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The Primary Math and Reading Initiative (PRIMR)

Kisumu Information and Communication Technology (ICT) Intervention: Endline Report

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The Primary Math and Reading Initiative (PRIMR)

Kisumu Information and Communication Technology (ICT) Intervention: Endline Report

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Abbreviations

cwpm	correct words per minute
DID	difference-in-differences
DQASO	District Quality Assurance and Standards Officer
EGRA	Early Grade Reading Assessment
FPE	Free Primary Education, Kenya
GOK	Government of Kenya
ICT	information and communication technology
KCPE	Kenya Certificate of Primary Education
KES	Kenyan shilling
KESSP	Kenya Education Sector Support Programme
KNEC	Kenya National Examinations Council
LOI	language of instruction
lpm	letters per minute
MoEST	Ministry of Education, Science, and Technology
NESSP	National Education Sector Support Programme
ORF	oral reading fluency
PRIMR	Primary Math and Reading Initiative
RTI	RTI International (trade name of Research Triangle Institute)
SD	standard deviation
SSME	Snapshot of School Management Effectiveness
TAC	Teachers' Advisory Centre
TSC	Teachers' Service Commission
USAID	United States Agency for International Development
wpm	words per minute

Executive Summary

The rapid improvement in primary school enrollment in Kenya is a credit to the tremendous effort that the Government of Kenya (GOK) has made in improving access to education since the introduction of Free Primary Education (FPE) in 2002. However, the increases in enrollment have not been matched by improved learning outcomes. As indicated in the National Education Sector Support Programme policy document (MoEST, 2013), the objective of placing information and communication technology (ICT) in education was to expand learning opportunities, facilities, and channels of delivery. The Ministry of Education, Science, and Technology (MoEST), with RTI International technical support and funding from the United States Agency for International Development (USAID)/Kenya, implemented a randomized control trial looking at the impact of ICT options in Kenya in 2013. The main objectives of the Primary Math and Reading Initiative (PRIMR) ICT program were to assess the impact of ICT interventions implemented at three levels of the education system and to measure the effectiveness and cost-effectiveness of those options against each other.

Design and Methodology

The ICT study's research design utilized random selection of zones and random assignment of zones to treatment. The intervention was implemented between January and October 2013 in Kisumu County. The goal of the intervention was to provide the MoEST with information on how to maximize ICT for cost effective learning improvements in Kenya. The intervention was implemented in 80 government schools located in 8 zones in Kisumu County, a relatively wealthy but diverse county in the Lake region of Kenya. The three treatment groups were: (1) **Teachers' Advisory Centre (TAC) tutor tablets:** In 2 zones, in 10 schools each zone, electronic tablets were provided to TAC tutors to bolster their instructional support to pupils in their schools; PRIMR materials were preloaded on the tutors' tablets; (2) **Teacher tablets:** In this treatment group, also implemented in 20 schools, teachers taught using enhanced teachers' guides on tablets, preloaded with PRIMR instructional materials, virtual flashcards, additional literacy materials, and the RTI-developed continuous-assessment software Tangerine: Class™ utilizing pupil achievement data; and (3) **Pupil e-readers:** In this treatment, pupils in the third subgroup of schools were given e-readers to improve their literacy skills. These e-readers were used daily during English and Kiswahili lessons (implementing PRIMR methods) and were available through after-school reading clubs, which were implemented in 20 schools. Finally, in 2 zones, 10 schools each zone served as the control group and received no intervention in 2013; however, these 20 schools began receiving the most cost-effective treatment in January 2014.

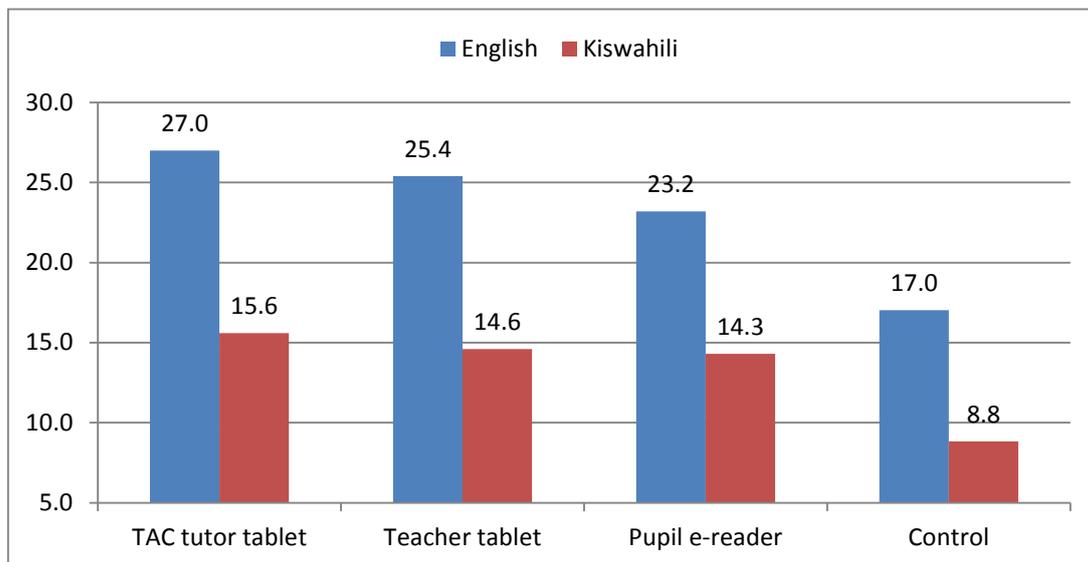
To measure the impact of the ICT interventions under study, we undertook baseline (January 2013) and endline (October 2013) Early Grade Reading Assessments (EGRAs) in Class 2 before and after the intervention. Data were collected from a random sample of 20 pupils (10 boys and 10 girls) from each of the 80 schools in the 8 zones in the study. 1580 pupils were assessed at baseline, and 1560 at endline. To remove the small differences in outcome variables at the baseline, we utilized a difference-in-differences (DID) model to estimate the causal impact of the three groups over the control. This Executive Summary shares the key findings.

Impact of PRIMR ICT

Pupils in all three treatment groups scored significantly higher statistically on key outcomes compared to pupils in the control group. The effect size for e-readers, the teacher tablets, and the TAC tutor tablets was .35 standard deviations (SD), .47 SD, and .44 SD, respectively. Though all three treatment groups showed large impacts on achievement, there were no statistically significant differences in the magnitude of the impact between the three treatment groups. This is notable given that the TAC tutor group is very similar in practice to the non-ICT base PRIMR program.

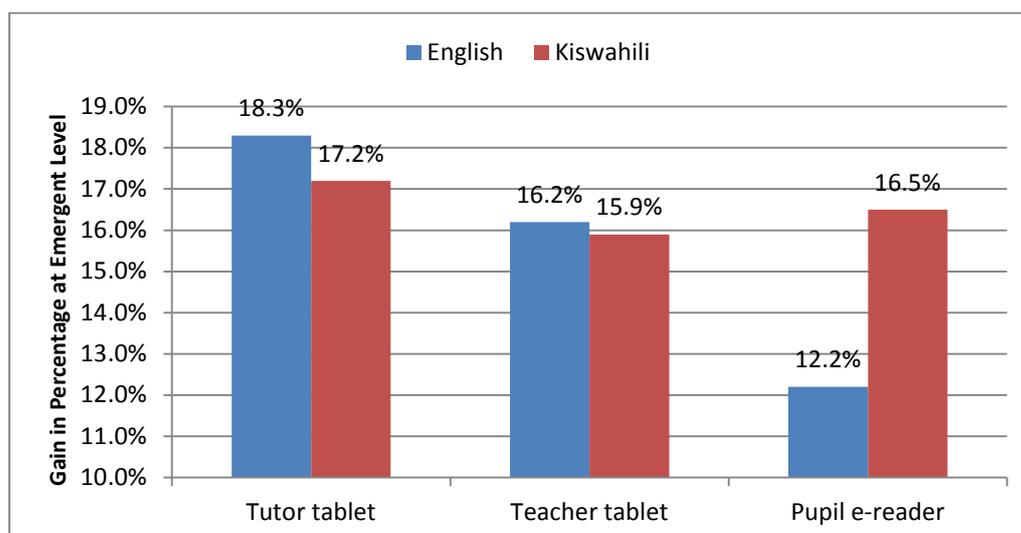
Figure ES.1 below presents the gain over the baseline scores in oral reading fluency (correct words per minute [cwpm]) for the three treatment groups and the control groups. These results were produced from DID models and remove the differences in literacy outcomes at the January 2013 baseline. Note that the results of all three PRIMR treatment groups show much higher gains than the control, in both English and Kiswahili.

Figure ES.1. Gain over baseline in oral reading fluency for 3 ICT groups and control



The impact of PRIMR can be examined another way. *Figure ES.2* presents the causal impact of the study's three ICT treatment groups on the percentage of pupils reading at least at the emergent reader benchmark level set by the MoEST (30 cwpm or more for English; 17 cwpm or more for Kiswahili). All three treatment groups showed a dramatically increased percentage of pupils reading at the emergent level. It appears that the TAC tutor tablet group showed slightly greater impact on this measure, though the differences between groups were not statistically significant.

Figure ES.2. Impact of PRIMR on the percentage of pupils reading at emergent level



Cost

To measure the cost effectiveness of the three ICT treatments, we computed the unit costs per pupil of each. The basic costs comprise the sum total of pupil books, teachers' guides, teacher training, classroom observations, and TAC tutor training for the PRIMR core model. The basic cost of the PRIMR core model translated to \$2.28 per subject per pupil, which was slightly less than the costs in the control group. The ICT cost per pupil depended on the treatment group and at what level ICT was placed in the treatment. For example, the e-reader cost was applied at the pupil level while the cost of the TAC tutor tablet was split across the many schools in the zone and the pupils in each school. Per pupil, the e-reader cost \$40, the teacher tablet \$3, and the TAC tutor tablet \$.10. Given that the impact of the three treatment groups on learning outcomes was similar, the per-pupil cost of ICT makes a significant difference in the cost-effectiveness analysis. This is shown in *Figure ES.3*, which presents the oral reading fluency gains over the baseline results per dollar spent. Cost-effectiveness matters a great deal in this study. The TAC tutor tablet program is nearly two times more cost effective than either the teacher tablet or control groups, and 10 times more cost effective than the pupil e-reader group. The teacher tablet program is somewhat more cost effective than the control group, but not substantially so. The pupil e-reader group is six times less cost-effective than the control condition. The key message is that while PRIMR's ICT programs were all effective, the per-pupil costs of each treatment are remarkably different. The effect size matters, but cost matters more.

Figure ES.3. Oral reading fluency gains over baseline per dollar spent

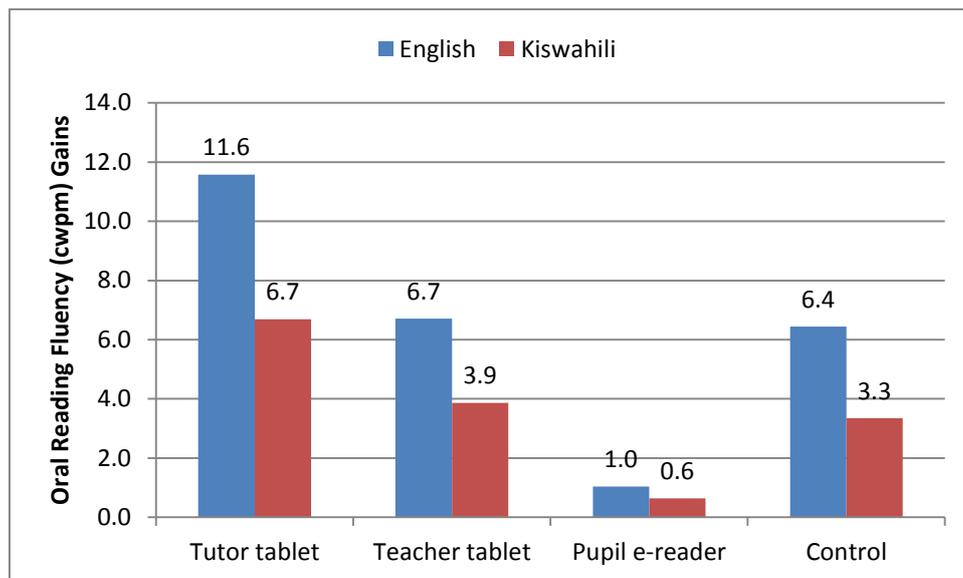
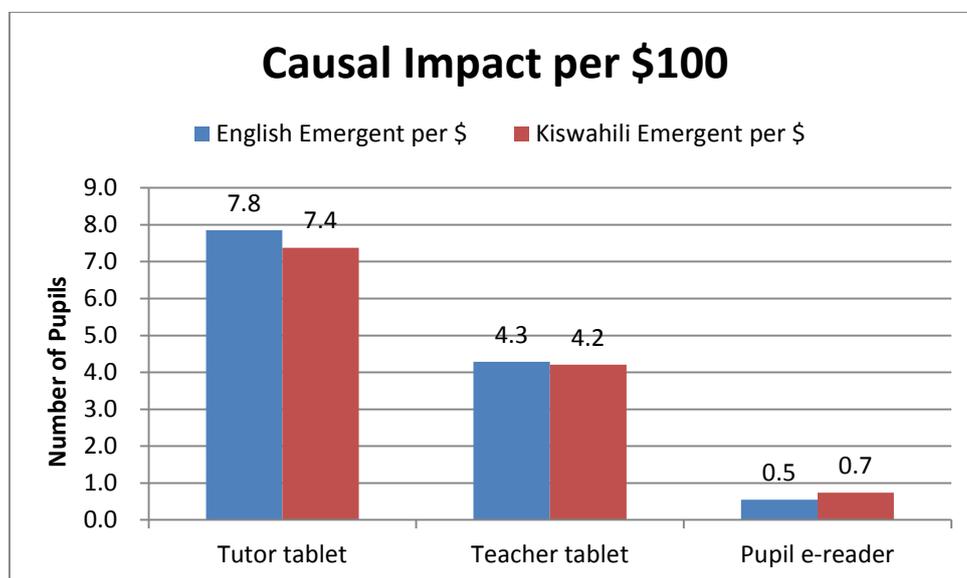


Figure ES.4 below presents cost-effectiveness another way. This shows the causal impact of the three treatment groups against the number of pupils who would read at the MoEST’s emergent benchmark for \$100 spent, inclusive of all relevant costs. This shows that the TAC tutor tablet program is nearly twice as cost-effective as the teacher tablet program, and the TAC tutor tablet program is nearly 15 times as cost-effective as the e-reader program.

Figure ES.4. Increase in numbers of pupils at emergent reader benchmark per \$100 spent



Effect of TAC Tutor support

TAC Tutors were key in the successful implementation of ICT PRIMR. They provided teacher support by visiting intervention schools on the program. During each visit, TAC tutors and the PRIMR staff completed monitoring data forms that were then analyzed by the PRIMR monitoring and evaluation and technical teams. Findings from these monitoring visits were used to further support teachers and TAC tutors in effective program implementation. TAC tutors were required to observe teachers at least twice per month. The frequency of school visit was later informed by need where teachers who demonstrated higher instructional mastery were visited less frequently as compared to those who had not. Each classroom observation would be followed by a sampling of at least three pupils to evaluate the learning content for that particular lesson, lesson coverage, and the mastery level of content that would have been taught the previous week. It was also followed by a reflection (with teachers) on areas of success and challenges in instructional delivery. These reflections were spearheaded by the TAC tutor. In some cases, TAC tutors were expected to model lessons in areas that teachers found difficult. The number of visits to classrooms was strongly correlated with pupil outcomes, as Figure 3 shows. This data suggests that the more TAC tutors visit, the higher pupils achieve on literacy measures.

Lessons Learned

1. **Focused training in ICT:** PRIMR exposed TAC tutors, teachers—and pupils—to new technology; however, PRIMR trained TAC tutors and teachers with a focus on improving instruction to increase learning and not on mastering the ICT. While, for this study, teachers and tutors eventually learned how to use the ICT, the PRIMR team was struck by the length of time and amount of repetition needed to ensure that teachers and tutors successfully adopt the ICT.
2. **The MoEST and Teachers' Service Commission (TSC) were instrumental in the success of ICT PRIMR.** At the launch of the Kisumu program, the Kisumu TSC office ensured that teachers trained in PRIMR would not be transferred to non-PRIMR schools. It also requested that PRIMR be given a first priority among other activities.
3. **The PRIMR approach was demand driven.** In the e-reader group, teachers expressed interest in acquiring reading material. Teachers used other textbooks and revision packs on the e-readers. Examples of requested titles included Christian Religious Education books and Kamusi.
4. **TAC tutor instructional support.** TAC tutors' efforts to provide instructional support to teachers were an essential part of the success of PRIMR and its impact on learning outcomes. Regular monitoring of TAC tutors' work was also done by TSC and MoEST officials in charge of quality assurance and standards. The in-person, regular, focused support built into PRIMR and the Kisumu ICT pilot study was critical to the success of the program.
5. **Storage and maintenance of ICT hardware:** Most of the Kisumu County schools working with PRIMR kept their electronic devices safely and used them responsibly in class.

6. **The PRIMR experience shows that ICT programs can have several other unintended effects.** These included more parental and community involvement in schools, improved pupil attendance, and Class 2 classrooms being viewed as examples of quality teaching. It also presented a channel that enhanced peer teaching.
7. **PRIMR is one of few ICT programs that have improved learning outcomes.** Much research shows that ICT does not improve outcomes, but PRIMR worked, in all three treatment modalities. There are particular characteristics about PRIMR's ICT experimental program that we think are essential. First, PRIMR utilized ICT on top of an already successful intervention program, and the ICT was targeted at particular areas that needed improvement. Second, PRIMR had clear goals to measure success. Third, the ICT introduced the instructional improvement process at different levels, ensuring that ICT was solving a problem relevant to the improvement program.

Recommendations

1. ICT is of great interest in the education sector in Kenya. The PRIMR ICT pilot study shows that **ICT can have a notable impact on learning outcomes in literacy, if integrated with an instructional support program.** Given that the TAC tutor tablet program had the largest impact on the key variables and that the program was very simple, we think that the evidence suggests it was PRIMR's instructional approach augmenting the ICT, rather than ICT alone, that was primarily responsible for the improved outcomes. This is because the TAC tutor tablet program was virtually indistinguishable from the basic PRIMR intervention without ICT.
2. **Adequate training is a precursor to successful program implementation.** The program must have adequate training time to build the capacity of participants at all levels on the hardware, software, and implementation of ICT. In addition, training time at the school level on proper storage and maintenance can have huge cost-effectiveness impacts, as this will decrease loss of or damage to devices.
3. **Having the requisite ICT infrastructure is important;** program implementation will suffer if it is missing. For PRIMR, implementation was negatively affected by the lack of electricity in many locations PRIMR was implemented. It follows that there is need to establish necessary infrastructure before incorporating ICT in early education on a large scale.
4. It is essential for **ICT education projects to consider and respond to the needs of all stakeholders** involved in the successful implementation. Apart from the education implementers, this PRIMR ICT project involved parents as well as the Kisumu community in its implementation. Parents and guardians were essential to the success of the PRIMR ICT study.
5. **Routine and frequent support is key to improving outcomes.** Schools with the most frequent TAC tutor visits reported superior performance in literacy outcomes. In order to fully harness the effect of ICT in schools, therefore, teaching should be accompanied by frequent support. PRIMR has expanded on this recommendation within PRIMR's expanded national tablet program (which gives tablets with PRIMR materials to all TAC tutors in the country) by streamlining the reporting of data for monitoring to the cloud.

6. **Provision of adequate instructional materials is an essential part** of ensuring that pupils have enough practice with the key elements of literacy development. The Kisumu study shows that ICT can be used to increase the access pupils have to reading materials.
7. **Focus on cost when considering ICT.** The results of the PRIMR ICT study
PRIMR's results show that effectiveness of ICT at different levels does not change the impact of PRIMR noticeably. What does vary is the cost of ICT based on the level of the program. Providing the ICT at higher levels, that is, tablets for TAC tutors rather than for pupils, limits cost as well as targets the ICT on a manageable problem.

Introduction

Background of the PRIMR Kisumu ICT Intervention

The Government of Kenya (GOK) has made an effort to ensure increased access to primary education through Free Primary Education (FPE). This effort is reflected in the rise in enrollment rates seen through all levels of education. At the primary school level, an increase in enrollment was achieved after the introduction of FPE in January 2002. Through these programs, the GOK provides a capitation grant of KES 1,100 per public primary school-going child.

Despite the success in getting pupils into classrooms, the quality of education remains lower than the MoEST expects. For example, Kenya Certificate of Primary Education (KCPE) average performance in key subjects is still low. The results of last year's KCPE (KNEC, 2014) indicated that the average scores for English, Kiswahili, and mathematics were 48.9, 49.3, and 50.0 respectively. Furthermore, more than 10,000 pupils were reported to have obtained a total score of less than 100 out of the possible 500. Since all subjects (apart from Kiswahili) are examined in English, many Kenyans argue that poor outcomes on national examinations are related to poor performance in English and Kiswahili.

Studies undertaken of early grade learning in Kenya have shown poor performance at the lower schooling levels. For example, the 2012 Uwezo survey findings showed that children are not acquiring basic competencies in literacy and numeracy at the right age or grade (Uwezo Kenya, 2012). In particular the study noted that 7 out of 10 children in Class 3 cannot do Class 2 level work. Similarly, findings from the PRIMR ICT study baseline survey showed that in English, pupils could read at a fluency of only 9.3 correct words per minute (cwpm) as compared to the national benchmark established by the Ministry of Education, Science, and Technology (MoEST) of 65 cwpm; while in Kiswahili pupils' reading fluency was a dismal 8.9 cwpm, again quite low compared to the benchmark of 45 cwpm (Piper, Kwayumba & Mugenda, 2014).

As indicated in the the draft National Education Sector Support Programme (NESSP) document (2014), the objective of ICT in education is to expand learning opportunities, facilities, and channels of delivery. It is in this context that the MoEST requested that the United States Agency for International Development (USAID)/Kenya design an ICT pilot project—the resultant Primary Math and Reading Initiative (PRIMR)—with technical assistance from RTI. The main objective of PRIMR was to assess the impact of three different ICT interventions implemented at different levels of the educational system on pupil outcomes in Kenya. The sections that follow provide details on the design and implementation of the PRIMR Kisumu ICT pilot study in Kenya.

PRIMR Kisumu ICT Research Program Design

PRIMR's Kisumu ICT intervention started in January 2013 and was part of a larger experimental design that began implementation in January 2012. The program was implemented in a total of 8 randomly selected zones (4 rural, 4 peri-urban), with 2 zones

assigned to each of 3 treatment groups, and 2 zones assigned to the control group (1 rural and 1 peri-urban assigned to each treatment group). Each of the groups (3 treatment, 1 control) had 20 schools (10 rural, 10 peri-urban), with the treatment groups carrying out the activities described in this section.

The fundamental question that PRIMR’s Kisumu County ICT intervention study sought to answer was how and whether a set of ICT interventions in Kenya made a difference for pupil achievement in Class 2 literacy. The use of ICT was intended not to introduce teachers and pupils to flashy machines, but to see whether and how ICT could improve and simplify teaching and learning. Each ICT intervention was compared against both each other intervention and the control group to measure effectiveness and cost-effectiveness. As noted, the ICT trial was implemented and managed by PRIMR in Kisumu County.



Pupils reading using e-readers in Kisumu County

Zone Selection

The study began with the selection of zones. Again, eight zones total were selected for this program (4 rural, 4 peri-urban), with 2 of them assigned to each of 3 treatment groups, and 2 zones assigned to the control group (1 rural, 1 peri-urban to each group). Each of the groups (3 treatment, 1 control) had 20 schools (10 rural, 10 peri-urban). Peri-urban and rural zones were selected for comparisons of how the interventions work in both settings. **Table 1** shows the zones and treatment groups, along with pupil totals for each.

Table 1. Treatment groups for ICT interventions

Treatment Group	ICT Intervention	Schools	Pupils	Zones
PRIMR + tutor tablet	TAC tutors with tablets for supervision and assessment	20	701 339	Ragumo (peri-urban) Bolo (rural)
PRIMR + teacher tablet	Teachers with tablet with multimedia lesson plans, virtual flashcards, and continuous-assessment tools	20	432 452	Nyabondo (rural) Barkorwa (peri-urban)
PRIMR + pupil e-reader	Pupils with e-readers, loaded with PRIMR content, Kenyan textbooks, and supplementary reading materials	20	603 328	Otonglo (peri-urban) Kodingo (rural)
Control	None	20	~1000	Ahero (peri-urban) Chulaimbo (rural)

Interventions Assessed

All four groups were subjected to a rigorous set of baseline (January 2013) and endline (October 2013) assessments to determine what causal effect each ICT intervention had on student achievement. This design, mixed with the randomized assignment of schools to the interventions, allowed RTI to estimate what impact each ICT intervention had on student achievement. The design also allowed for estimation of whether and how the ICT interventions affected student outcomes over and above the standard PRIMR package of interventions, implemented elsewhere in Kenya. PRIMR therefore assessed the following three interventions against a group of control schools.

PRIMR + TAC tutor tablet:

Under this treatment, Teachers' Advisory Centre (TAC) tutors were provided with a tablet that contained educational materials on efficient and effective teacher support. This also included PRIMR materials for the TAC tutors.

PRIMR + teacher tablet: Under this treatment, teachers were provided with a tablet to supplement their PRIMR instruction. The tablet contained multimedia lesson plans; supplementary pedagogical aids, including letter flashcards and the Papaya application, which had audio capabilities to practice letter sounds; and the Tangerine:Class application, which contained various pupil assessments.

PRIMR + pupil e-readers: Under this treatment, e-readers were provided to pupils and teachers. They contained the PRIMR reading textbooks in English and Kiswahili, relevant textbooks from Kenyan publishers, and hundreds of age-appropriate stories related to the Kenyan curriculum including English and Kiswahili dictionaries.

Given Kenya's interest in scaling up ICT interventions, this experimental study focused on understanding the mechanisms by which the various ICT interventions worked. The three research questions investigated were as follows: 1) Does the technology improve achievement?, 2) How cost effective are the interventions?, and 3) How do the interventions change learning to improve achievement? Overall, we anticipated that this study would provide Kenya with information relevant to decision making regarding which ICT interventions are the best investment in terms of student outcomes and whether ICT interventions are worth the cost, given scarce resources available at scale-up.



A teacher using a tablet for Kiswahili instruction



TAC tutor using tablet to assess a pupil's skills

The goal of this Kisumu ICT intervention was to provide MoEST with information on how to maximize ICT for cost-effectively improving learning in Kenya.

PRIMR Basics Included

Alongside the three ICT components on trial, the PRIMR Kisumu ICT intervention also made use of the following key elements of PRIMR that were common to all three treatment groups.

- **Inexpensive books:** The

PRIMR Kisumu ICT project team made several decisions that would ensure savings on book purchases. For example, all elements of the literacy program—which for English and Kiswahili included phonics activities, illustrations, and daily primer stories—were embedded in one book. The book had attractive black and white illustrations. The per-book cost of the most recent versions, with 152 pages of text, was less than \$0.75. Note that the 2014 versions of the book have color illustrations and are \$0.85.

- **Basic instructional aids:** While PRIMR encourages teachers to create additional instructional aids, this is not a core part of the program. The PRIMR Kisumu ICT project team made explicit decisions not to emphasize wall charts, big books, or other short-term-use but expensive materials. The aids provided to teachers were an A3-sized pocket chart with three pockets and a set of laminated letter flashcards in business-card size. Other aids provided to teachers included a stopwatch and laminated pages for tracking pupil progress on literacy for both English and Kiswahili.
- **Self-contained lesson plans:** For English and Kiswahili, the teachers' guides consisted of two volumes and included specific lesson strategies. The teacher's tablet group received these lesson plans in electronic and interactive formats. Teachers were also given an assessment manual of fewer than 30 pages, a sheet of training tips, and a two-page document to track pupil progress; pupils were given a single B5 sheet to track reading at home.
- **Modest training:** PRIMR decided to invest proportionally more training money in follow-up and observation than in other activities. This allows for five days at the beginning of Term 1, three days at the beginning of Term 2, and two days at the beginning of Term 3. However, because of the ICT component, training of TAC tutors and teachers lasted slightly longer, which resulted in a training period of 16 days for TAC tutors and 12 days for teachers. The additional days were dedicated to training in implementing PRIMR using ICT components.

- Classroom observations:** Much of PRIMR's attention and energy was spent on supporting TAC tutors as they visit schools and observe classrooms. TAC tutors were provided travel reimbursement based on the proportion of teachers they observed twice per month. This budget, which was the same in KESSP, encouraged TAC tutors to support schools that were located far away from their offices. The reimbursements were based on detailed observation forms that give PRIMR the information needed to make course corrections, matched with school logs signed by the head teacher. This system was utilized in the PRIMR and ICT PRIMR studies alike. Similar to the support mandated of the District Quality Assurance and Standards Officers (DQASOs), PRIMR's technical team supported TAC tutors in the PRIMR Kisumu ICT implementation in classrooms.

Overall Program Implementation in 2013

The PRIMR Kisumu ICT project baseline assessed the learning levels of pupils assigned to treatment and control before the start of the intervention. This assessment was a survey (rather than a sample) of each of the 60 schools from the six ICT treatment zones and 20 schools from the two control zones. In each school, 20 pupils (10 girls and 10 boys) were sampled. Baseline results showed that, overall, oral reading fluency (ORF) in English and Kiswahili was 9.3 cwpm and 8.9 cwpm, compared to the national benchmark of 65 cwpm and 45 cwpm respectively (Piper, Kwayumba & Mugenda, 2013).

In January 2013, six TAC tutors in the randomly assigned intervention zones were trained by PRIMR technical staff on the implementation of PRIMR. The training for the core PRIMR design and program was identical for the three treatment groups, what differed was the ICT tool that applied in each treatment group, and the level that ICT tool was applied. The training was integrated between technical and ICT trainings, with the focus on the implementation of the PRIMR program. The aim of the training was to build the capacity of TAC tutors to support teachers in delivering effective literacy instruction. The rest of the training focused on building capacity for effective delivery of PRIMR using the various ICT tools. Training was holistic, since it also covered aspects of operation, trouble-shooting, and maintenance of the physical ICT hardware.

By January 2013, electronic training materials were prepared, including the English and Kiswahili course books and teachers' guides, the Papaya letter sound practice activity, multimedia lesson plans, and hundreds of supplementary readers for pupils to practice their newfound skills with.

After the TAC tutor training, TAC tutors trained teachers in their respective intervention zones. The purpose of the training was to provide teachers with practice and support on how to effectively implement PRIMR in their schools. The training was also aimed at ensuring that teachers were competent in using respective ICT tools in undertaking teaching and learning in their schools.

Implementation Specifics by Treatment Group

This section of the report provides details on how each of the three treatment groups was implemented in Kisumu County, in order to better interpret the findings sections that follow.

Implementation in TAC Tutor Tablet Zones

In the TAC tutor tablet intervention zones (Ragumo and Bolo), the two TAC tutors were each provided with a tablet that contained materials on efficient and effective teacher support. In addition to containing all of the content on the teacher tablets, TAC tutor tablets contained a TAC tutor manual with detailed information on PRIMR, classroom observation, and teacher support as well as pupil assessment. These TAC tutor tablets were designed to help the TAC tutors support instruction more effectively. The impact of the TAC tutor tablet was therefore determined by any increase (or decrease) in TAC tutors' skill in supporting teachers.

We found that one of the two TAC tutors struggled with the tablet, repeatedly forgetting his password and having to have the tablet reset. The dosage of the tablet-based materials was modest, and there is limited evidence that the ICT tools on the tablet fundamentally improved the quality of classroom support. However, the number of classroom visits by TAC tutors in the TAC tutor tablet zone was quite high, and there is evidence that the number of visits impacts outcomes in the zone. However, there is less evidence that the tablet itself had a causal impact on TAC tutor visits. In short, the TAC tutor tablet program was in practice very similar to the base PRIMR program without ICT.

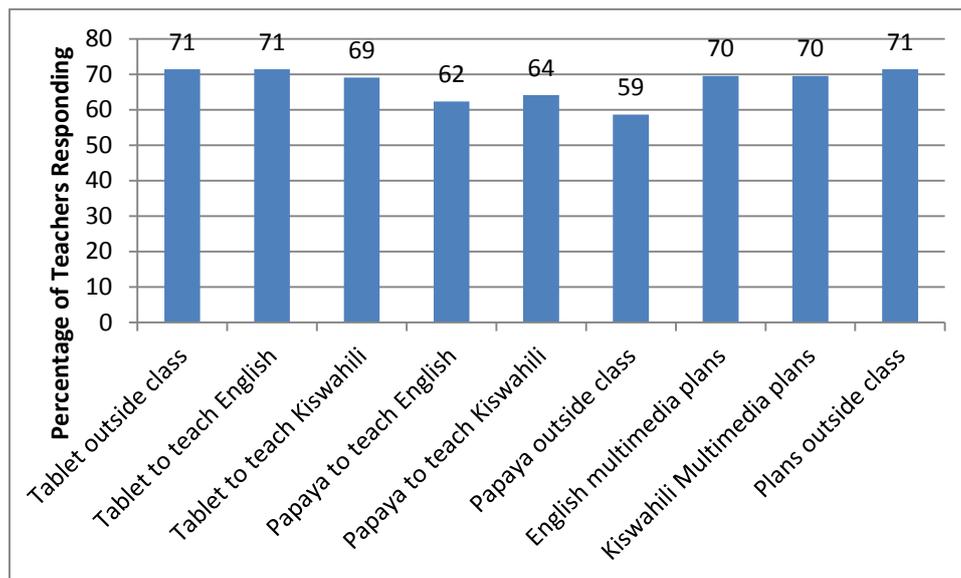
Implementation in Teacher Tablet Zones

Teachers in two zones (Barkorwa and Nyabondo) used tablets to support their teaching. The tablets contained several applications, including Papaya, a virtual flashcard application; Tangerine: Class, the continuous assessment tool on the tablet that was linked to the lesson plans; and several e-book files. These e-book files included multimedia versions of the lesson plans with embedded audio, the pupil versions of the course books, as well as other TAC tutor and teacher reference materials. Apart from electronic files, teachers were also provided with printed versions of lesson plans to use in case of tablet failure.

During the first month of implementation, many teachers preferred to use the printed versions of the teacher's guides. Later on, the frequency of use of the multimedia lesson plans increased. This increase was credited to the fact that the multimedia lessons could provide sounds of letters and words that proved difficult for pupils and teachers. The Papaya application was helpful in ensuring that letter sounds were pronounced correctly. Teachers also used this application in teaching the formation of words from letters. Tangerine:Class was used to conduct pupil evaluations using progress assessments. The assessments were undertaken on a term basis in addition to weekly curriculum mastery checks. The Tangerine: Class tool was not used on a consistent basis by most teachers, and only a few followed the instructions from Tangerine: Class as to what content to reteach.

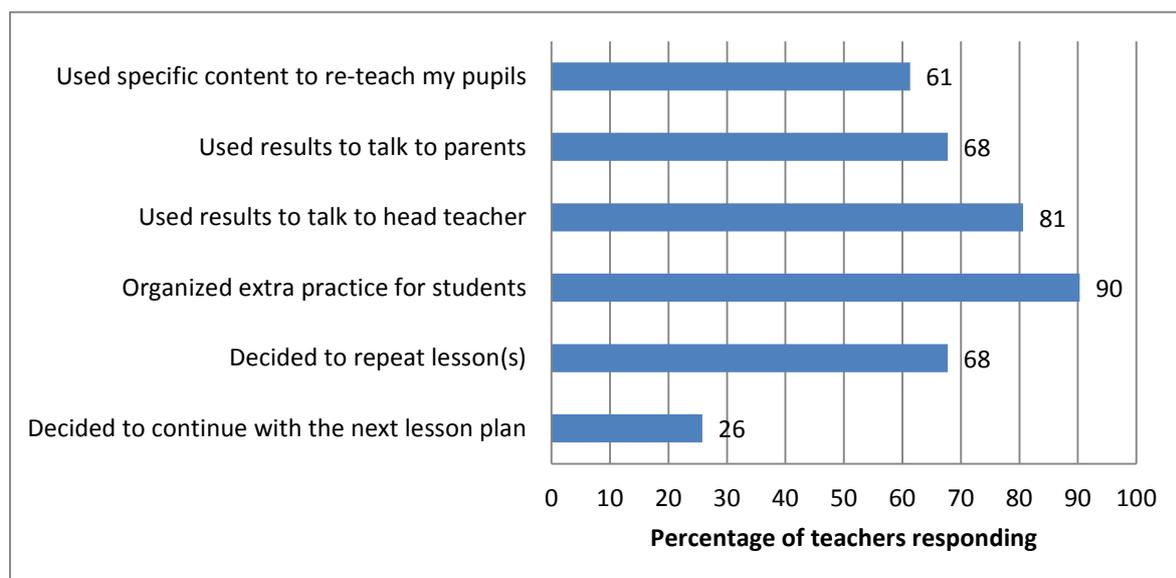
An analysis of data collected during TAC tutor school visits showed ongoing usage of the tablet content. TAC tutors met with the PRIMR technical staff monthly to discuss progress and troubleshoot basic problems. Based on TAC tutor reports from school visits and classroom observations, teachers used their tablets consistently in class and in many cases for other activities outside of the classroom. This is explained in *Figure 1*.

Figure 1. Tablet usage by teachers in teacher tablet group



Regarding the evaluation data from Tangerine:Class, teachers used the assessment results for instructional decision making in various ways. **Figure 2** below highlights the different instructional decisions reported by teachers in response to the assessment results. Ninety percent of the participating teachers reported using data from regular mastery checks to identify those pupils needing remedial action and practice. Results were also used to decide whether to proceed with the subsequent lesson or to re-teach earlier lessons. For individual pupils, the application also identified specific items that pupils struggled with. There is some evidence that teachers over-reported their usage of the tablets in classrooms, as several of the teachers struggled to consistently assess their pupils in school.

Figure 2. Teacher reported usage of Tangerine: Class results



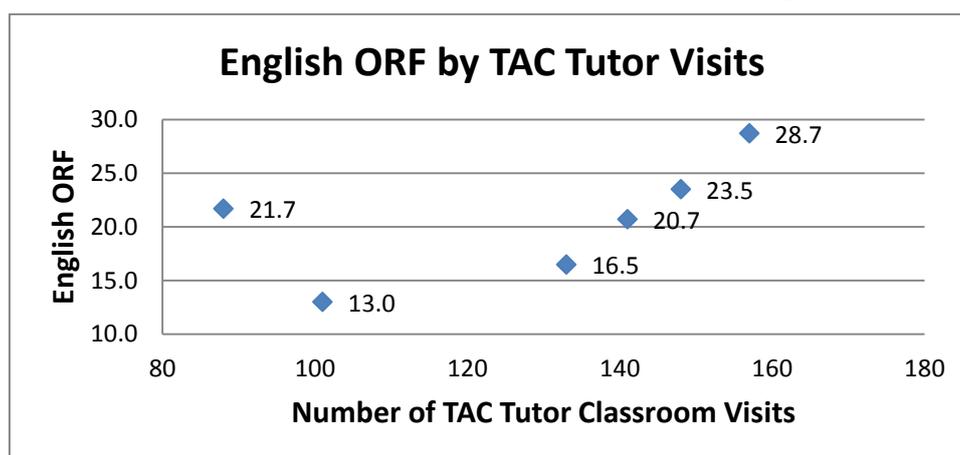
Implementation in Pupil e-Reader Zones

For the e-reader treatment group (Otonglo and Kodingo zones), the availability of the e-readers gave pupils an immense opportunity to access and read more books than any of the other treatment groups, and many more than the control. Impressively, the analysis of e-reader usage at the culmination of the ICT program revealed that pupils in the e-reader intervention read an average of 18 books in the 2013 academic year. This number could have been higher had more of the pupils been allowed to take the e-readers home with them. To allow for more reading time at school, given the schools' reticence to have the e-readers travel home, many schools worked with the Worldreader team to establish the Free Reading activity in the afternoons. During Free Reading, pupils selected books of their own choice and read. Teachers provided one-on-one support to pupils who were struggling with decoding or comprehension. A minimum of half an hour was recommended for this session. Teachers accommodated Free Reading at the most suitable time for their particular schools. More often than not, this was in the afternoon after lessons were completed for Class 2 pupils. Attendance at this Free Reading session was impressive, with more than 70% of pupils attending in the average school. Over time, both school administration and parents were more confident about the safety of both the pupils and the devices. Pupils began to take their devices home in term 2 and continued to do so for the rest of the year.

Instructional Support by TAC Tutors in All Treatment Groups

Immediately after the January 2013 training, teachers began implementing the Kisumu ICT PRIMR program. They were supervised and supported by their respective TAC tutors who were in turn supported by the PRIMR technical team. During each visit, TAC tutors and the PRIMR staff completed monitoring data forms that were then analyzed by the PRIMR monitoring and evaluation and technical teams. The findings were used to further support teachers and TAC tutors in effective implementation. TAC tutors were required to observe teachers two times each month. Each observation would be followed by a sampling of at least three pupils to evaluate the learning content for that particular lesson, lesson coverage, and the mastery level of content that would have been taught the previous week. It was also followed by a reflection (with teachers) on areas of success and challenges in instructional delivery. These reflections were spearheaded by the TAC tutor. In some cases, TAC tutors were expected to model lessons in areas that teachers found difficult. The number of visits to classrooms was strongly correlated with pupil outcomes, as *Figure 3* below shows. While we do not claim a causal link between classroom visits and performance, this suggests that the more often that the TAC tutor visited the classrooms, the higher the English ORF rate at the endline.

Figure 3. Number of TAC tutor classroom visits and English ORF at endline



Subsequent TAC tutor and teacher trainings were held in May and August. These were refresher courses whose objectives were to first review the progress made in the implementation of the PRIMR Kisumu ICT component and address challenges experienced during the term. The content and length of these meetings and trainings did not differ between the three treatment groups except for where the specific ICT intervention was concerned.

Other PRIMR activities that were common to all three treatment groups included the monthly meetings, reading contests, and the mini-Early Grade Reading Assessment (EGRA), a study implemented by PRIMR to determine whether pupils were achieving at adequate levels. The monthly meetings were held in respective zones chaired by TAC tutors, after which they presented observations from their respective zones at a meeting held at the RTI office. Topics included lesson coverage, technology challenges, and best practices. These meetings were important in identifying and addressing program implementation challenges.

Reading contests were organized at the zonal level on a termly basis in all three treatment groups. Schools selected their two best pupils (a boy and a girl) in reading, who competed with pupils selected from other schools. They were assessed using a common tool and awarded prizes depending on performance. The reading contests not only developed a competitive literacy environment but also helped build the capacity of teachers and head teachers in organizing mock literacy assessments.

Challenges of PRIMR ICT Implementation

The PRIMR Kisumu ICT intervention was undertaken for one school year, a very short period in which to demonstrate an impact on learning. This section highlights intervention related challenges.

Challenges Related to ICT

During the TAC tutor training, it became evident that all groups of trainees needed more intensive training on ICT hardware. Teachers, in particular, found the use of tablets in teaching and learning to be quite challenging. It was further observed that, even though TAC tutors and teachers showed an interest in learning, full mastery of tablet use was achieved

only several months after the initial training. Specifically, both teachers and tutors found it difficult to manipulate the ICT and, to some extent, the content. Utilizing Tangerine:Class for continuous assessment was rated as the area in which teachers struggled the most.

Multiple activities affecting learning: The additional activities that schools undertake in Kisumu County reduced the time spent learning. PRIMR ICT lesson coverage was heavily affected by these additional activities. This implies that some key lessons on improving literacy anticipated by the intervention were not in fact covered, which limits the effect of the intervention.

Teacher mobility: Teachers were key stakeholders in the implementation of the Kisumu ICT trial. Despite the strong support of the Teachers' Service Commission (TSC) county director to ensure that PRIMR-trained teachers were not transferred to non-PRIMR zones, nearly one-quarter of the PRIMR-trained teachers dropped out due to sickness, maternity leave, and further studies. In these cases, a substitute teacher was trained to take up the program. Since, on average, it took at least one month for a teacher to become fully conversant with PRIMR methodology as well as with the use of the relevant ICT tools in teaching and learning, this affected learning outcomes.

Teachers' strike: The long teacher strike in July 2013 substantially reduced the PRIMR Kisumu ICT project implementation duration. This affected the magnitude of the impact.

Parental support: Many teachers found it difficult to read with their children and keep up the home tracker recording their efforts. For the e-reader program, some parents could not afford or were unwilling to pay the KES 10 that was required by some schools for the charging of the pupil e-reader. It was also reported that some parents were unwilling to sign commitment forms to allow pupils to carry home e-readers. They felt that they could be surcharged in the event of the loss of the e-reader.

Endline Assessment

Early Grade Reading Assessment

In the PRIMR Kisumu ICT study, EGRA is used to measure the impact of the interventions. The Kenyan EGRA assesses a set of skills critical to early literacy acquisition. The tailored version of the tool used for the ICT endline study in Kisumu built upon the versions used earlier in Kenya. In order to better understand literacy acquisition in Kenya, PRIMR assessed several tasks at the endline that were not assessed at the baseline. **Table 2** notes the tasks that were undertaken, by language and at the baseline and endline.

Table 2. EGRA subtasks administered for English and Kiswahili

Subtask	Languages Assessed	Baseline	Endline
Letter-sound fluency	English and Kiswahili	Yes	Yes
Segmenting	English	No	Yes
Syllable fluency	Kiswahili	No	Yes
Non-word fluency	English and Kiswahili	Yes	Yes
Vocabulary	English	No	Yes
Oral passage reading	English and Kiswahili	Yes	Yes
Comprehension	English and Kiswahili	Yes	Yes
Listening comprehension	Kiswahili	Yes	Yes
Maze comprehension	Kiswahili	Yes	Yes
Pupil context interview	English	Yes	Yes

The EGRA subtasks measured various literacy outcomes, as follows.

- Letter-sound fluency: ability to identify the sounds of letters fluently. Assessed in English and Kiswahili.
- Syllable fluency: ability to fluently identify syllables. Measured in Kiswahili.
- Segmenting: measures the phonemic awareness skill of segmenting sounds in English.
- Non-word fluency: ability to decode new or unfamiliar words fluently. This subtask consists of made-up words that follow the linguistic rules but do not actually exist in either English or Kiswahili. Measured in English and Kiswahili.
- Vocabulary: ability to understand the meaning of common English words.
- Oral reading (connected text) fluency: ability to read an approximately 60-word story fluently. Measured in English and Kiswahili.
- Reading comprehension: ability to answer comprehension questions based on the story. Measured by percent correct out of the five comprehension questions. Measured in English and Kiswahili.
- Listening comprehension: ability to understand a simple story read aloud by the assessor. Measured by percent correct out of three comprehension questions. Measured in Kiswahili.
- Maze stories: ability to read and comprehend a short story requiring that pupils supply missing words. Measured in Kiswahili.
- Pupil context interview.

Additional Tools

Pedagogical quality was assessed using a tailored version of the Snapshot of School Management Effectiveness (SSME) tool. The SSME contains a classroom observation checklist for collecting information such as the languages used by the teacher during instruction and the teacher's interaction with pupils (is the teacher speaking to the entire class, a group, or a single pupil? Are pupils left to work on their own or in groups?). These

data were supplemented with information collected through interviews with TAC tutors, head teachers, teachers, and pupils.

The TAC tutor questionnaire contained questions on the following:

- TAC tutor duties and responsibilities
- Teacher supervision and support
- Opinion of the relevance, effectiveness, and improvement of the PRIMR Kisumu ICT initiative.

The head teacher questionnaire contained questions on the following:

- Staffing levels in the school; teachers' training level, including whether they had received special training in implementing a literacy program
- Teacher attendance and supervision
- Instructional materials in schools—textbooks for English and Kiswahili as well as other literacy materials
- Parental involvement in school management and accountability
- School infrastructure such as availability of electricity, clean and safe drinking water, sanitation facilities in the school, library, and computer rooms, among other facilities
- ICT facilities and equipment in the school and their use in teaching and learning.

The teacher questionnaire contained questions on the following:

- Pupil attendance
- Teacher training, with a focus on English and Kiswahili
- Methods used in pupil assessments, and frequency of assessments
- Use of assessment results
- Instruction materials in schools—schemes of work, lesson plans, English and Kiswahili textbooks, and other literacy materials
- Activities that are frequently used in teaching
- Opinion on the class level by which pupils should demonstrate various learning outcomes
- ICT facilities and equipment used in teaching and learning at the classroom level.

Research Design and Sampling

The PRIMR Kisumu ICT study followed a randomized control trial design. Sampling was undertaken in three steps. It first involved the selection of zones eligible for participation, which was determined to be the entire county of Kisumu. These zones were then randomly assigned to treatment groups, stratified by peri-urban or rural location. The second stage of sampling entailed a random selection of 10 schools from each of the eight zones giving a total of 80 schools across the eight zones. The third stage of sampling was at the pupil level, where PRIMR utilized simple random sampling stratified by gender.

Barkorwa and Nyabondo zone were assigned to the teacher tablet treatment group. Ragumo and Bolo were assigned to the TAC tutor tablet group, while Kodingo and Otonglo were assigned the e-reader group. Chulaimbo and Ahero served as control zones for 2013 but

received the most cost-effective intervention in 2014. *Table 3* shows the zones and treatment groups.

Table 3. Type of ICT treatment, by zone

Treatment	Type of zone	
	Peri-urban	Rural
Tablets for TAC tutors	Ragumo	Bolo
Tablets for teachers	Barkorwa	Nyabondo
e-Readers	Otonglo	Kodingo
Control	Ahero	Chulaimbo

This randomized selection and assignment formed the basis of the PRIMR Kisumu ICT intervention as well as for the baseline and endline assessments of the intervention. For both the baseline and the endline, the assessments used a survey of the schools but a sample of the students, utilizing simple random sampling. After determination of the sampling interval by gender (number of pupils present by gender divided by 5), pupils were requested to form queues separated by gender. Pupils included in the studies were then selected for the assessment at the calculated interval.

Sampling

At the zone level the baseline and endline assessment was a survey, sampling all 80 schools. At the school level, both the baseline and endline studies targeted 20 Class 2 pupils per school, a head teacher, and at least one teacher from each of the 80 schools. We utilized simple random sampling at the Class 2 level to obtain a sample of 20 pupils by school. *Table 4* shows the achieved pupil sample at the endline, by treatment type.

Table 4. Achieved pupil sample by treatment group and zone

Zones	Treatment				Total	Number of schools
	Control	E-readers	Teacher tablets	TAC tutor tablet		
Ahero	200	—	—	—	200	10
Barkorwa	—	—	196	—	196	10
Bolo	—	—	—	188	188	10
Chulaimbo	186	—	—	—	186	10
Kodingo	—	193	—	—	193	10
Nyabondo	—	—	199	—	199	10
Otonglo	—	200	—	—	200	10
Ragumo	—	—	—	198	198	10
Total	386	393	395	386	1,560	80

Our achieved sample was quite close to our planned sample.

Difference-in-Differences Analysis

Recall that each of the PRIMR Kisumu ICT interventions (tablets for TAC tutors, tablets for teachers, e-readers for pupils) was randomly assigned to randomly selected zones (stratified by peri-urban and rural status), with an objective to determine the effectiveness and cost-effectiveness of each option. Though the random assignment was done carefully, the baseline analysis showed that there were some differences between the groups on a few tasks and a couple of the comparisons, particularly for letter sound fluency. Given the high correlations between letter sounds and other subtasks on EGRA, it is evident that these differences could spread to fluency and comprehension over time. In order to ensure that our analysis could attribute causality to the impact of PRIMR, we utilized a difference-in-differences (DID) identification strategy. DID removes the differences in baseline prior to the implementation of the program to measure an unbiased effect of the program, in this case PRIMR.

Reliability Estimates

In this section, we present the reliability scores of the tasks and the overall assessments. In order to do this we generated Pearson's bivariate correlations as well as the Cronbach's alpha reliability test for both English and Kiswahili. Results are as shown below.

English Tool Analysis

Table 5 presents bivariate correlations for subtasks in the English EGRA tool. There were statistically significant positive correlations between letter sound fluency, decoding fluency, and reading comprehension. The results are similar to those for baseline instruments. The correlations between decoding fluency are the highest at 0.86.

We also found statistically significant relationships between letter sound fluency, decoding fluency, ORF, and comprehension. The high correlation between ORF and the percentage score in comprehension questions is expected since the EGRA only allowed comprehension questions to be asked depending on the portion of the passage the pupil read

Some tasks reported weaker, though statistically significant relationships with each other. For example the lowest correlation was observed between phonemic awareness, vocabulary, and oral reading comprehension. This points out that, in Kisumu County, knowing the initial sound and generally being able to sound words out correctly does not necessarily mean that one understands them.

Table 5. Pearson’s correlations for EGRA English subtasks

	Letter sound fluency	Decoding fluency	Segmenting	Oral reading fluency	Vocabulary	Reading comprehension
Letter sound fluency	1.00					
Decoding fluency	0.64***	1.00				
Segmenting	0.61***	0.46***	1.00			
Oral reading fluency	0.56***	0.86***	0.39***	1.00		
Vocabulary	0.36***	0.44***	0.32***	0.49***	1.00	
Reading comprehension	0.31***	0.47***	0.21***	0.63***	0.43***	1.00

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

We undertook a Cronbach’s alpha reliability test to determine the reliability of the English EGRA tool. This was done in order to validate the internal consistency of the EGRA instruments used during the endline assessment.

As shown in **Table 6**, results for the English EGRA, all subtasks recorded alpha coefficients above the required threshold of 0.7, with an overall alpha score of 0.85. These Cronbach’s alpha levels imply that the internal consistency of the Kisumu EGRA endline was acceptable. These scores are similar to what was found at the baseline in Kisumu and in other Kenyan EGRA.

Table 6. Cronbach’s alpha for the English subtasks

Subtask	Item-test correlation	Item-rest correlation	Alpha
Letter sound fluency	0.77	0.65	0.82
Decoding fluency	0.86	0.78	0.79
Segmenting	0.66	0.51	0.84
Oral reading fluency	0.87	0.80	0.79
Vocabulary	0.67	0.52	0.84
Reading comprehension	0.68	0.53	0.84
Total			0.85

EGRA Kiswahili Tool Analysis

We also undertook reliability analysis for the ICT Kiswahili EGRA endline tool. **Table 7** shows bivariate correlations for the subtasks in this tool. According to **Table 7** all tasks were found to have statistically significant positive correlations with each other. Similar to the English EGRA tool, decoding fluency and ORF had the highest correlation—nearly 0.9.

Though positively correlated, the correlation between listening and maze subtasks with the rest of the tasks was weak (<0.4). This implies that both the maze and the listening subtask

were not measuring the same constructs as the other subtasks. These results are similar to those obtained for the baseline Kiswahili EGRA tool analysis.

Table 7. Pearson’s correlations for EGRA Kiswahili subtasks

	Letter sound fluency	Syllable fluency	Decoding fluency	Oral reading fluency	Reading comprehension	Listening comprehension	Maze comprehension
Letter sound fluency	1.00						
Syllable fluency	0.71***	1.00					
Decoding fluency	0.62***	0.82***	1.00				
Oral reading fluency	0.60***	0.79***	0.90***	1.00			
Reading comprehension	0.45***	0.58***	0.65***	0.72***	1.00		
Listening comprehension	0.24***	0.28***	0.27***	0.31***	0.43***	1.00	
Maze comprehension	0.32***	0.37***	0.44***	0.47***	0.45***	0.30***	1.00

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

As indicated in *Table 8*, the Cronbach’s alpha for the Kiswahili EGRA was more than 0.8 for each subtask, with the overall alpha recorded at 0.88. This showed a high internal validity of the EGRA endline Kiswahili instrument. Similar results were obtained for the EGRA Kiswahili Kisumu ICT baseline tool.

Table 8. Cronbach’s alpha for the Kiswahili subtasks

Subtask	Item-test correlation	Item-rest correlation	Alpha
Letter sound fluency	0.74	0.63	0.87
Syllable fluency	0.85	0.78	0.85
Decoding fluency	0.88	0.83	0.84
Oral reading fluency	0.90	0.85	0.84
Reading comprehension	0.81	0.72	0.86
Listening comprehension	0.53	0.38	0.90
Maze comprehension	0.63	0.50	0.88
Total			0.88

Equating Procedures

Equating of tasks at the endline and baseline was undertaken with the aim of standardizing the difficulty levels of stories and comprehension questions.

Nine experienced research assistants were trained in how to administer the equating tasks (English and Kiswahili). Data were collected from three schools and 126 pupils. The three schools selected represented peri-urban and rural settings. In each of the three schools, an equal number of pupils by gender were randomly selected. Data were analyzed and findings used to adjust the difficulty levels of the endline oral passages. The equating coefficient was obtained by dividing baseline ORF scores and the endline oral reading scores (i.e., Equating co-efficient = Baseline Scores / Endline scores). This process ensured that the scores for baseline and endline were comparable.

Findings

Impact of PRIMR Kisumu ICT Intervention

Descriptive Analysis

The sections above show how the PRIMR Kisumu ICT intervention was designed. This section shows its impact on pupil outcomes. A descriptive analysis of the endline data showed significant differences in literacy outcomes at the end of the intervention. **Table 9** below shows the difference between the control and treatment groups (combined together) in their EGRA subtask outcomes, differentiating by language and gender. The table shows the simplest way to express the impact of the intervention, and the difference in mean scores between treatment and control groups at the endline.

The treatment groups had higher literacy outcomes than the control group on all tasks. This difference between treatment and control is smaller as the tasks become more complex. This is reflected in the decreasing effect size as we shift from letter sound fluency to reading fluency and comprehension. The effect size on English letter fluency for boy and girl pupils is 1.14 and 1.20 respectively. Letter fluency effect sizes are also high in Kiswahili (1.17 for boys and 1.25 for girls). The lowest effect sizes are observed for oral reading fluency (0.07 and 0.16 for boys and girls, respectively). Effect sizes for Kiswahili ORF were 0.11 and 0.37 for boys and girls.

The table also shows that there was an increase in the proportion of pupils who could read at the established MoEST emergent benchmark level for English and Kiswahili. More pupils in treatment schools could read at the emergent level of 30 cwpm or above in English or 17 cwpm or above in Kiswahili.¹ This emergent level fluency rate in English was achieved by 47.0% of boys at treatment schools compared with 31% of boys at control schools. Similarly 57.8 % and 45.0% of girls in treatment and control groups reached at least the emergent level.

The Kiswahili findings paint a similar picture; 60.7% of boys and 68.9% of girls in treatment groups were able to attain the emergent fluency rate, in comparison to 41.9% of boys and 52.0% of girls in the control groups.

Table 9. Treatment and control groups' EGRA subtask scores

Subtask	Language	Gender	Control		Treatment		Program Effect		
			Mean	Standard Error	Mean	Standard Error	Standard deviation	Program effect	Effect size
Letter sound fluency	English	Boy	21.17	1.07	53.54	0.67	28.49	32.37	1.14
		Girl	24.86	0.99	61.25	0.60	30.27	36.12	1.20
	Kiswahili	Boy	18.28	1.01	51.78	0.74	28.55	33.50	1.17
		Girl	21.01	1.41	59.36	0.84	30.76	38.35	1.25
Syllable fluency	Kiswahili	Boy	25.14	1.16	37.04	0.68	24.11	11.90	0.49

¹ More modest gains were found for the proportion of pupils who could read at the fluent level, given how few pupils reached that level in Kisumu County. For English, in treatment schools, 8.4% and 14.6% of boy and girl pupils were able to read at least 65 cwpm, compared to 6.4% and 9.4% in control schools. For Kiswahili, 7.3% of boys and 14.6% of girls respectively in the treatment group were able to attain the MoEST Kiswahili fluency benchmark of 45 cwpm. This compares positively with 4.6% of boys and 3.0% of girls in control groups.

Subtask	Language	Gender	Control		Treatment		Program Effect		
			Mean	Standard Error	Mean	Standard Error	Standard deviation	Program effect	Effect size
		Girl	30.96	1.41	46.03	0.81	25.34	15.07	0.59
Non-word decoding fluency	English	Boy	15.34	0.92	22.19	0.45	15.91	6.85	0.43
		Girl	18.92	0.99	27.67	0.60	17.10	8.75	0.51
	Kiswahili	Boy	12.52	0.78	17.57	0.40	13.98	5.05	0.36
		Girl	15.73	0.85	21.53	0.46	14.68	5.80	0.40
Oral reading fluency	English	Boy	21.61	1.28	29.30	0.73	24.58	7.69	0.31
		Girl	28.64	1.74	37.32	0.88	27.50	8.68	0.32
	Kiswahili	Boy	14.66	0.87	20.94	0.56	15.55	6.28	0.40
		Girl	19.15	1.12	26.32	0.53	17.04	7.17	0.42
Reading comprehension (% correct)	English	Boy	7.50	0.09	14.20	0.01	0.23	0.07	0.29
		Girl	12.00	0.01	16.60	0.01	0.26	0.05	0.18
	Kiswahili	Boy	17.96	0.01	23.57	0.01	0.25	0.06	0.23
		Girl	19.10	0.02	26.89	0.01	0.25	0.08	0.32
Listening Comprehension (% correct)	Kiswahili	Boy	37.96	0.01	39.43	0.01	0.27	0.01	0.05
		Girl	35.29	0.02	45.30	0.01	0.27	0.10	0.37
Phonemic awareness (% correct)	English	Boy	20.00	0.02	63.00	0.01	0.37	0.43	1.16
		Girl	17.40	0.02	67.00	0.01	0.38	0.50	1.31
Vocabulary (% correct)	English	Boy	61.00	0.09	63.60	0.00	0.15	0.03	0.17
		Girl	62.00	0.01	64.10	0.00	0.16	0.02	0.13
Maze comprehension (% correct)	Kiswahili	Boy	12.43	0.01	14.13	0.00	0.10	0.02	0.16
		Girl	13.17	0.01	16.03	0.00	0.11	0.03	0.26
Proportion of fluent readers (% of population)	English	Boy	6.40	0.02	8.40	0.01	0.27	0.02	0.07
		Girl	9.40	0.03	14.90	0.01	0.34	0.06	0.16
	Kiswahili	Boy	4.64	0.02	7.27	0.01	0.25	0.03	0.11
		Girl	3.10	0.01	14.64	0.01	0.31	0.12	0.37
Proportion of emergent fluent readers (% of population)	English	Boy	31.00	0.03	47.00	0.02	0.50	0.16	0.32
		Girl	45.90	0.03	57.81	0.02	0.50	0.12	0.24
	Kiswahili	Boy	41.85	0.03	60.72	0.01	0.50	0.19	0.38
		Girl	52.00	0.03	68.85	0.01	0.48	0.17	0.35
Overall	English	Boy							0.49
Overall	English	Girl							0.51
Overall	Kiswahili	Boy							0.37
Overall	Kiswahili	Girl							0.48

The analysis above simply grouped all three treatment groups together and compared them with control. In this section we present the impact of each treatment group compared with control. Further analysis shows that pupils in each of the individual treatment groups performed better than those in control. As indicated in **Table 10** below, the general performance is consistently highest in the TAC tutor tablet group. Given that these analyses do not remove the differences at the baseline, they sometimes show that the mean results for groups are higher in control zones than in the teacher tablet zone. For example, for ORF, the results are control=25.3 cwpm; e-reader=36.0 cwpm; teacher tablet=23.9 cwpm; TAC tutor tablet=39.7cwpm. Results for the percentage of fluent readers in English by group are low. Under the TAC tutor group, 13.5% pupils were able to attain the 65 cwpm benchmark threshold established by MoEST. Similarly 14.8% and 5.9% of pupils in the e-reader and the teacher tablet groups reached the 65 cwpm fluency rate. This however, compares somewhat favorably with the 8.0% pupils in the control group who were able to read in English at the benchmark fluency level of 65 cwpm. The percentages of pupils reading at the emergent benchmark level of 30 cwpm in English were 62.5% of pupils in the TAC tutor tablet group, 56.3% in the e-reader group, and 38.1% in the teacher tablet group, compared to 38.8% of pupils in the control group.

Table 10. Endline English scores by treatment group

Subtask	Control	Pupil e-reader	Teacher tablet	TAC tutor tablet
Letter sound fluency	23.0	54.0	49.3	68.8
Decoding fluency	17.2	25.9	20.0	28.8
Oral reading fluency	25.3	36.0	23.9	39.7
Phonemic awareness (%)	18.6	61.1	56.6	78.6
Vocabulary (%)	61.5	63.7	56.7	71.1
Reading comprehension (%)	10.0	15.6	9.6	20.9
Fluent (%)	8.0	14.8	5.9	13.9
Emergent (%)	38.8	56.3	38.1	62.5

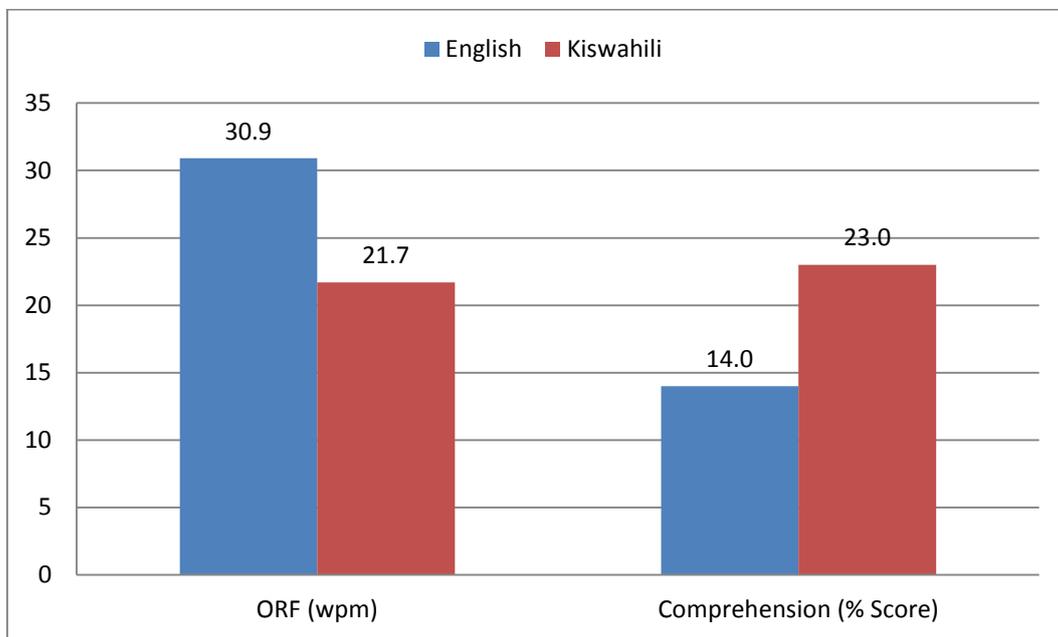
Table 11 below presents detailed scores observed on various Kiswahili subtasks. The performance pattern is similar to that in English, with pupils in the TAC tutor group consistently performing better than pupils in the other three groups. Few pupils reached the MoEST benchmark for fluency in Kiswahili (45 cwpm). Specifically, 3.8%, 13.1%, 6.4%, and 13.1% of pupils in the control, e-reader, teacher tablet, and TAC tutor tablet groups respectively reached the benchmark. More pupils however surpassed the emergent reading benchmark of at least 17 cwpm (47.4%, 67.2%, 52.7%, and 73.8% in control, e-reader, teacher tablet, and TAC tutor tablet groups, respectively).

Table 11. Endline Kiswahili scores by treatment group

Subtask	Control	Pupil e-reader	Teacher tablet	TAC tutor tablet
Letter sound fluency	19.7	55.0	48.8	62.6
Syllable fluency	28.2	43.5	33.8	46.9
Decoding fluency	14.2	21.6	15.6	21.8
Oral reading fluency	17.0	24.9	19.1	26.6
Reading comprehension (%)	18.6	26.9	19.5	29.0
Listening comprehension (%)	36.6	43.7	36.6	46.6
Maze comprehension (%)	12.8	15.4	12.4	17.3
Fluent (%)	3.8	13.1	6.4	13.1
Emergent (%)	47.4	67.2	52.7	73.8

The lower ORF scores for Kiswahili have been linked to the agglutinating nature of Kiswahili, where word length is increased by adding parts of speech to the word that in English would be separate words. It is, however, interesting that despite low ORF scores in Kiswahili compared to English, comprehension scores in Kiswahili are much higher than in English, as *Figure 4* shows. This finding is interesting given the preference for many in Kisumu County for English, but buttresses the MoEST’s language policy to emphasize the language of the catchment area rather than English as the language of instruction.

Figure 4. ORF and comprehension by language



PRIMR Kisumu ICT Impact Utilizing Difference-in-Differences Analysis

Analysis of the baseline data revealed a statistically significant difference in performance across the groups. Specifically, the teacher tablet baseline results were lower than those from other groups, including the control (Piper, Kwayumba & Mugenda, 2013). Therefore, it could

be that the gains in the teacher tablet group at the endline appear lower simply because the baseline results were low. The section above ignores this difference and simply presents the results at the endline, without correcting for baseline differences. In order to determine the causal impact of the treatment, we implemented DID analyses using both OLS and logistic regression models.

When DID models were fit, they revealed that all three treatment groups had statistically significant impacts on the key variables. This includes the teacher tablet group, whose impact on outcomes was masked when the endline only results were presented. The rest of this report presents the DID results and the associated effect size. *Table 12* presents the DID analyses of English scores.

Table 12. Impact of PRIMR Kisumu ICT on English outcomes

	PRIMR ICT	<i>Effect Size</i>	Pupil E- Readers	<i>Effect Size</i>	Teacher Tablet	<i>Effect Size</i>	TAC Tutor Tablet	<i>Effect Size</i>
Letter sound fluency (correct letters per min)	29.6	<i>0.83</i>	27.2	<i>0.76</i>	30.6	<i>0.86</i>	26.2	<i>0.73</i>
Decoding fluency (correct non-words per min)	6.3	<i>0.31</i>	6.5	<i>0.32</i>	7.0	<i>0.35</i>	7.6	<i>0.38</i>
Phonemic awareness (Segmenting) (% correct out of 10 items)	47.1	<i>1.04</i>	40.8	<i>0.90</i>	51.1	<i>1.13</i>	42.5	<i>0.94</i>
Oral reading fluency (correct words per min)	5.8	<i>0.18</i>	5.5	<i>0.17</i>	8.1	<i>0.26</i>	9.2	<i>0.29</i>
Vocabulary (% correct out of 20 items)	2.4	<i>0.13</i>	-1.2	<i>-0.06</i>	5.8	<i>0.31</i>	2.2	<i>0.12</i>
Reading comprehension (# correct out of 5 questions)	7.8	<i>0.26</i>	6.4	<i>0.22</i>	9.9	<i>0.34</i>	9.4	<i>0.32</i>
Reading at emergent level (% of pupils reading 30 cwpm+)	11.8	<i>0.20</i>	11.2	<i>0.19</i>	15.4	<i>0.26</i>	17.0	<i>0.28</i>
Average Effect Size		<i>0.42</i>		<i>0.36</i>		<i>0.50</i>		<i>0.44</i>

Results for Kiswahili, presented in *Table 13* below, also show significant and large impacts for treatment over control using the DID models. The letter sound fluency effects were nearly .9 SD for all three treatment groups. Syllable fluency effects were large for all three treatment groups, with teacher tablet and TAC tutor tablet groups showing a larger impact than the e-reader group. Impacts were very similar for the decoding fluency subtask and the oral reading fluency task, with pupils able to read between 4.8 and 6.4 cwpm more as a result of PRIMR's intervention. Reading comprehension impacts were also there, as were maze comprehension impacts. Gains were larger in the teacher tablet and TAC tutor tablet groups than in the e-reader group. The overall gain in the percentage of pupils reading at emergent levels was remarkably similar, at more than 15% for each of the three groups. PRIMR's Kisumu ICT

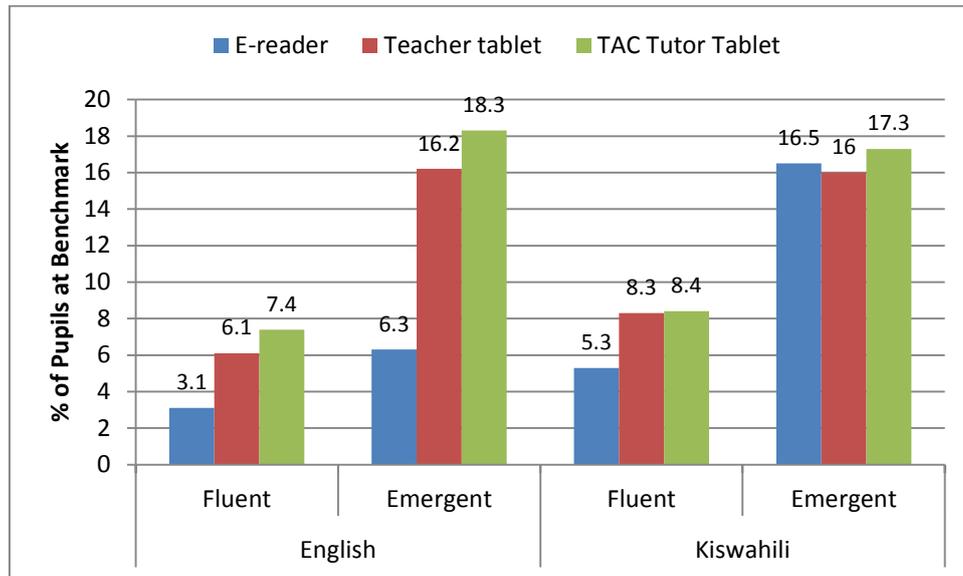
intervention impact effect sizes were largest in the teacher tablet group at .44 SD, but very similar for the TAC tutor tablet group, at .43 SD. The e-reader tablet group also showed substantial gains at .34 SD.

Table 13. Impact of PRIMR ICT on Kiswahili outcomes

	PRIMR ICT	<i>Effect Size</i>	Pupil E- Readers	<i>Effect Size</i>	Teacher Tablet	<i>Effect Size</i>	TAC Tutor Tablet	<i>Effect Size</i>
Letter sound fluency (correct letters per min)	31.9	<i>0.88</i>	31.7	<i>0.88</i>	32.3	<i>0.90</i>	31.4	<i>0.87</i>
Syllable fluency (correct syllables per min)	14.1	<i>0.47</i>	11.4	<i>0.38</i>	17.9	<i>0.59</i>	16.2	<i>0.54</i>
Decoding fluency (correct non-words per min)	4.8	<i>0.27</i>	4.8	<i>0.27</i>	5.8	<i>0.33</i>	6.4	<i>0.37</i>
Oral reading fluency (correct words per min)	4.8	<i>0.24</i>	5.1	<i>0.26</i>	5.5	<i>0.28</i>	6.3	<i>0.32</i>
Reading comprehension (# correct out of 5 questions)	6.6	<i>0.22</i>	6.2	<i>0.21</i>	7.7	<i>0.26</i>	7.7	<i>0.26</i>
Maze comprehension (% correct)	3.5	<i>0.27</i>	1.8	<i>0.14</i>	5.8	<i>0.44</i>	4.8	<i>0.36</i>
Reading at emergent level (% of pupils reading 30 cwpm+)	14.7	<i>0.25</i>	15.4	<i>0.26</i>	15.2	<i>0.26</i>	15.9	<i>0.27</i>
Average Effect Size		<i>0.37</i>		<i>0.34</i>		<i>0.44</i>		<i>0.43</i>

Tables 12 and 13 above present the impact of the three treatment groups on all measures assessed by PRIMR. *Figure 5* below presents the impact of the PRIMR Kisumu ICT intervention on the proportion of pupils able to read at the fluent and emergent benchmarks. These figures are from models that include control variables. The results show that the TAC tutor tablet and teacher tablet groups had larger impacts on these key measures than the e-reader groups, though the e-reader group also increased the proportion of pupils reading at the appropriate benchmarks.

Figure 5. Causal impacts on the proportion of pupils reading at fluent and emergent benchmarks by treatment group and language



The TAC tutor group consistently displays high impact compared to the other two groups. This could perhaps be explained by the effort made by various TAC tutors to supervise and support teachers as they undertook the ICT intervention. Comparative analysis of the frequency of schools visits in term 1 made by the TAC tutors and performance revealed a positive correlation between the two (Piper & Kwayumba, 2013).

The effect shown by the teacher tablet group could be, apart from simply an effect of possessing the tablet or ICT, a result of efficient and effective use of the teacher tablet information. Remember that apart from PRIMR lessons, pupil books, and other learning materials such as tutor and teacher tip-sheets, teacher tablets were fitted with applications that further aided teaching and learning in schools. These included Papaya, an application that was used to help pupils correctly sound out letters and to construct letters and words, and Tangerine: Class. The latter is an open-source software program, optimized for mobile devices, which enabled teachers to systematically collect, analyze, and use results from continuous assessment of pupil’s early literacy to improve teaching and learning. Looked at from another angle, it might be that the additional impact shown in the TAC tutor group was due to the relative simplicity of this intervention in the Kisumu environment and to the fact that teachers were required to simply teach better rather than to utilize ICT, which for them proved a challenge. In any case, no definitive answers about which ICT intervention was better are possible from this data given the strong similarity in pupil outcomes.

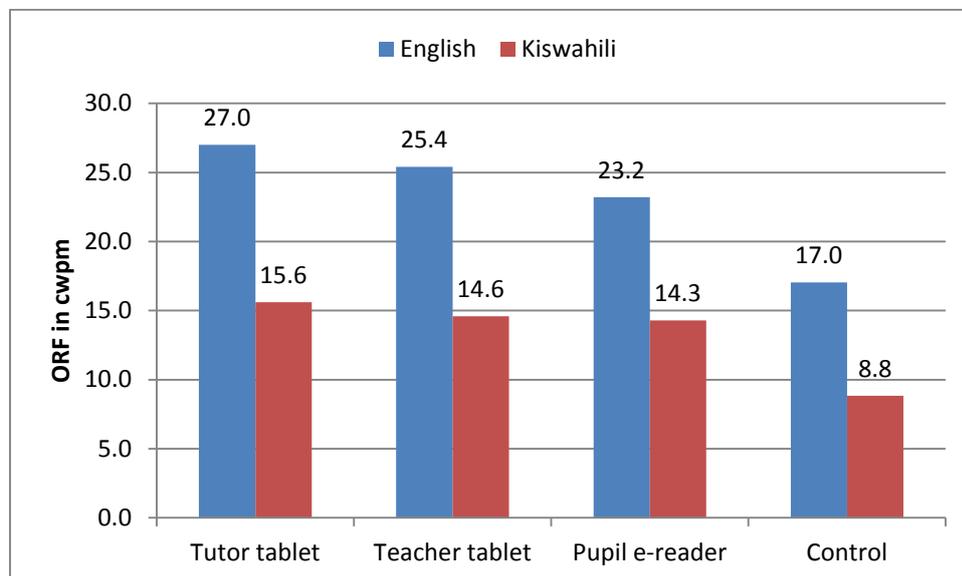
It was observed that e-readers also had a positive and a significant impact on literacy. This was expected given that e-readers exposed learners to significantly more literacy materials. As observed in other EGRA studies (Piper & Korda, 2009), (Piper & Mugenda, 2013), (Piper, Kwayumba & Mugenda, 2013), improvement in access to literacy materials as well as textbooks is correlated with improved literacy outcomes. It is, however, observed that despite more reading materials being provided to pupils, the gains in the Kisumu e-reader group were

not as great as those in the other two groups. Pupils first must be taught before they can practice their literacy skills, and this teaching must be supervised and mentored.

Effectiveness of PRIMR Kisumu ICT Impact by Treatment

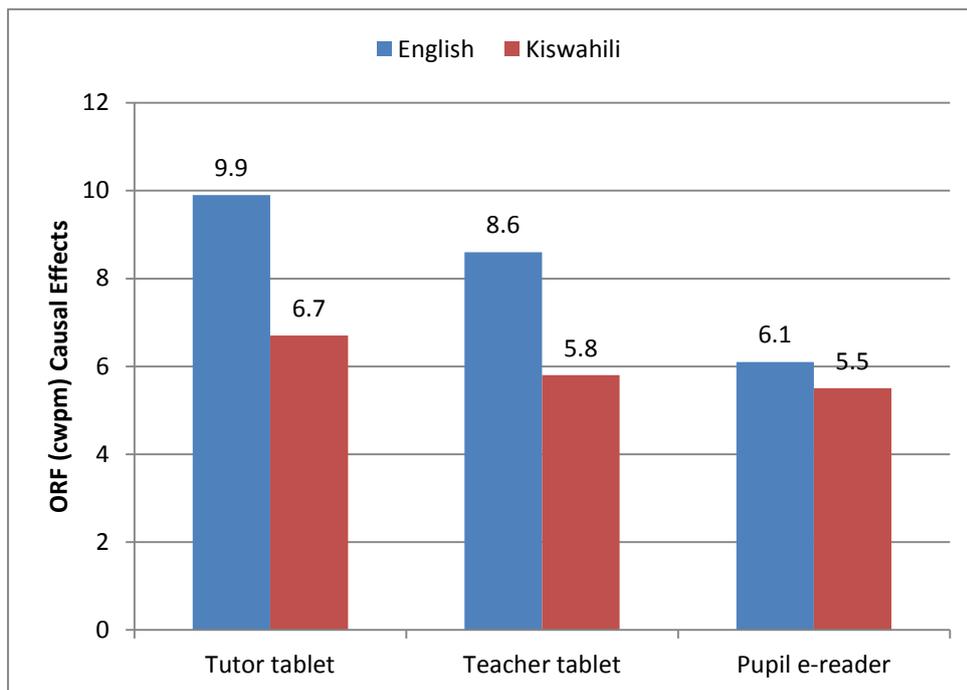
We first present the findings on the overall gains since the baseline, including those in control schools in comparison to the other three treatments. **Figure 6** below shows an increment across all the four treatments. Having accounted for the differences between treatment groups at the baseline, the increment in ORF in control schools can be attributed to the natural one as a result of normal teaching (without PRIMR ICT) since baseline. The figure also shows that pupils in the three treatment schools performed better in both English and Kiswahili. For example, pupils in schools receiving the TAC tutor treatment had a gain over baseline of 27.0 cwpm and 15.6 cwpm compared to their counterparts in control schools at 17.0 cwpm and 8.8 cwpm for English and Kiswahili, respectively.

Figure 6. Gain over baseline in ORF



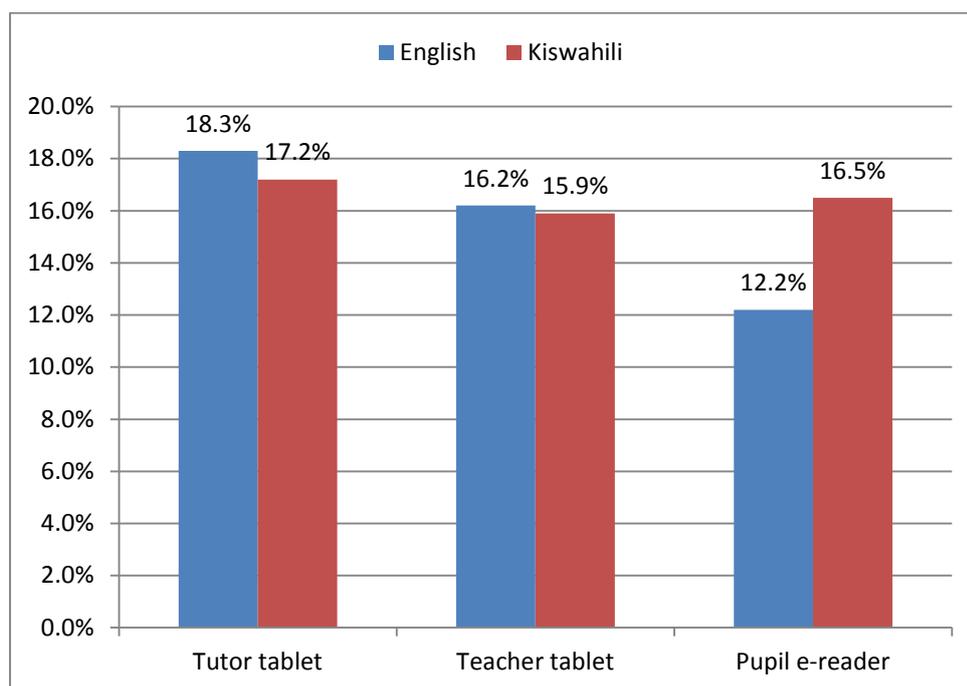
To get a clear impression of the three ICT trials, an additional effect of the treatment was computed. This is the gain over that in control schools by treatment. As indicated in **Figure 7** pupils in the three treatment groups were more fluent compared to those in the control group. Specifically, pupils in TAC tutor tablet, teacher tablet, and pupil e-reader groups scored 9.9 cwpm, 8.6 cwpm, and 6.1 cwpm more than those in control groups. Comparisons between scores in Kiswahili between the three treatment schools and control also follow the same trend: causal effects that decrease in magnitude from the TAC tutor tablet group, to the teacher tablet group, to the e-reader group.

Figure 7. Causal impact of PRIMR Kisumu ICT intervention on ORF



When further analyzed in terms of the effect on fluency level, specifically at the emerging fluency benchmarks of 30 cwpm and 17 cwpm in English and Kiswahili, respectively, an additional 18.3% and 17.2% of pupils reach emergent levels for English and Kiswahili, respectively. The lowest additional impact is reported for the e-reader group, with an additional 12.2% and 16.5% of pupils reaching the emergent level in English and Kiswahili, respectively. **Figure 8** shows the treatment effect on the proportion of pupils reaching the emergent reading benchmark.

Figure 8. Causal impact of PRIMR on the proportion of pupils reading at the emergent benchmark or better



Cost Effectiveness of PRIMR Kisumu ICT Programs

The results above show that all three PRIMR ICT interventions in Kisumu were effective in improving learning achievement. Beyond this, we can assess the cost-effectiveness of the ICT interventions. Though various ICT components under trial produced, individually, statistically significant impact when measured in comparison to control groups, it is essential to measure the cost-effectiveness of each treatment group.

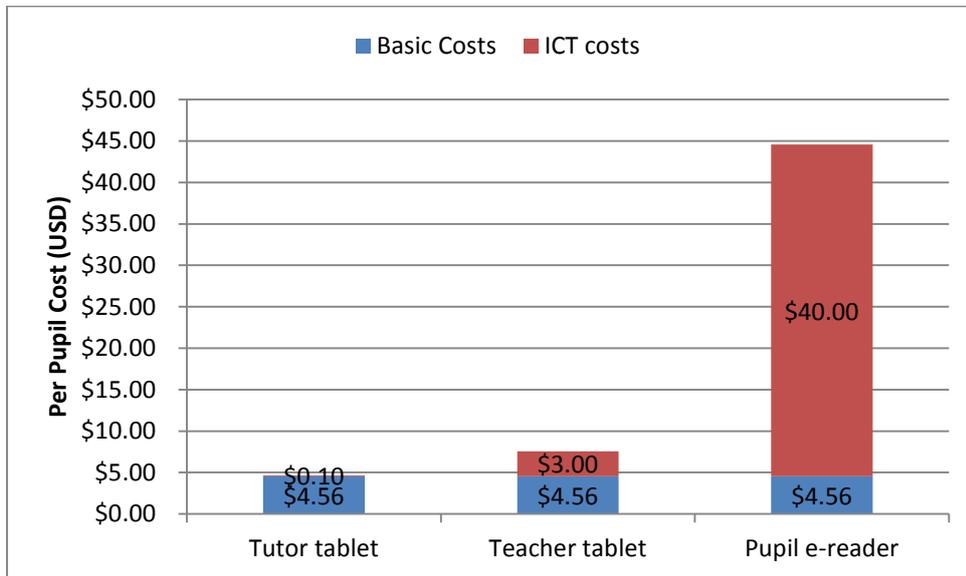
To measure the cost effectiveness of the three ICT trials, we first computed the unit cost of each ICT component. First, it is worth noting that we used a conservative figure for the unit cost for both the tablet and the e-reader based on the assumption that the price of ICT continues to go down. In 2012, when the PRIMR Kisumu ICT intervention was designed, the unit cost of a tablet was \$210; for calculations here we use a cost figure of \$150. Similarly, the unit cost of an e-reader was \$70 in 2012, and we are using a unit cost of \$40 in 2014.

Cost effectiveness was measured by dividing the PRIMR effect for each treatment group by the per-pupil per-subject unit cost of each of the ICT tools. The basic costs of the PRIMR Kisumu ICT intervention, for all treatment groups, include the cost of pupil books, teachers' guides, teacher training, classroom observations, and TAC tutor training. The basic unit cost for PRIMR Kisumu ICT is therefore a ratio of the sum total of the total cost for program materials and training, divided by the number of pupils. This basic cost translated to \$4.56, or \$2.28 per pupil per subject, and is uniform for all the three ICT intervention groups.

The cost of the ICT program was computed per pupil for each treatment group. The unit cost of the TAC tutor tablet was arrived at by dividing the cost of a tablet by the number of pupils supported by the TAC tutor, which is the sum total of pupils in the TAC tutor's zone. This translated to \$0.10 per pupil. The unit cost of the teacher tablet is a ratio of the total cost of

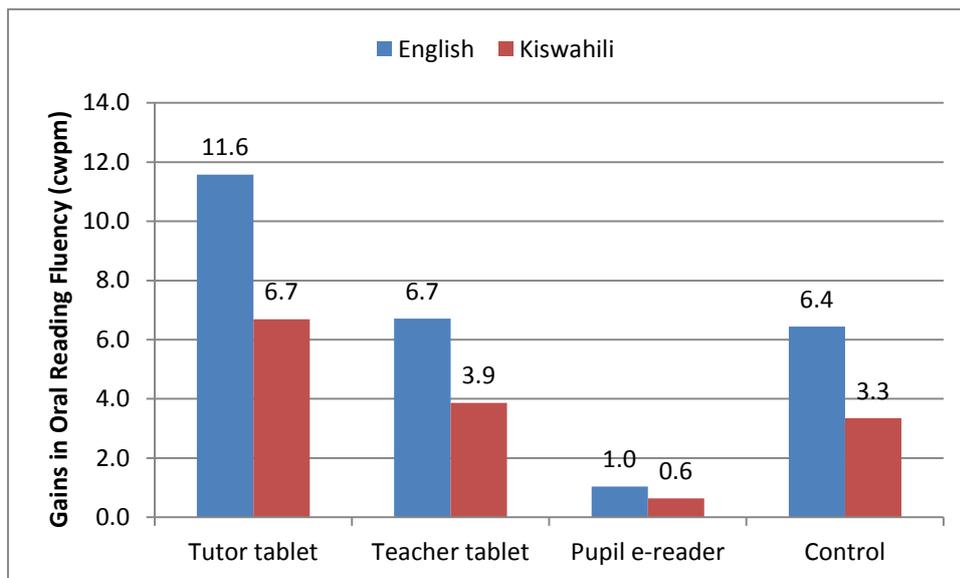
teacher tablets divided by the number of pupils in teacher tablet schools. This translated to an average cost of \$3.00. The e-reader cost is not divided by pupils, since e-readers were provided in a 1 to 1 ratio. The total cost of the PRIMR Kisumu ICT intervention by treatment group is shown below in *Figure 9*. The overall PRIMR unit cost of the pupil e-reader is significantly higher than that of the other treatments.

Figure 9. ICT costs per pupil



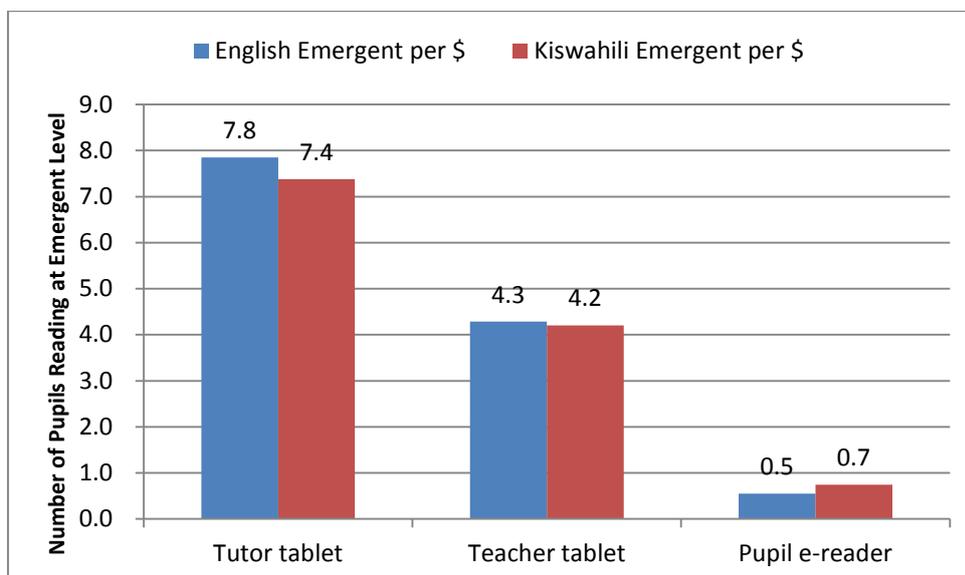
We then computed the gains in oral fluency over baseline per dollar. *Figure 10* shows that the TAC tutor tablet treatment group has the highest rates of oral reading fluency. Under the TAC tutor tablet, an investment of one dollar translates to an additional fluency of 11.6 cwpm and 6.7 cwpm for English and Kiswahili, respectively. These rates are higher than those for the control group. The teacher tablet treatment has a significant improvement in fluency per unit cost, though less than the TAC tutor group. The teacher tablet group is similar in cost effectiveness to the control group. In terms of costs, however, cost effectiveness is the lowest for the e-reader group, with even the control group showing a much larger ORF gain per dollar compared to the e-reader group. This implies that it is much cheaper and more effective to implement PRIMR ICT without e-readers. This will likely remain the case even as the e-reader costs drop, at least for the foreseeable future. More research should be undertaken to determine how best to implement the e-reader program without having to maintain a 1 to 1 ratio.

Figure 10. ORF gains over baseline per dollar



As indicated in *Figure 11* below, an investment of \$100 translates into an additional 7.8 and 7.4 pupils reaching the emergent fluency level in English and Kiswahili, respectively, under the TAC tutor treatment. That \$100 investment in the teacher tablet treatment increases the percentage of pupils reaching emergent reading fluency by a similar number of pupils in English and Kiswahili (4.3 and 4.2 pupils) respectively. When \$100 is invested in the pupil e-reader treatment group, fewer than 1 student reaches the emergent level in English or Kiswahili.

Figure 11. Causal impact per \$100

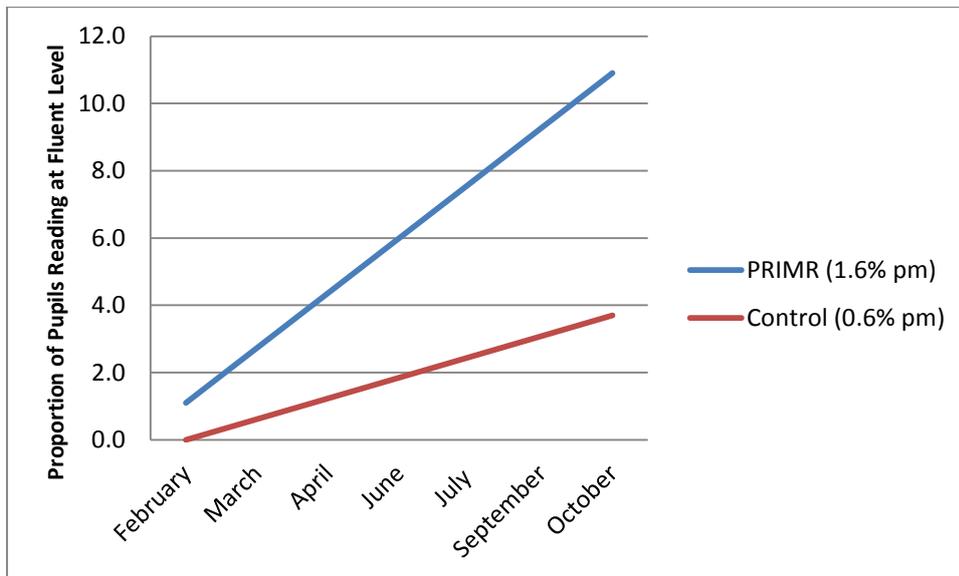


Impact of PRIMR Kisumu ICT on Rate of Improvement

In order to demonstrate whether the PRIMR Kisumu ICT treatments are changing literacy outcomes compared to the control, we created *Figure 12* below. *Figure 12* presents the

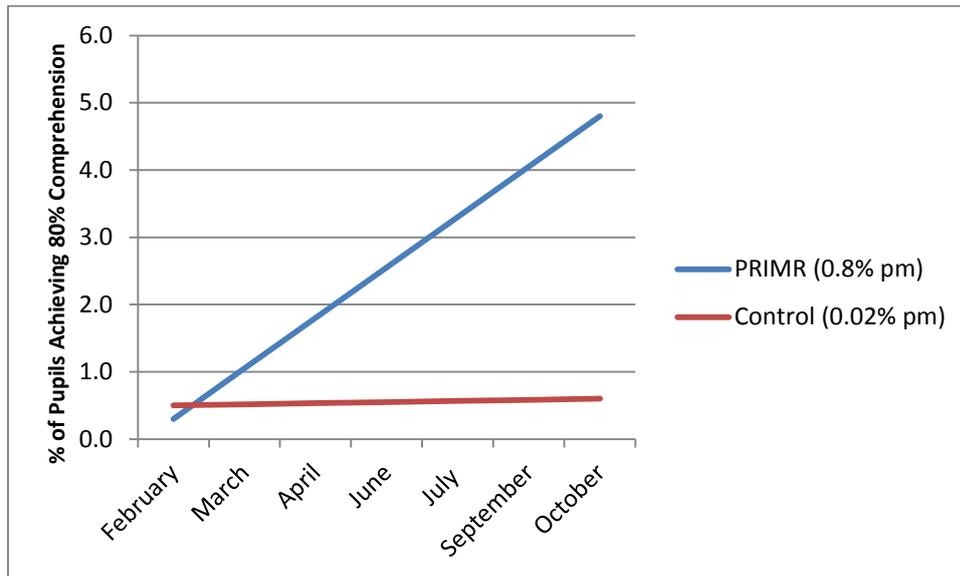
change in the proportion of pupils fluently reading Kiswahili from the beginning of the intervention to the endline. This figure smooths the gains over time, but we are not suggesting that these gains are this fluid. The figure shows that the rate at which pupils learned to read Kiswahili fluently was dramatically different in treatment and control schools in Kenya.

Figure 12. Increase in the proportion of pupils reading Kiswahili fluently over time



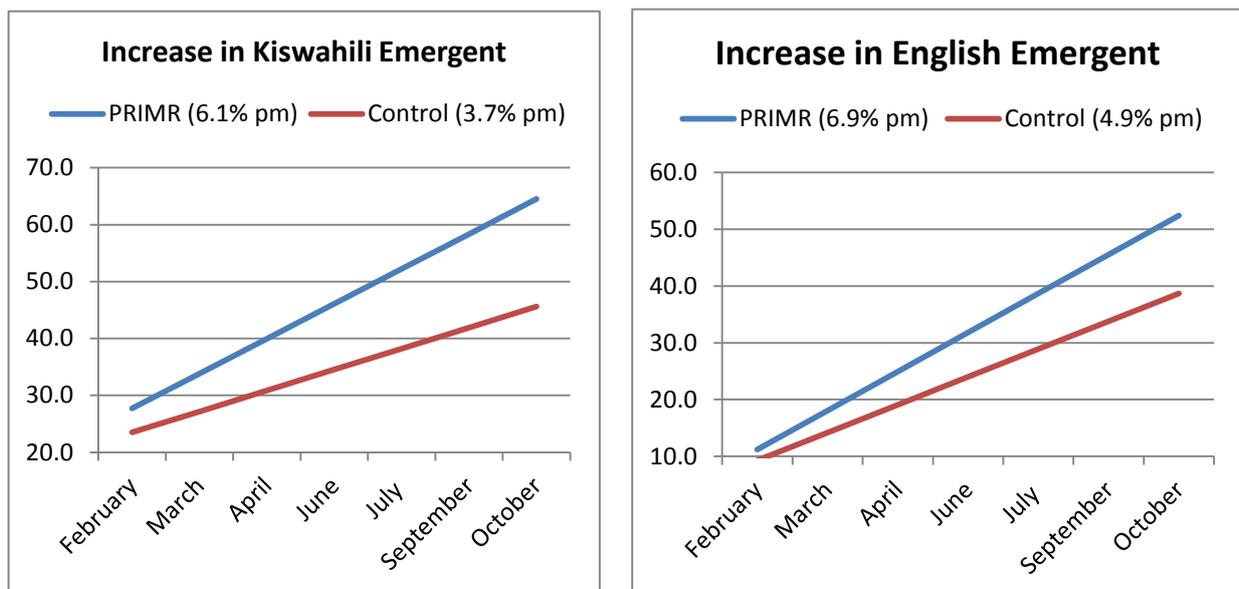
To determine if the rate of improvement in the number of fluent readers was accompanied by an improvement in comprehension we created **Figure 13**. The figure shows that control schools were not increasing the rates of learning in Kenya at a rate similar rate to the treatment schools. It should be noted that the gains in PRIMR Kisumu ICT school rates of learning were not efficient or effective enough to ensure that all pupils could read and comprehend English, but were much faster.

Figure 13. Increase in the proportion of pupils achieving 80% comprehension in English



The Kisumu County figures for both “fluent” and “comprehending at 80% or higher” are very low, so it is somewhat misleading to present the results for those figures. Instead, in **Figure 14**, we present the gains in the proportion of pupils reading at the emergent benchmark for English and Kiswahili set by the MoEST in August 2012. The results show that gains for the PRIMR Kisumu ICT groups were significantly faster than the gains for the control group.

Figure 14. Increase in emergent reading by treatment (Kiswahili left and English right)

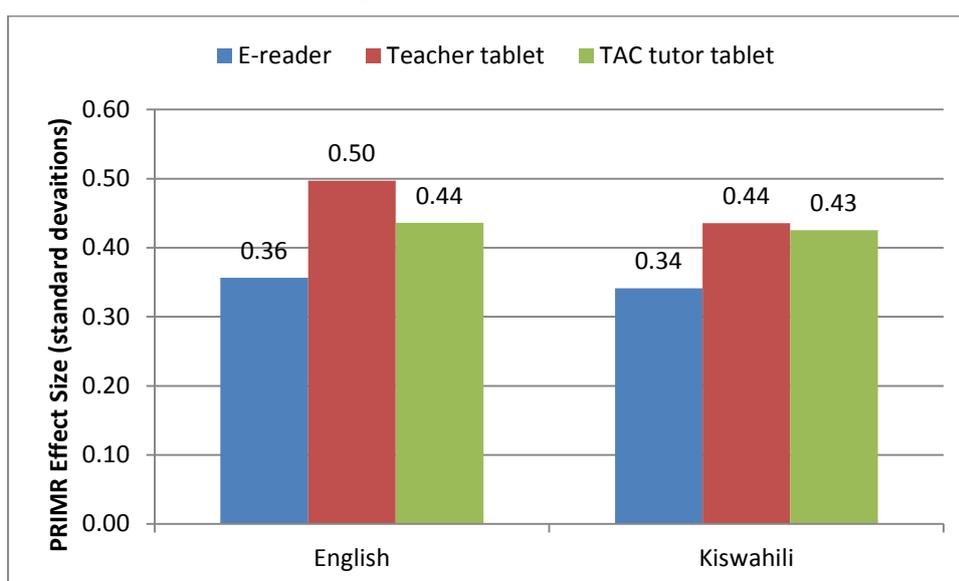


PRIMR Kisumu ICT Effect Size in Literacy

The PRIMR Kisumu ICT intervention produced statistically significant better literacy outcomes in treatment compared to the control group. This section presents the effect sizes for each of the PRIMR treatment groups. The PRIMR effect sizes are computed by dividing the program effect by the pooled standard deviation.

Tables 12 and **13** above presented effect sizes for each of the treatment groups for each subtask. The main finding of that section of the report is that there were generally remarkable similarities in the effect size of the PRIMR Kisumu ICT treatment groups. We calculated an overall effect size for each language by treatment group and present them in **Figure 15** below. This shows that the effect sizes range from .36 to .50 for the two languages and treatment groups. The effect sizes appear slightly higher in English, but not much so. The teacher tablet group seems to have the largest overall effect size for English, with the TAC tutor tablet and the teacher tablet groups having the largest effect size for Kiswahili. The e-reader group has the smallest effect size of the three treatment groups for both English and Kiswahili.

Figure 15. Effect sizes for English and Kiswahili by PRIMR Kisumu ICT treatment group



PRIMR Impact Evaluation by Gender and Urbanicity

Given our interest in understanding how this PRIMR intervention's effect differs by key variables, this section presents our analysis of whether and how the PRIMR Kisumu ICT impact differs by gender and by urbanicity.

PRIMR Impact Evaluation by Gender

Table 14 below presents the English gains for PRIMR Kisumu ICT by control group. **Table 14** presents two key points. First, in control schools, girls' performance is increasing more than boys', for all tasks, save comprehension, which had no change in the control schools. In treatment schools, both boys' and girls' performance increased over control. This brings us to our second point. In several tasks, the PRIMR Kisumu ICT causal gain for boys was

somewhat larger than the gain for girls. For example, the PRIMR causal effect for boys was 6.5 cwpm in English fluency compared with 5.4 cwpm for girls. The substantive difference is modest, but this analysis shows that PRIMR ICT is reducing the gender gap created in control schools. However, the final columns in *Table 14* show that the overall gains for the PRIMR Kisumu ICT intervention (including the control and the PRIMR causal effect) are somewhat larger for girls than they are for boys, except for comprehension where the overall gain is equal.

Table 14. ICT gain over baseline English literacy outcomes by gender

Subtasks	Boy			Girl		
	Gain in Control Schools	Additional PRIMR Gain over Control	Overall Gain	Gain in Control Schools	Additional PRIMR Gain over Control	Overall Gain
Letter fluency	11.8	28.1	39.9	13.1	31.3	41.2
Decoding fluency	8.4	5.7	14.1	9.7	7.2	15.4
Oral reading fluency	14.1	6.5	20.6	18.9	5.4	25.4
Reading comprehension	0.0	4.3	4.3	0.0	4.7	4.3
Pupils at emergent level	24.3	15.4	39.7	33.7	9.0	49.1

We also analyzed the impact of the PRIMR Kisumu ICT intervention in Kiswahili by gender. As in English, girls generally perform better than boys in the control schools in Kiswahili, but the PRIMR treatment effect is somewhat larger for boys than girls. *Table 15* below shows that at endline, ORF for girls was 9.8 cwpm, compared to boys at 7.3 cwpm; 25.4% of girls compared to 18.3% of boys attained the emergent benchmark; and letter fluency for girls is slightly higher than for boys (5.2 letters per minute [clpm] and 5.0 clpm). However, the treatment effect results in an additional 20.2% of boys reaching the emergent benchmark compared to 9.5% of girls. The finding is similar to the one observed in English, with PRIMR reducing the gender gap seen in control schools.

Table 15. ICT gain over baseline Kiswahili literacy outcomes by gender

Subtasks	Boy			Girl		
	Gain in Control Schools	Additional PRIMR Gain over Control	Overall Gain	Gain in Control Schools	Additional PRIMR Gain over Control	Overall Gain
Letter fluency	5.0	30.0	35.0	5.2	34	35.2
Decoding fluency	7.1	5.0	12.1	9.0	4.8	14.0
Oral reading fluency	7.3	5.0	12.3	9.8	4.9	14.8
Reading comprehension	2.8	1.4	4.2	2.2	2.3	3.6
Listening comprehension	17.8	0.2	18.0	18.6	0.3	18.8
Pupils at emergent level	18.3	20.2	38.5	25.4	9.5	45.6

PRIMR Kisumu ICT Impact Evaluation by Peri-Urban / Rural Stratification

The PRIMR Kisumu ICT intervention was undertaken in both peri-urban and rural zones. Our objective in stratifying the treatments by urbanicity was to investigate the possible variation in impact by school location. We did this in response to the literature that consistently shows that ICT programs that work in urban locations often fail in rural areas. The intervention design ensured that this urban and rural comparison could be tested, and this allowed us to determine any differences in outcome by type of zone.

Our findings reveal that, in control schools, there was a larger increase in literacy outcomes in peri-urban zones compared to rural zones between January and October 2013. This is to be expected. Interestingly, our analysis shows that the causal impact of the PRIMR Kisumu ICT intervention in English was somewhat larger in rural schools than in peri-urban ones. Pupils in peri-urban schools recorded an improvement of 19.7 cwpm in ORF in English compared to their rural counterparts, whose fluency improved by 12.1 cwpm (*Table 16*). However, an improved fluency of 9.7 cwpm was observed in rural schools as a result of treatment, compared to a 3.2 cwpm improvement that was observed for peri-urban schools. This shows that the peri-urban schools are not driving the PRIMR ICT impact in English and that, in fact, the PRIMR ICT interventions are lessening the rural disadvantage.

Table 16. ICT gain over baseline English literacy outcomes by urbanicity

Subtasks	Rural			Peri-Urban		
	Gain in Control Schools	Additional PRIMR Gain over Control	Overall Gain	Gain in Control Schools	Additional PRIMR Gain over Control	Overall Gain
Letter fluency	10.1	32.2	42.3	14.4	27.8	42.2
Decoding fluency	7.1	9.1	16.2	10.4	4.7	15.1
Oral reading fluency	12.1	9.7	21.8	19.7	3.2	22.9
Reading comprehension	0.4	1.5	1.9	0.0	6.0	6.0
Listening comprehension	3.2	3.2	6.4	10.8	3.2	14.0
Pupils reading at benchmark level	20.7	22.1	42.8	35.2	5.0	40.2

The results for Kiswahili in the peri-urban and rural zone comparison are similar to those for English (*Table 17*). Generally, pupils in peri-urban control schools gain more in literacy compared to those in rural control schools. On the other hand, the effect of PRIMR ICT interventions is larger in rural schools than in peri-urban ones. For example, the percentage of control pupils reaching the emergent level at endline is 24.1% in peri-urban schools compared to 18.2% in rural schools. However, the ICT treatment's causal effect meant that an additional 22.2% of pupils in rural treatment schools reached the emergent level compared to an additional 10.2% of pupils in peri-urban treatment schools.

Table 17. ICT gain over baseline Kiswahili literacy outcomes by urbanicity

Tasks	Rural			Peri-Urban		
	Gain in Control Schools	Additional PRIMR Gain over Control	Overall Gain	Gain in Control Schools	Additional PRIMR Gain over Control	Overall Gain
Letter fluency	5	30.8	35.8	5.2	32.9	38.1
Decoding fluency	6.3	6.8	13.1	9.3	3.6	12.9
Oral reading fluency	7.1	6.4	13.5	9.5	3.9	13.4
Reading comprehension	0.2	1.2	1.4	0.4	2.2	2.6
Listening comprehension	2.2	-	-	15.8	10.5	26.3
Maze comprehension	0.9	-	-	2.4	5.4	7.8
Pupils reading at benchmark level	18.2	22.2	40.4	24.1	10.2	34.3

In conclusion, the PRIMR Kisumu ICT intervention limited the disadvantage experienced by rural schools in Kisumu County. Critically, given that the majority of schools in Kenya are rural, this suggests that PRIMR’s ICT impact could be maintained at scale. Further, even though literacy outcomes for girls are superior to those for boys, the PRIMR Kisumu ICT intervention limited the inequity between genders.

Other Factors Affecting Learning

Performance in literacy scores can also be influenced by factors beyond the simple inclusion in the PRIMR Kisumu ICT treatment groups. In this section, an analysis of various student factors was undertaken by regressing each factor against the English ORF scores in models that include the DID estimator. This section presents only factors that had a statistically significant impact on English ORF when controlling for the PRIMR ICT effect. *Figure 16* below shows a graphical impression of these results.

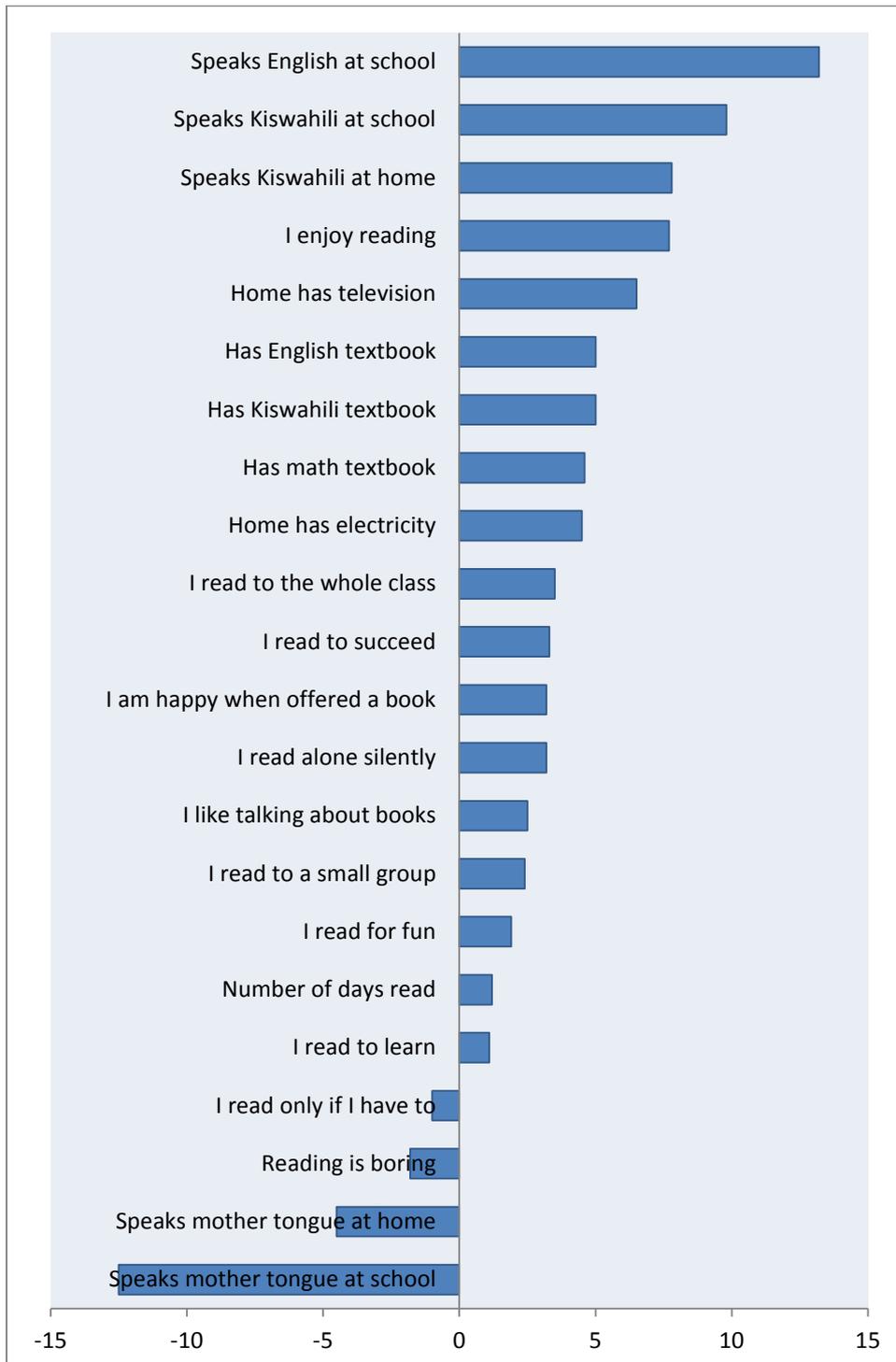
Pupils who spoke both English and Kiswahili at schools read 13.2 cwpm and 7.8 cwpm more than those who did not. Notably, pupils who spoke their own mother tongue at school recorded 13.5 cwpm fewer in English. Speaking Kiswahili at home is correlated with higher English ORF scores, as pupils who spoke Kiswahili at home reported a superior fluency rate of 7.8 cwpm. However, speaking a mother tongue at home is correlated with fluency rates 4.5 cwpm lower.

Regarding socio-economic status, pupils whose households had electricity read 4.5 cwpm more than those whose households did not have electricity, whereas those with television sets read 6.5 cwpm more than their counterparts. We surmise that it is not electricity or television sets that are responsible for the differences, but that those who live in the peri-urban areas where such things are more common have other advantages that allow them to read more fluently.

Regarding learning materials, pupils who had English, Kiswahili, and math textbooks read 5.0 cwpm, 5.0 cwpm, and 4.6 cwpm more fluently than those who did not. Lastly, it was

evident that attitudes towards literacy influenced literacy outcomes. This is reflected in the finding that pupils who enjoyed reading and who felt that they needed to read in order to succeed in the future read 7.7 cwpm and 3.3 cwpm more compared to their counterparts. Conversely, those who felt that reading was boring and read only if they had to scored 1.8 cwpm and 1.0 cwpm respectively lower than their counterparts.

Figure 16. Factors influencing fluency (cwpm)



Lessons Learned

1. **Focused training in ICT:** PRIMR exposed TAC tutors, teachers—and pupils—to new technology; however, PRIMR trained TAC tutors and teachers with a focus on improving instruction to increase learning and not on mastering the ICT. While, for this study, teachers and tutors eventually learned how to use the ICT, the PRIMR team was struck by the length of time and amount of repetition needed to ensure that teachers and tutors successfully adopt the ICT.
2. **The MoEST and Teachers' Service Commission (TSC) were instrumental in the success of ICT PRIMR.** At the launch of the Kisumu program, the Kisumu TSC office ensured that teachers trained in PRIMR would not be transferred to non-PRIMR schools. It also requested that PRIMR be given a first priority among other activities.
3. **The PRIMR approach was demand driven.** In the e-reader group, teachers expressed interest in acquiring reading material. Teachers used other textbooks and revision packs on the e-readers. Examples of requested titles included Christian Religious Education books and Kamusi.
4. **TAC tutor instructional support.** TAC tutors' efforts to provide instructional support to teachers were an essential part of the success of PRIMR and its impact on learning outcomes. Regular monitoring of TAC tutors' work was also done by TSC and MoEST officials in charge of quality assurance and standards. The in-person, regular, focused support built into PRIMR and the Kisumu ICT pilot study was critical to the success of the program.
5. **Storage and maintenance of ICT hardware:** Most of the Kisumu County schools working with PRIMR kept their electronic devices safely and used them responsibly in class.
6. **The PRIMR experience shows that ICT programs can have several other unintended effects.** These included more parental and community involvement in schools, improved pupil attendance, and Class 2 classrooms being viewed as examples of quality teaching. It also presented a channel that enhanced peer teaching.
7. **PRIMR is one of very few ICT programs that have improved learning outcomes.** Much research shows that ICT does not improve outcomes, but PRIMR worked, in all three treatment modalities. There are particular characteristics about PRIMR's ICT experimental program that we think are essential. First, PRIMR utilized ICT on top of an already successful intervention program, and the ICT was targeted at particular areas that needed improvement. Second, PRIMR had clear goals to measure success. Third, the ICT introduced the instructional improvement process at different levels, ensuring that ICT was solving a problem relevant to the improvement program.

Recommendations

1. ICT is of great interest in the education sector in Kenya. The PRIMR ICT pilot study shows that **ICT can have a notable impact on learning outcomes in literacy, if integrated with an instructional support program.** Given that the TAC tutor tablet program had the largest impact on the key variables and that the program was very simple, we think that the evidence suggests it was PRIMR's instructional approach

augmenting the ICT, rather than ICT alone, that was primarily responsible for the improved outcomes. This is exemplified by the fact that the PRIMR TAC tutor program was not noticeably different from the base, non-ICT PRIMR intervention.

2. **Adequate training is a precursor to successful program implementation.** The program must have adequate training time to build the capacity of participants at all levels on the hardware, software, and implementation of ICT. In addition, training time at the school level on proper storage and maintenance can have huge cost-effectiveness impacts, as this will decrease loss of or damage to devices.
3. **Having the requisite ICT infrastructure is important;** program implementation will suffer if it is missing. For PRIMR, implementation was negatively affected by the lack of electricity in many locations PRIMR was implemented. It follows that there is need to establish necessary infrastructure before incorporating ICT in early education on a large scale.
4. It is essential for **ICT education projects to consider and respond to the needs of all stakeholders** involved in the successful implementation. Apart from the education implementers, this PRIMR ICT project involved parents as well as the Kisumu community in its implementation. Parents and guardians were essential to the success of the PRIMR ICT study.
5. **Routine and frequent support is key to improving outcomes.** Schools with the most frequent TAC tutor visits reported superior performance in literacy outcomes. In order to fully harness the effect of ICT in schools, therefore, teaching should be accompanied by frequent support. PRIMR has expanded on this recommendation within PRIMR's expanded national tablet program (which gives tablets with PRIMR materials to all TAC tutors in the country) by streamlining the reporting of data for monitoring to the cloud.
6. **Provision of adequate instructional materials is an essential part** of ensuring that pupils have enough practice with the key elements of literacy development. The Kisumu study shows that ICT can be used to increase the access pupils have to reading materials.
7. **Focus on cost when considering ICT.** The results of the PRIMR ICT study PRIMR's results show that effectiveness of ICT at different levels does not change the impact of PRIMR noticeably. What does vary is the cost of ICT based on the level of the program. Providing the ICT at higher levels, that is, tablets for TAC tutors rather than for pupils, limits cost as well as targets the ICT on a manageable problem.

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