouble shooting so that simple problems can be fixed within the school to enable the continued use of the interactive whiteboards. Given, the lack of sufficient technicians to support the project, another possible strategy for dealing with technical issues is the introduction of a technical phone hotline staffed by trained individuals who can assist in trouble shooting. Another possibility already being considered and which was discussed during the midline Sankoré project workshop in Dakar in 2016, is the use of local suppliers for the provision of the interactive whiteboards. The feasibility and cost effectiveness of this strategy must be investigated fully but such a modification may decrease the technical issues associated with the kits (if the machines are made to be more resilient to local and environmental conditions) and may improve the provision of technical support more generally.

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.

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