

Case Study: Tangerine[®]:Class for data-informed instructional decision making in Kenya

Abstract

This case study will highlight practical lesson learned from the use of mobile devices with Tangerine[®]:Class open-source software for data-informed instructional decision-making from a year-long, rigorous study conducted by RTI International in Kenya. Throughout 2013, twenty-one teachers and 600 pupils used Tangerine:Class on Android tablets in a randomized controlled trial. While the trial was focused on early reading instruction, the applicable lessons learned are also for mathematics and independent of subject matter. Practical findings concern training and support, the logistics of individual pupil assessments in large classrooms; the nature of instructional decision-making; and the use of data and interactions between teachers, headteachers and parents.

Keywords

Tangerine, Kenya, early reading, data-informed decision making, tablets, randomized controlled trial, open source, special needs, teachers, headteachers, parents

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INTRODUCTION

Throughout the 2013 school year, 21 class two teachers and 600 pupils in two rural zones in Kisumu, Kenya, used Tangerine[®]:Class software on 7-inch Android tablet devices as part of a randomized controlled trial (RCT).

Tangerine:Class is open source software, optimized for mobile devices, that enables teachers to systematically collect, analyze, and use results from continuous assessments of pupils' early reading or mathematics skills. It is designed for use on smartphones and tablets in low-resource environments without Internet. Tangerine:Class not only facilitates the administration of continuous assessments, but also helps teachers understand results. The software provides guidance to inform instructional decisions about pacing and ability grouping, and suggests activities to promote parental engagement. It can be applied for early mathematics and reading instruction, thus maximizing the value of investment in device, training and support.

The Kisumu RCT aimed to evaluate the contribution different mobile technologies make to enhance pupil reading acquisition within a larger education reform effort – the Primary Math and Reading (PRIMR) Initiative, funded by the United States Agency of International Development (USAID) implemented by RTI International. While the Kisumu RCT focused on early reading instruction, lessons learned from the teacher tablet/Tangerine:Class intervention group reported on in this case study, are applicable also for mathematics.

The specific mobile interventions trialed in Kisumu were: 1) the use of tablets to bolster the Teachers' Advisory Centre (TAC) Tutor instructional support system; 2) the use of teacher tablets with classroom pedagogical support, specifically Tangerine:Class; and 3) the use of e-readers to help pupils practice reading. All three interventions were designed in support of the proven PRIMR evidence-based instructional program that incorporated provision of books, lesson plans, supplementary readers, and instructional aids alongside teacher training and supervision support. Pupils in all the three treatment groups scored significantly higher statistically on key outcomes compared to pupils in the control group, but the teacher tablet group yielded the highest effect sizes. The effect size for the teacher tablets/Tangerine:Class group, the TAC tutor tablets group, and the e-readers group, was .47 standard deviations (SD), .44 SD, and .35 SD respectively.

The RCT carefully analyzed cost of each intervention as a consideration for sustainability and replication. Results from the TAC Tutor and teacher tablet/Tangerine:Class intervention group indicate that the pupil learning gains observed can be implemented using ICT context-appropriately and cost-effectively, even in such a low-resource setting. As a result of the 2013 Kisumu RCT, the Government of Kenya, with support from the Department for International Development (DFID), UK, and in partnership with RTI International will scale up the use of tablets to strengthen the TAC Tutor instructional support

system nation-wide in 2014. All 1,056 TAC Tutors and coaches supporting informal schools across the country will receive a 7-inch tablet device with the proven, carefully selected instructional content, including a customized version of Tangerine:Class, to enhance instructional support to early reading and mathematics instruction.

This may as well be an unprecedented example, particular in the developing world, of mobile instructional technology going to scale based on rigorous, data-informed decision- and policy-making.

CONCEPTUAL FRAMEWORK AND RESEARCH BASE

The design of Tangerine:Class is based on the scientific understanding of the acquisition and assessment of early reading and mathematics skills, and research on technology for classroom-based continuous assessment, and curriculum-based measurement (CBM). CBM was originally designed for teachers to document growth in pupil learning and to use data from CBM to assist instructional decision-making, especially in reading, writing, and mathematics.

The administration of classroom-based assessments is essential to gaining understanding of children's current ability, the goals for children's learning ability, and the ways instructional practice can bridge the gap between the two.

Studies on CBM have indicated that the combination of regular mastery checks that verify pupils' mastery of short-term goals, long-term progress monitoring

evaluations, and data-utilization guidance is particularly powerful in this process (Fuchs, Fuchs, & Hamlett, 1989).

Research, particularly in the US, confirms the contribution technology makes to CBM implementation in both reading and mathematics. A review of research found that teachers benefited from software assistance in recording and scoring. The technology increased satisfaction with CBM procedures and saved time in their implementation (Stecker, Fuchs, & Fuchs, 2005). Teachers also adhered better to CBM decision making if supported by technology presenting pupil results in graphical format. Studies observed that a system that supported teachers in instructional decision making based on CBM results, not only yielded more frequent instructional changes by teachers, but also triggered changes in the nature and quality of the interventions, which in turn affected significant growth in pupil learning (Stecker et al, 2005).

As technology matured and school-based computing infrastructure developed in high-income countries, web-based progress monitoring systems started to emerge and the landscape for software products facilitating CBM diversified. In the US, the increasing focus on accountability on pupil progress and mandate for regular testing stipulated in the 2001 No Child Left Behind (NCLB), may have contributed to this trend (Means, 2006; Goo, Watt, Park, & Hops, 2012). Many such systems include diagnostic features, comprehensive

items banks, intervention and computer-assisted instruction features and materials, and are being distributed as comprehensive packages.

Particular gains in pupil mathematics learning were demonstrated with web-based systems that included practice items matched to pupil skill levels, computer-based assessment, and data analysis, scoring and reporting features (Ysseldyke, Spicuzza, Kosciulek, Teelucksingh, Boys, & Lemkuil, 2001; Ysseldyke & Bolt, 2007). In recent years, systems have also become compatible with mobile devices such as handhelds, tablets, mobile phones, and clickers.

Mobile devices for classroom-based assessments are mainly used in two ways – either directly by pupils or mediated by a teacher. The reported opportunities of mobile devices for early mathematics in general lies in the mobility of the devices; their multi-functionality integrating image, audio and video; and their icon- and touch-based interfaces facilitating adoption (Pouezevara & Strigel, 2012).

However, while publishers of software products, including those for mobile devices, publicize evaluation reports on their product(s), limited rigorous independent research was conducted in recent years. There are particularly few studies that focus specifically on progress monitoring or the advantages of mobile devices in mathematics instruction (for a recent review of technology applications and mathematics achievement, see Cheung & Slavin, 2011). Where results are available, progress monitoring features are often confounded by other features

and implementation dimensions - at least in reading (Cheung & Slavin, 2012), making it difficult to ascertain specific correlations. Furthermore, not all systems that include “assessment” features actually adhere to the CBM-required technical integrity of assessment design.

Most critically, applicability of such tools has never been studied in a low-resource environment like Kenya, particularly where teachers have no access to high-end technology infrastructure, Internet, or support, and; little experience in evidence-based approaches to the teaching of mathematics and classroom-based continuous assessment approaches. The RCT in Kenya thus also filled a critical gap in this knowledge base.

CASE STUDY CONTEXT

Kisumu County is one of the new devolved Counties in Kenya. Its headquarters is Kisumu City. It has a population of 968,909 (2009 National census). The county is divided into 7 sub-counties - PRIMR works in 8 zones within five sub-counties.

Kenya’s education system is structured in eight years of primary education, four years of secondary, and four years of university education. Emphasis is placed on Mathematics, English, and vocational subjects. The Kenya Ministry of Education Science and Technology (MoEST) tasks include distribution of learning resources, and implementation of education policies.

Kenya's Teachers Service Commission (TSC) is the body responsible for teacher management; it recruits, transfers, promotes and dismisses teachers. RTI works hand in hand with the Kenya government in the implementation of PRIMR.

The Teacher tablet intervention described in this case study was implemented in 10 schools each in the Barkorwa and Nyabondo zones of Kisumu County. Teacher income is between KES 8,000 (equivalent to approx. USD93) and KES12,000 (USD140) per month - very low compared to other jobs with persons of the same academic level. Teachers in these two zones live in rural homes and small market centers. 80% of teachers in Barkorwa live in rural homes of which only 20% have electricity. In Nyabondo zone the situation is similar. 70% of the teachers live in rural homes of which half of them have electricity. Whereas most of the schools in Nyabondo have access to a stable mobile network, those in Barkorwa experience mobile connectivity problems because of its topography. All teachers participating in the program had a basic GSM mobile phone.

Pupil learning in the county faces a number of barriers: use of poor teaching methods; high absenteeism by both teachers and pupils; lack of adequate instructional materials and infrastructure; high pupil-teacher ratios; and poor parent-teacher relationships. In spite of these challenges, evidence-based programs, such as PRIMR have been successful in improving learning outcomes.

LESSONS LEARNED - TANGERINE:CLASS ON ANDROID TABLETS

Research framework

The Kisumu Randomized Controlled Trial (RCT) was designed to measure a hypothesis of whether ICT, and specifically, mobile technology interventions contribute significantly to pupil achievement in Class 2, and in a cost-effective and locally feasible manner. As shown in Figure 1, the study featured three mobile technology treatments: TAC Tutor tablets, Teacher tablets and the Pupil e-Readers. In order to measure the effect of these three treatments, a control group was introduced. The research design utilized random selection of zones and random assignment of zones to treatment.

Treatment Group	ICT Intervention	Schools	Pupils	Zones
PRIMR + tutor tablet	TAC Tutors with tablets for supervision and assessment	20	701 339	Ragumo (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 (urban)
PRIMR + pupil e-reader	Pupils with e-readers, loaded with PRIMR content, Kenyan textbooks, and supplementary reading materials	20	603 328	Otonglo (urban) Kodingo (rural)
Control	None	20	1000	Ahero (urban) Chulaimbo (rural)

Figure 1. Kisumu RCT structure. This table provides an overview of the intervention and control groups in the study.

All the four groups were subjected to baseline, midline and endline surveys and assessments that helped to measure the causal effect each ICT intervention had on pupil achievement. Specifically, a Kiswahili and English language version of the early grade reading assessment (EGRA) were used to assess pupil reading. Teacher interviews, headteacher interviews and user logs from the tablets were used as additional data sources.

For this case study, the remaining section of this chapter focuses on a description of Tangerine:Class, and practical findings from the teacher tablet group, and not the other two implementation groups. Four main topics are being discussed: 1) teacher training and support; 2) the logistics of individual pupil assessments in large classrooms; 3) the nature of instructional decision-making; and 4) the use of data and interactions between teachers, headteachers and parents. Practical findings are derived from data collected via the “formal” study data collection tools including the EGRA and interviews mentioned above, but also from training observations, classroom observations and anecdotal feedback from TAC Tutors.

Description of Technology

As outlined above, Tangerine:Class is open source software, optimized for mobile devices, that enables teachers to systematically collect, analyze, and use results from continuous assessments of pupils’ early reading or mathematics skills. Figures 2-6 are select screenshots from the application.

Classes

School name mixed2
School year 2014
Grade 1
Stream a
Curriculum Math



School name mixed2
School year 2014
Grade 2
Stream a
Curriculum Math



[add](#) [All curricula](#)

Figure 2. Tangerine:Class home screen. This figure shows the home screen of Tangerine:Class.

Assessment status

Search student name

	NumID	Addition	Subtraction
Ana	✓	✓	✓
Becky	✓	✓	?
Mark	?	?	?
Tom	?	?	?

Current assessment

< 1 >

Back

Figure 3. Tangerine:Class assessment management screen. This figure shows the assessment and pupil selection screen of Tangerine:Class.

Version bed7c69 Teacher john Logout

Addition

Start 46

2+1=(3)	3+2=(5)	6+3=(9)
4+5=(9)	4+4=(8)	5+1=(6)
2+6=(8)	7+3=(10)	5+5=(10)
2+8=(10)	8+9=(17)	4+8=(12)
8+5=(13)	9+9=(18)	4+9=(13)
10+4=(14)	7+10=(17)	

Stop 27

Restart

Input mode

Mark Last attempted

Done Cancel

Figure 4. Tangerine:Class progress assessment screen. This figure shows an example of a progress assessment in Tangerine:Class.

Week4-NumID

5	18	32
21	13	7
46		
Done	Cancel	

Figure 5. Tangerine:Class mastery check screen. This figure shows an example of a mastery check in Tangerine:Class.



Version
b6d7c69

Teacher

john

Logout

Week2-Count-10

Week2-Shapes

Summary

Subtest Name	Week2-Count-10
Class Size	4
Students Assessed	4
Average Correct (%)	65%
Average Correct	6.5 / 10
Students to watch	

Student grouping

Name	% correct	Status
Tim	100	Great
Judy	75	Good
Becky B	75	Good
Mark	63	Good
Ana	38	Poor
Adam	13	Concerning

Figure 6. Tangerine:Class Class Grouping report. This figure shows an example of a class grouping report in Tangerine:Class.

Training and Support

Training. In January 2013, TAC Tutors trained the participating teachers from Barkorwa and Nyabondo zones in a 5-day training activity. A total of 21 teachers and 20 headteachers were trained in the PRIMR program, the use of the tablets and Tangerine:Class. Specific hardware training was limited to building basic familiarity with the tablet, including buttons, ports, basic navigation and general troubleshooting. Training on the tablet content was integrated with sessions on the PRIMR instructional approaches the software was focused at. Thus, use of Tangerine:Class was part of training on continuous assessment and the implementation of the PRIMR curriculum based measurements (weekly mastery checks) and termly progress measurements. A total of 3.5 hours of training were scheduled for theoretical sessions on the purpose of various types of assessments, frequency of assessments, and use of assessment results, as well as practical demonstration and role-play sessions on the effective use of Tangerine:Class.

During initial teacher training, the teachers were provided with the Nexus 7 tablets, for use in class and at their homes. Not a single Nexus tablet got lost, stolen or broke during the 9 months of implementation. Subsequent 4-day teacher trainings were held in May and August, 2013. These were mainly refresher courses to review progress and address challenges in the implementation of the

PRIMR intervention in general, and in the use of the Tangerine:Class in particular.

Reflection and Recommendations. None of the participants had used a tablet device before this activity. The training built their familiarity step-by-step starting with the most basic hardware operations in a one-hour session. Overall, the tablets were relatively easy for users to navigate and the icon-based touchscreen interface facilitated rapid adoption. More difficulty was observed with teachers remembering the various applications and their features. The 3.5 hours that were scheduled for Assessment and Tangerine:Class training matched the actual training time it took to enable teachers to understand the basic interface of the application, add a classroom, register pupils to the classroom, conduct assessments and access results/reports. However, additional time would have been needed to deepen teacher understanding of the application. Teachers did not have any difficulty understanding the graphs Tangerine:Class produces and reported that the data guidance is clear and useful. More difficulty was observed with users understanding good practices in administrating the assessments and how to organize the entire assessment process efficiently to minimize its duration. It took some teachers several months to do this efficiently. As these issues became apparent, they were included in the refresher trainings. Overall, the integrated, practical and “modeling” nature of the trainings was a good and valid approach.

A high variance was observed between participants, with some gaining significant familiarity within a short time and others only later. This required differentiation in organizing sessions and practice to ensure that training time was maximized for all participants. The level of motivation, willingness to learn and enthusiasm for engaging with the tablets was high among all participants. Teachers cared very well for the devices, kept them charged and caused very few scratches. The only issues were lost or broken styluses or charger cables.

Teacher Support. For the entire intervention period, PRIMR technical staff and TAC Tutors made routine visits to the school. At least two such visits were made per month to offer technical and instructional support to teachers. Monthly visits to schools were already part of TAC Tutor's existing responsibilities, thus neither the position itself nor the school visits added new or additional costs to the education system. PRIMR helped focus their purpose and systematize data collection and reporting.

Reflection and Recommendations. The in-person, regular, focused support built into PRIMR and the Kisumu ICT Pilot Study were absolutely critical to the success of the program and adoption of the mobile technology. The classroom observations provided TAC Tutors with a demonstration of the teachers' actual capacity, and Tangerine:Class data provided reliable insight into their pupils' progress on a regular basis. This is supported by quantitative data collected from across intervention groups that indicate a positive correlation

between frequency of TAC Tutor visits and pupil academic improvement as highlighted in Figure 7, below.

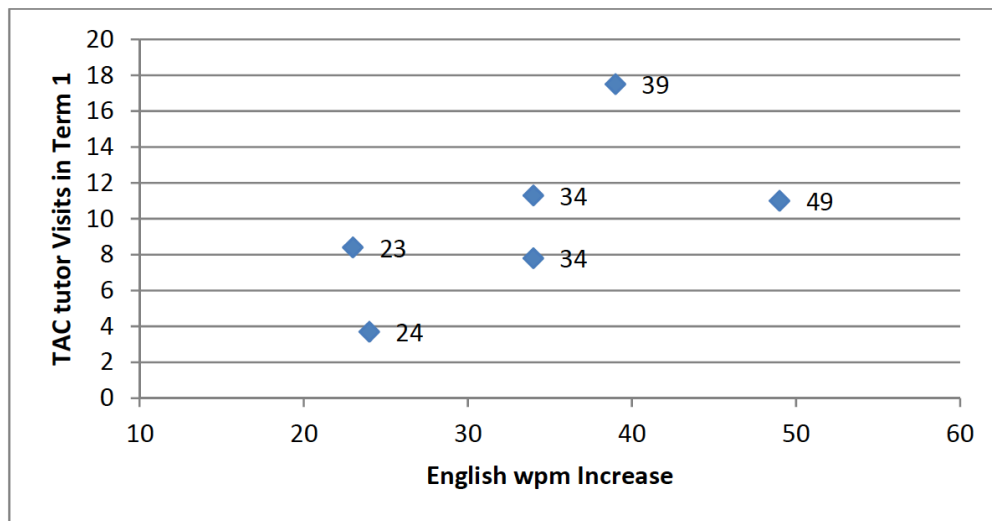


Figure 7: Observation-Performance correlation. This figure shows how pupil performance increases (for English reading skills, measured in correct word per minute) by frequency of TAC Tutor/observations.

Actual Tablet and Tangerine:Class Use. An analysis of data collected during TAC Tutor schools visits showed ongoing significant use of the tablets, as well as Tangerine:Class in all participating schools. TAC Tutors and PRIMR technical staff also met on a monthly basis to discuss progress. Based on TAC Tutor reports from school visits, teacher interviews, and classroom observations, teachers used tablets nearly daily.

Reflection and Recommendation. Given the lightweight and small design of the tablets, teachers preferred teaching off the lesson plans on the tablet, rather than printed lesson plans, and were more likely to transport tablets between homes and school than bulky print materials. The Tangerine:Class log feature tracks activities such as log-in attempts and feature use by event, date and duration, thus documenting when and for what teachers used the application. This provided data on actual use, and the opportunity for targeted training and support. This data indicates that at least 3-4 teachers conducted the assessments very poorly, even with Tangerine:Class, and rarely used the application at all. According to anecdotal feedback by TAC Tutors, this may be related to teacher changes, with new teachers coming on board in the middle of the year with limited training. Future initiatives should consider training more than one teacher per school.

Logistics of individual pupil assessments in large classrooms

As noted above, Tangerine:Class incorporates two types of assessments: Progress assessments and curriculum mastery checks. Progress assessments were undertaken for the entire list of pupils in the class to be able to record reliable data longitudinally. A practiced teacher needed about 5 minutes per child to conduct the termly progress assessment. In two out of the 20 schools, teachers with large classrooms needed extra time, a little more than a week, to cover the termly

progress assessments for their entire class. Enthusiasm caused by the presence of tablets at schools helped in ensuring pupils willingly reported for extended school hours. Administration of mastery checks was simplified through reduced items (requiring only about 2 minutes to implement per child) and systematic sampling. Through this sampling process, pupils in the class were divided into equal samples to participate in weekly mastery assessments. With a reduced sample of 12-15 pupils, the mastery checks would take about 25 minutes to implement. To avoid reducing critical instructional time it was planned that mastery checks would take place during break time.

Reflection and Recommendation. Schools ended up finding different, locally appropriate arrangements for when to conduct the assessments. Most schools opted for afternoons in consultation with parents, as many participating teachers reported using the mastery checks results to organize and inform remedial instruction right after the assessments.

It took a considerable supervision time and training during school visits for teachers to master the correct sampling technique. Midway through the program, a new feature was introduced in Tangerine:Class that color-coded pupil names based on the number of weeks since they had last been assessed. Without sampling, teachers assess all pupils, making them feel that the exercise is tedious and time-consuming, particularly in large classrooms. Future training should focus more on the sampling technique.

Finally, the mobility of the tablet devices proved to be a critical advantage to facilitate adoption of Tangerine:Class and the PRIMR assessment approach in general. Teachers were able to consult tablet resources anywhere and had full flexibility in where, how and when assessments were being conducted.

Nature of Instructional Decisions

Teachers used mastery check results from Tangerine:Class for instructional decision-making in various ways. As can be seen in Figure 8, 90% 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.

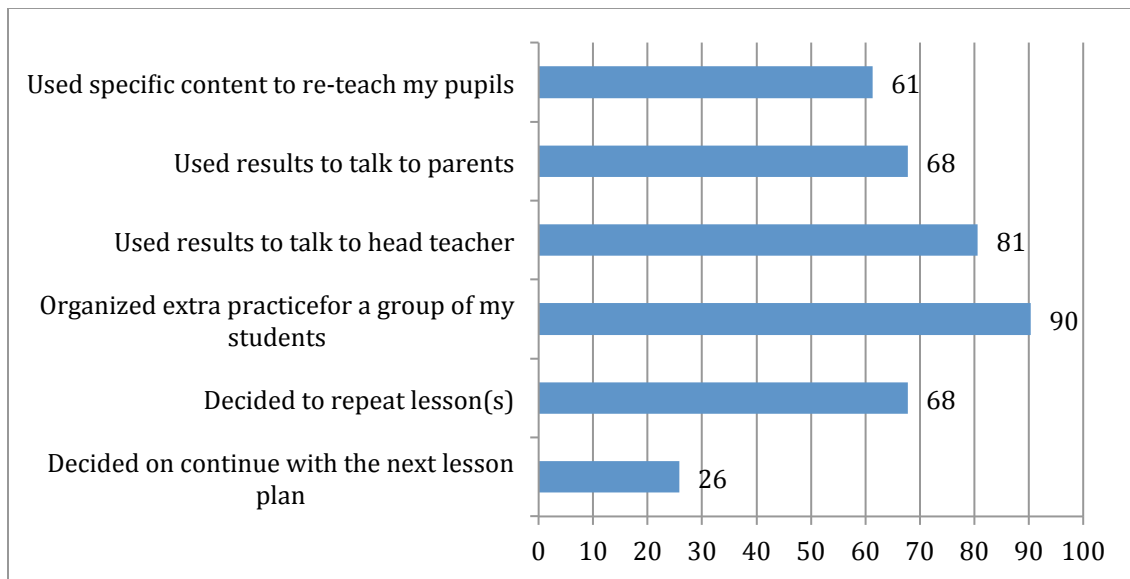


Figure 8. Uses of Tangerine:Class results. This figure outlines the proportion of teachers reporting to take different instructional decisions based on data recorded from mastery checks in Tangerine:Class.

Tangerine:Class teachers used the results from the termly progress assessments to assess whether pupils were improving in their progress towards the end-of-grade targets. As assessment results are comparable from one termly assessment to the next, such classroom-based information provided feedback on the impact of the instructional program longer term.

Reflection and Recommendation. As outlined above, teachers used results for different purposes. Tangerine:Class featured three main report types, of which the class grouping report was used most frequently. Overall teachers were

comfortable interpreting the reports, graphs and data tables. However, the depth of their instructional decision making, e.g., reviewing itemized results for individual pupils and organizing personalized remediation that would also change teaching strategies, was neither observed, nor realistically expected.

Interactions between Teachers, Headteachers and Parents

Both the headteacher and the participating class 2 teachers were trained in the use of Tangerine:Class. This improved the interactions between these two groups in that whenever the teacher was not in school, the headteacher would step-in and teach a specific lesson or conduct assessments. According to a teacher focus group, in many schools, headteachers would regularly assist with the logistics of the termly progress monitoring assessments or regular mastery checks. As Figure 8 above outlines, 81% of teachers report that they are using Tangerine:Class results to communicate with their headteacher. Furthermore, 68% of teachers report using results to communicate with parents. Reports from focus groups indicate that teachers actually showed the individual pupil's results from the mastery checks directly on the tablet to parents to discuss their child's progress.

Reflection and Recommendation. These described interactions between teachers, headteachers and parents were unanticipated. Given the weak and often absent relationships between teachers and parents, as well as reportedly little

instructional supervision and communication between teachers and headteachers, these findings are promising. More in depth research on this issue is needed to further qualify if and how this may actually affect pupil learning. Similarly, future initiatives may consider collecting data more systematically on the nature, frequency and timing of these interactions. Parents were not interviewed for the purpose of the Kisumu ICT Pilot Study, and would be an important informant in future research.

CASE STUDY REFLECTIONS

Reflections on building a culture of data-informed instructional decision making. The current assessment system in Kenya is geared towards using results only to inform pupils' grades. The PRIMR approach (with or without technology) thus includes regular review of curriculum mastery to inform instruction. Teachers in implementation groups not using Tangerine:Class found it cumbersome to assess every pupil, calculate and later interpret the scores. Some were not able to do the calculations. Whereas, teachers using Tangerine:Class found the application user friendly and saving them time on scoring and analyzing. Tangerine:Class provided instant analysis in simple graphs.

Use of CBM applications such Tangerine: Class could be even more effective if continuous assessment and use of data for instructional decision making were more widely adopted as drivers of enhanced instruction and trackers

of pupil progress towards end-of-grade benchmarks. In Kenya benchmarking is not a common practice. PRIMR, in consultation with MoEST introduced end-of grade benchmarks for reading fluency (with benchmarks for mathematics under discussion). Over time, the Kisumu teachers using Tangerine:Class learned to understand and appreciate the rationale for frequent tracking of pupil curriculum mastery and progress, as indicated by the relatively high levels of sustained use of the application, helping them keep classroom instruction focused on ensuring learners master the requisite skills and competencies.

Reflections on Sustainability. Is it possible to scale up applications such as Tangerine:Class on mobile devices in low income contexts? Actual cost data from the teacher tablet implementation group in the Kisumu RCT was USD3 per pupil for that school year for the ICT portion of the program. The basic unit cost of PRIMR (books, training, etc) for one subject is USD2.28 per pupil. This is only slightly more than the per pupil and subject cost in the control group. The control group did not have the PRIMR-specific books, training or tablet device, but the traditional books and professional development offered by the system. The total actual cost of the PRIMR teacher tablet intervention was USD5.28 per pupil for one subject in that school year; USD7.56 for two subjects (English and Kiswahili). In spite of this larger per pupil cost compared to the control group, the cost-effectiveness between implementation and control group is similar, and even slightly better in the intervention. For each dollar of investment, the oral reading

fluency gains (for English) were 6.7 correct words per minute (cwpm) over baseline for the pupils in the teacher tablet group, and 6.4 cwpm in the control group. More notably, the actual effect size of the teacher tablet group intervention (for English) was .5 standard deviations, with pupils in the teacher tablet group gaining 25.4 cwpm over baseline, compared 17 cwpm for the control group - a dramatic increase in the rate of reading acquisition.

Finally, given the diffusion of mobile technology in Kenya and the ever-dropping prices for tablets and smart phones, it is not unreasonable to expect that teachers, even in rural areas, may want and be able to afford a compatible device within the next 5 years. In such a “Bring Your Own Device” model, a significant cost factor of the program (initial device purchase cost) can be excluded from the sustainability calculation of direct costs to the education system, making this an even more promising avenue for improved mathematics instruction at scale.

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