

Implementing large-scale instructional technology in Kenya: Changing instructional practice and developing accountability in a national education system

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ABSTRACT

Previous large-scale education technology interventions have shown only modest impacts on student achievement. Building on results from an earlier randomized controlled trial of three different applications of information and communication technologies (ICTs) on primary education in Kenya, the Tusome Early Grade Reading Activity developed the National Tablets Program. The National Tablets Program is integrated into the Tusome activity by providing tablets to each of more than 1,200 instructional coaches in the country to use when they visit teachers. This enables a national database of classroom instructional quality, which is used by the education system to monitor overall education quality. The tools provided on the tablets are designed to help coaches increase the quality of their instructional support to teachers, and deepen the shallow accountability structures in Kenya's education system. Using results of a national survey, we investigated the ability of the National Tablets Program to increase the number of classroom observations done by coaches and to improve student learning outcomes. Survey results showed high levels of tablet program utilization, increased accountability, and improvements in learning outcomes. We share recommendations regarding large-scale ICT interventions and literacy programs.

Keywords: *Technology; ICT; literacy; accountability; Kenya*

INTRODUCTION

Increasing numbers of large-scale, government-supported educational reforms have introduced information and communication technology (ICT) to address educational problems, including the need for higher quality classroom teaching and materials. For example, Peru, Uruguay, and Portugal implemented one-laptop-per-child programs, and more recently Turkey, the Republic of Korea (South Korea), and Kenya are turning to one-tablet-per child or digital textbook programs, with the Kenya program providing 1.2 million devices.¹ A recent review (Tamim, Borokhovski, Pickup, & Bernard, 2015) found 11 national tablet initiatives under way, suggesting wide interest in large-scale educational tablet and laptop programs. Pouezevara and colleagues (2013) characterized the drivers of these one-to-one device large-scale distribution programs along four key motivations: political, social, economic, and educational transformation. Yet evidence is scarce as to whether the introduction of one-to-one technology can achieve these broad objectives.

The Kenyan government's statements about its Digital Literacy Program reveal economic and pedagogical aspirations (ICT Authority, 2016). By introducing tablets loaded with curricular materials and instructional content, the government hopes to "radically change teaching and learning in schools" while triggering economic growth and improved infrastructure. The Digital Literacy Program includes local assembly of the devices (ICT Authority, 2016).

¹ Relevant resources include: **Peru**—Beuermann, Cristia, Cruz-Aguayo, Cueto, & Malamud (2012); **Uruguay**—Pittaluga & Rivoir (2012); **Portugal**—Trucano (2012); **Turkey**—Pouezevara, Dincer, Kipp, & Sarnsik (2013); **South Korea**—Jang, Yi, & Shin (2016); **Kenya**—ICT Authority (2016).

The Kenyan Ministry of Education (MoE) introduced the National Tablets Program on behalf of coaches who support teachers implementing a new literacy initiative. The use of tablets for instructional support began with a pilot in 2013; by 2017 it had become a critical part of the interventions under the MoE's Tusome Early Grade Reading Activity.² The National Tablets Program integrates ICT to support the goal of improving literacy in grades 1–3. In Tusome, teachers receive training on how to use textbooks and teachers' guides designed to improve literacy outcomes. Teachers are supported in public school classrooms by the government's Curriculum Support Officers (CSOs), and in low-cost private schools by Tusome-hired instructional coaches.³ These CSOs and coaches (called coaches going forward) often were promoted from the teaching or head teaching force prior to their coaching career. Each coach receives a tablet loaded with software for recording teacher observation findings and for providing feedback to teachers. The tablets are equipped with model teaching videos and a software application to support letter sound knowledge, as a way to help teachers improve their instruction (Piper, Zuilkowski, Kwayumba, & Strigel, 2016). The purpose of the software installed on the tablet is to assist the coaches to more effectively offer instructional support to teachers during their visits. Data from the coaches' use of the tablets is provided to county- and national-level leaders for accountability purposes. The context of our study is the national-level Tusome program, implemented through coaches, to improve teachers' skills in implementing Tusome's new instructional program.

The national survey data available from Tusome allow for an analysis of whether and how the tablet intervention is changing classroom practice and introducing increased accountability. This effort is, to our knowledge, the first program focused on improving instructional support on a national scale in a developing country through the use of ICT. Thus, evidence of its added value is important to compare to the recent spate of negative results from large-scale laptop and tablet programs, as discussed in the literature review below.

The objectives of the study were as follows. First, given the aforementioned mixed ICT results to date, for purposes of comparison, we examined the literature on the impact of ICT interventions on learning outcomes and on teacher practice, in education and in similar social science fields. Second, we studied the findings from an original survey asking coaches and County Directors using the Tusome ICT tablets program to express their views on the quality and effectiveness of the program. Third, to obtain yet another perspective, we reviewed the findings from an external evaluation of Tusome that analyzed the program's impact on learning outcomes and, more proximally, on the ability of coaches to conduct classroom observations across Kenya. The remainder of the paper reflects these objectives.

LITERATURE REVIEW

In order to identify where the Kenya National Tablets Program fits into the broader evidence base of ICT applied to supporting educational outcomes on a large scale in developing countries, we reviewed literature from three types of interventions: the impact of ICT targeted at student use in

² The tablets program received funding starting in 2013, through the National Tablets Programme (2013–2015, British Department for International Development [DFID]/Kenya); the Primary Math and Reading (PRIMR) Initiative (2011–2014, the United States Agency for International Development [USAID] and DFID); and the Tusome ("Let Us Read") Early Grade Reading Activity (2014–2019, USAID and DFID).

³ In Kenya, low-cost private schools are found in peri-urban or slum areas; they are also known as Alternative Provision of Basic Education and Training (APBET) institutions. As noted in the text, instructional coaches are hired by the Tusome activity to support teachers in clusters of APBET schools in the nonformal settlements, while CSOs support teachers in public school zones with both technical and administrative tasks. For succinctness, we consolidate these titles and use the term *coaches* going forward, except when comparing the two or intentionally specifying one or the other.

classrooms; the moderating effect of teachers on the impact of ICT programs; and the use of ICT for administrative support in the education and health fields.

Impact of ICT for Students in Classrooms

Findings on the effects of ICT on student learning at scale vary considerably depending on the type of intervention, but in general they have been disappointing. Few examples of ICT in the classroom have shown statistically significant effects on student outcomes or even enrollment, repetition, and dropout rates (Christia, Cserwonko, & Garofalo, 2011), and fewer still have shown cost-effective impacts (Bando, Gallego, Gertler, & Romero, 2016; McEwan, 2015; Ortiz & Christia, 2014). Whether classroom technology has an impact depends on factors beyond just the presence of technology, but specific uses have not always been reported in the literature. When they have, the literature has pointed to positive outcomes associated with total instructional time on the device, including out-of-school use (Bebell & Kay, 2010; Texas Center for Educational Research [TCER], 2008); whether it was applied to a specific instructional challenge or subject area (Cramer & Smith, 2002; McEwan, 2015; Ortiz & Christia, 2014; Silvernail, Pinkham, Wintle, Walker, & Bartlett, 2011); and whether it helped teachers tailor teaching to student needs through adaptive instruction (Evans & Popova, 2015).

While the studies cited above primarily involved wealthy countries, there has been some recent research of ICT interventions in Africa. A tablet-based math tutoring program in Malawi showed significant positive effects for Grade 3 students (Pitchford, 2015). This software is now being tested at larger scale in Tanzania under the global learning XPRIZE competition, examining how this program's effectiveness compares to that of others in rural Tanzania. A computer-based early phonics game used in Grade 1 in Zambia resulted in significant positive improvements when students or teachers used the program. There was an additional impact on outcomes when both students and teachers used the software (Jere-Folotiya et al., 2014). In Kenya, a small-scale program that provided e-readers for students, carried out under the Primary Math and Reading (PRIMR) Initiative in Kenya, showed statistically significant effects (Piper, Zuilkowski et al., 2016). The instructional program that underpinned the ICT program, however, potentially had a greater impact than the hardware and software on which it was delivered. The findings of the PRIMR study informed the Kenyan government in implementing the National Tablets Program presented here.

Evidence is emerging regarding the impact of ICT in the hands of students, and whether or how it improves learning outcomes, as described above; but few examples have described large-scale or national-scale programs that invested in ICT for students in classrooms. The results of large-scale implementation programs utilizing laptops or tablets provided to students in Portugal (Trucano, 2012), Peru (Beuermann et al., 2012), Uruguay (Pittaluga & Rivoir, 2012), and Honduras (Bando et al., 2016) have not consistently been able to attribute significant positive learning outcomes to the technology. On the other hand, a tablet program in Maine (USA) saw some improvements in learning outcomes (Silvernail et al., 2011).

Impact of ICT for Teachers on Learning Outcomes

There remains limited positive evidence on whether and how ICT directed at teachers has had an impact on learning outcomes. Researchers have agreed that understanding teacher capacity to integrate ICT is the critical link between ICT and improved learning outcomes (Bando et al., 2016; Bebell & Kay, 2010) such that technology is an amplifier of good teaching, and is rarely transformative on its own. For example, the research on ICT in Kenya showed that regardless of which of three ICT modalities was used (e-readers for students, tablets for teachers, or tablets for instructional supervisors), the underlying instructional intervention was effective, and the specific ICT intervention had little additional impact (Piper, Zuilkowski et al., 2016). Natia and Al-hassan (2015) argued that there was limited teacher capacity to successfully implement ICT in Ghana.

Similarly, Bando and colleagues (2016) reviewed evaluations of large-scale book provision and concluded that “neither laptop nor book provision alone has an effect on student learning. Computers and books seem to require mediation by teachers or parents to enhance learning” (p. 8).

Other studies have investigated whether ICT can improve student learning by improving teachers’ instructional delivery. Coaching has been singled out as an effective form of teacher support, when implemented well (Bruns, Costa & Cunha, 2017; Kraft, Blazar, & Hogan, 2016; Piper & Zuilkowski 2015). However, the costs and complexity involved in sending experienced coaches to support teachers have prompted many researchers to investigate how ICT could make coaching more cost-effective. For example, in well-resourced contexts, it is common to use videos or ICT to create communities of practice or virtual coaching networks (Ermeling & Yarbrow, 2014; Hall & Wright, 2007; Measures of Effective Teaching [MET] Project, 2012). One of the most rigorous studies of video-based coaching was the 2012 MET study, sponsored by the Bill & Melinda Gates Foundation. Teachers reported that they changed their instructional practices after viewing videos of their teaching that was shared with them by a coach. An evaluation of coaching software showed an effect size of 1.09 standard deviations (SD) for teacher knowledge and 0.66 SD for implementation fidelity of a Grade 1 reading intervention (Mathes, 2015). A coaching program in Brazil used online communication (Skype) to offset some of the costs of coaching visits, contributing to cost-effective impacts on student learning compared to alternatives (Bruns et al., 2017).

Although these examples showed that ICT could support better coaching through technology aimed at teacher use, the models evaluated in these articles required costly infrastructure and significant human capacity to implement, and therefore would not yet be suitable for many low-resource contexts without the resources needed to implement them.

Impact of ICT on Administrative Functions

Despite the recent increase in the amount of rigorous evidence on the impact of ICT applied at the student level on student outcomes, a gap remains in terms of how ICT used by education officers outside of the classroom for administrative functions can support student learning gains. Examples abound of using technology for school administration, academic recordkeeping, personnel management, and student attendance tracking, but research estimating the impact of this type of usage of ICT on improving student outcomes is scant. Bloom, Lemos, Sadun, and Van Reenen (2015) found that the quality of school management was correlated with student scores. Well-managed schools may provide better instructional support and therefore better teaching. Glewwe and Muralidharan (2015) referenced Bloom et al. (2015) as well as other promising experiments in improving governance and reducing teacher absenteeism through regular school monitoring, which could potentially contribute to improved learning. If ICT can amplify good educational management practice through its rapid analytical power, feedback possibilities, and real-time communication about instruction, then applying ICT to educational administration and governance may improve learning.

Given the limited evidence regarding the use of ICT in education management, we found it useful to look beyond *education* technology for examples of ICT supporting individual behavior change through coaching and case management. In the health sector, personal connected technologies (such as SMS) combined with automated coaching were shown to help individuals adhere to treatment and increase health-seeking behavior, such as smoking cessation or treatment adherence (Orr & King, 2015; Watson, Bickmore, Cange, Kulshreshtha, & Kvedar, 2012). SMS-based coaching is now being applied to teacher support or adult learning in low-income countries (Aker, Ksoll, & Lybbert, 2012; Jukes et al., 2016; Kaleebu et al., 2013). Agarwal et al. (2016) documented the use of mobile, digital case management tools to help health workers deliver services, improve compliance with care protocols, and improve data collection.

Few large scale impact studies have been carried out, however (Braun, Catalani, Wimbush, & Israelski, 2013). Borkum and colleagues (2015) found that a mobile-phone intervention to aid community workers in India increased antenatal visits compared with a control group, but they did not estimate the effect of these additional visits on health outcomes. Thriemer et al. (2012) showed that an intervention utilizing a coaching tool focused on midwives in Zanzibar increased deliveries at medical facilities by 40 percentage points. Early reports from an SMS program in Guinea designed to improve antenatal health-seeking behaviors suggest that women receiving supportive messages recorded 8% more follow-up antenatal care visits than women who did not (Colaço, 2017). Even though these studies are outside of the education sector, they suggest that ICT can support administrative aspects of coaching structures to improve service delivery and behavior change.

NATIONAL TABLETS PROGRAM

The National Tablets Program in Kenya was designed as a tablet-based instructional support program for coaches using ICT. The program design was guided by the findings from a PRIMR randomized controlled trial (RCT) examining the effectiveness and cost-effectiveness of applying technology to different levels of the educational system (Piper, Jepkemei, Kwayumba, & Kibukho, 2016; Piper, Zuilkowski et al., 2016), which demonstrated that helping CSOs and coaches to support instruction was the most cost-effective use of ICT. The tablets program was piloted as part of the PRIMR Initiative from 2013 to 2014, and expanded to a national level in 2015 via the Tusome Early Grade Reading Activity. It began with 70 users in 2013, then 200 in 2014, and then was scaled to each of Kenya's 1,100 CSOs and 70 instructional coaches in 2015 under Tusome. The program provided tablets to coaches rather than to teachers or students.

How Coaches Have Used the National Tablets Program

The purpose of the MoE's National Tablets Program is to buttress the quality of the instructional support given to teachers by Tusome coaches. Four digital resources are available on the program's tablets.

The first resource is Tangerine[®]:Tutor, an Android-based application developed by RTI International with funding from the UK Department for International Development (DFID). Tangerine:Tutor's classroom observational tool contains embedded lesson plans created especially for the Tusome national literacy program, including items for sharing the coaches' views of the quality of teaching. Using Tangerine:Tutor, after each classroom lesson observed by the coach, the coach assesses three randomly selected learners on a simple fluency measure appropriate for that portion of the academic year. The data from the observations collected by the coaches from Kenya's literacy classrooms are automatically analyzed by Tangerine:Tutor along with the students' reading fluency rates. According to the input provided during the observation, the Tangerine:Tutor software then suggests to the coach key points for emphasis, which the coach can use in a feedback discussion with the teacher. Tangerine:Tutor saves the feedback on the tablet so that when the coach visits that particular teacher again, he or she can reference previous progress. This model is not unlike the health-sector case management tools described above that help community health workers to monitor protocol adherence and determine a specific course of action for individuals.

The second resource on the coach tablet is PDF versions of all Tusome-designed books and materials. These documents are linked to the observational tool on the tablets, for easier reference during classroom visits. This allows the coach to compare what the teachers' guide suggests with what actually is being done in classrooms.

The third resource is a set of 30 instructional videos in English and Kiswahili. These videos range from four to ten minutes and are visual examples of how teachers effectively teach particular components of the Tusome instructional approach. Many of them have embedded quizzes that the coach can administer to ensure that teachers understand what they have seen. The Tangerine:Tutor tool suggests particular videos for the coach to show the teacher based on the results from the classroom observations and the student fluency measure.

The fourth resource in the National Tablets Program is a letter-sound practice tool called Papaya™. Kenya's teachers have different language backgrounds and a range of skill levels in English and Kiswahili. These two languages utilize the same alphabet but some letters are pronounced differently. As a result, both coaches and teachers sometimes struggle with correct pronunciation. The software helps coaches and teachers practice hearing and pronouncing the letter sounds that are most problematic to them. Papaya has recordings of the correct letter sounds for both languages, and also allows teachers to record their own pronunciation of the letter to compare with the example. The Tangerine:Tutor feedback will suggest that the teacher use the letter-sound practice tool if the classroom observational data highlight consistent problems in letter-sound accuracy.

In short, the coaches used the tools on the tablet in the ways described above to provide instructional feedback to teachers implementing the national Tusome intervention. The core instructional program evaluated in the PRIMR RCT was shown to be effective for raising students' performance in both literacy (Piper, Zuilkowski, & Mugenda, 2014) and numeracy (Piper, Ralaingita, Akach, & King, 2016). Thus, the Tusome training for coaches focuses on instructional coaching and improvement, with further training on how to use technology as a tool to coach teachers (Piper & Zuilkowski, 2015).

Kenya's education system at the subnational level is managed by Directors, who were each given a tablet and trained to utilize the data from a dashboard of compiled coach observation data for purposes of accountability. The dashboard has the potential to increase accountability structures of the MoE. It was designed to capitalize on the county-level competition inherent in Kenya's education system, as well as to expand the relatively weak accountability structures of the national level to the counties, and from the counties to the coaches. The dashboard allows national-level educational directors to compare performance between counties; and within counties, between zones.⁴

Each county has an MoE County Director of Education (CDE), who supervises the education system and policy implementation; as well as a Teachers' Service Commission County Director (TSC CD), who oversees teachers and instructional practices.⁵ Every month the dashboard aggregates the number of visits, and national education leaders and county directors are sent a monthly email with a summary of literacy performance with links to the active dashboard. The performance of the coaches in 2015 and 2016 was impressive, with the 1,170 coaches observing 99,851 classrooms. Because Tangerine:Tutor captures GPS coordinates for each observation location, the dashboard also produces a map of the visits so that county-level officers can hold the coaches accountable for the number of visits they make per month and confirm that those visits are legitimate ones.

⁴ As mentioned in the previous note, zones are groups of public schools, typically ranging from 15 to 30 schools in a geographic area, and are supported by the TSC-hired CSOs. Clusters are groups of APBET schools that are privately managed and serve populations in nonformal settlements or slum areas of Nairobi, Mombasa, Kisumu, and Nakuru, the largest cities in Kenya. To simplify the discussion in this paper going forward, we refer to both zones and clusters as *zones*.

⁵ For the purposes of this paper, we refer to the group of MoE CDs and TSC CDs as County Directors, except in a few instances that involve comparisons between the two types of directors.

Figure 1 presents a screenshot of the dashboard and shows how it aggregates the coach-collected classroom information into a comparison between counties that MoE and county officials can use to oversee the instructional improvement program. The Cabinet Secretary, Principal Secretary, national-level Directors, and county-level Directors were trained on how to view the dashboard and use it to expand accountability.

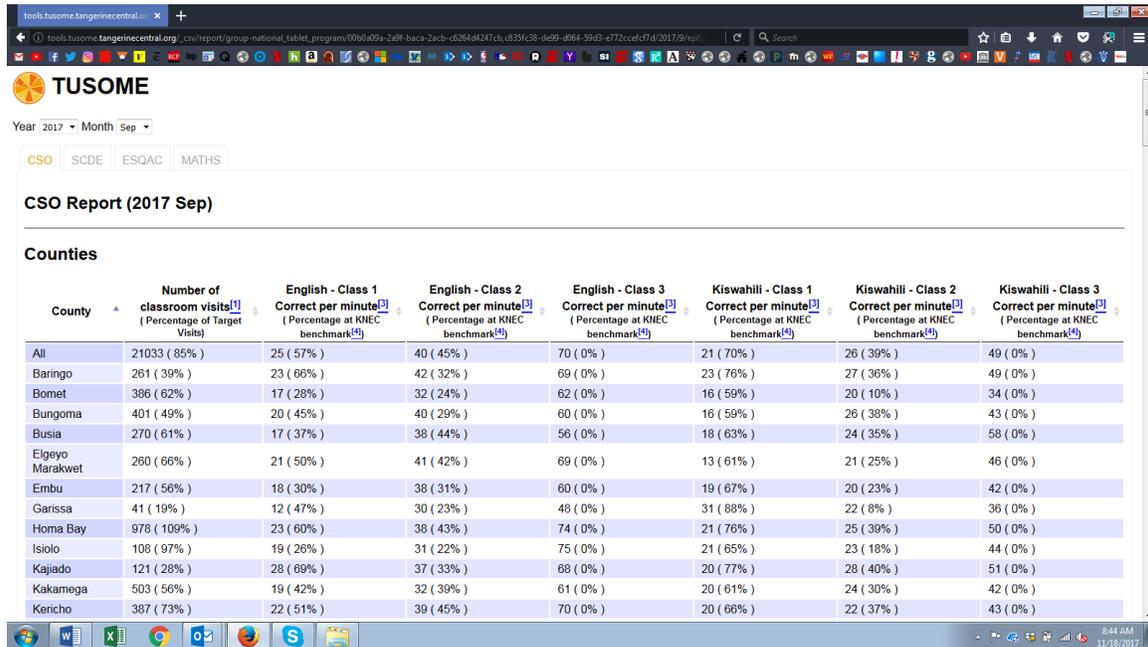


Figure 1: Dashboard from the National Tablets Program

Note. As of late 2017, the Kenya National Examinations Council (KNEC) was still establishing Class 3 (Grade 3) fluency benchmarks. Hence the dashboard shows 0% values for Class 3 percentages at KNEC benchmark.

Our review of the literature showed pessimism about the ability of large-scale tablet and laptop programs to improve learning outcomes. On the other hand, we found promising evidence of technology’s ability to make the education system more efficient in its support to classrooms, in ways that mimic the approaches of the health sector. This evidence, however, was sparse in terms of research that showed effects on educational outcomes or increased accountability, and was even sparser on estimating the effects of large-scale or national programs using ICT. The rationale for this study emerges from the limited evidence from prior studies on the impact of technology in the hands of students or teachers on either learning outcomes or accountability at a national level. Tusome’s National Tablets Program was one of the first opportunities to determine whether a program placing ICT in the hands of instructional coaches instead could have an impact.

The Tusome team designed one questionnaire to understand how coaches were implementing the tablet program, and another to investigate whether and how County Directors were using the tablet system for accountability. These tools were administered by the Tusome research team in May and June 2016. In addition, we were able to utilize the data from the external evaluation of Tusome to determine the impact of the intervention. Unlike previous sample-based analyses undertaken in

research in Kenya, this was the first truly national survey of the use of tablets in the Kenyan education sector. Given the gaps in the literature identified above, our study aimed to answer the following research questions.

1. Did coaches in the tablets program report that the use of the tablet and program-related software affected their support to teachers?
2. Did County Directors participating in the tablets program report that the data from the National Tablets Program on coach observations contributed to increased accountability?
3. Did coaches spend time in classrooms supporting teachers with tablets?
4. Did the Tusome program improve learning at the national level?

RESEARCH DESIGN

The research design for this study was a national census of the coaches and County Directors, using a set of questionnaires. As indicated in the previous section, to assess the ability of the National Tablets Program to buttress coaches' support to classroom teachers through technology, in mid-2016, the Tusome research team worked with the MoE to develop a questionnaire that the coaches administered to themselves with support from the Tusome research team. The coaches used the questionnaire to assess their skills on the four resources available on the tablet-based program. Questionnaire items covered which resources of the National Tablets Program the coach was skilled in using, as well as whether the program resources affected the coaches' ability to improve the quality of their instructional support (and thereby improve classroom instruction and learning). In addition, other items investigated whether the National Tablets Program had increased system accountability for instructional support and improved learning outcomes. Details about participation in the survey are presented below.

In addition to designing the questionnaire for the coaches, the Tusome research team worked with the MoE to develop a direct interview questionnaire for County Directors. The interview questions related to the facility of the County Directors with the tablet, with the dashboard, and with the Tusome instructional approach in general. The majority of the items in the County Directors' questionnaire solicited evidence related to whether the tablet-based tools and the dashboard were enhancing the accountability structures at the county and national levels.

The questionnaires and interviews offered a unique opportunity to estimate the effectiveness of ICT usage on a national scale in the education sector. The Tusome research team was able to undertake a national census of the implementation of the tablets program rather than a sample-based study. Before Tusome's annual national coaches' training in June 2016, the research team placed the coach questionnaire on all their tablets and requested that they complete and submit it via a cloud-based data server. In all, 831 coaches uploaded their responses, representing 76% of the national population of coaches. The data from County Directors were collected at an in-person interview led by Tusome staff. There were responses from 72% of Kenya's County Directors.

Additional data analyzed came from an external evaluation of the Tusome program, undertaken by MSI International. We used the evaluation report (Freudenberger & Davis, 2017) to create a table on the impact of Tusome, and data from MSI's sample-based coach questionnaire to analyze the behavior of coaches in 2016.

DATA ANALYSIS

The data from the national survey of coaches and County Directors were analyzed using *t*-tests to compare results between the two types of County Directors (MoE and TSC) on items investigating their utilization of the ICT program. Given that the response rates from coaches and County Directors were 72% and 76%, respectively, the data can be considered nationally representative and externally valid to the portion of coaches and County Directors who responded. The dichotomous variables were analyzed using simple *t*-tests in Stata to determine whether there were statistically significant differences. In addition, the national survey data collection tools often used five-point Likert scale results. In order to ease analysis, we simplified the five-point Likert scale data into simple comparisons between those who agreed or strongly agreed with a given statement, and those who felt otherwise; and those who reported frequently or very frequently undertaking a particular behavior, compared with those who did not. The data analytic strategies for the Tusome external evaluation are described in full in the report (Freudenberger & Davis, 2017). For this paper, it is important for the reader to be aware that the external evaluation compared literacy results in Kiswahili and English in 2016, after the Tusome program began, with literacy results in the same schools in 2015, prior to the implementation of Tusome. The schools selected were nationally representative and the results therefore externally valid to the national level. Results accounted for the weighting procedures, and standard errors were adjusted to account for the clustering of schools within counties.

FINDINGS

The survey investigated whether coaches were able to use the ICT resources of the tablets program consistently. As indicated above, the coaches were able to respond to a Likert scale of items estimating their ability to use the four resources on the tablets: Tangerine:Tutor, PDF versions of the Tusome books and materials, instructional videos for support, and Papaya letter sound practice.

Table 1: Level of usage of key tablets program resources

Questionnaire item	Frequently	Very frequently
What is your level of usage of Tangerine:Tutor?	56.1	31.9
What is your level of usage accessing PDFs of materials?	49.7	35.1
What is your level of usage of the instructional videos?	59.6	17.1
What is your level of usage of the Papaya sound practice app?	58.1	20.2

Questionnaire item	Agree	Strongly agree
I use the Tangerine:Tutor application during every observation	23.7	74.3
Tablet has helpful sound applications to help teachers	21.1	77.3
I use instructional videos during every observation	45.8	16.9
I use the Papaya application during every observation	42.7	14.5

Questionnaire item	Agree	Strongly agree
I access PDFs of materials during every lesson	42.0	50.0
I have improved in using the tablet	39.5	59.3
I am comfortable using the tablet	37.1	60.8

Table 1 shows that the tablet program of materials in PDF had the highest percentage of coaches citing that they used it very frequently (35.1%), and Tangerine:Tutor was used very frequently by 31.9% of the coaches, whereas instructional videos were least likely to be very frequently used (17.1%), although an additional 59.6% of coaches noted that they used the videos frequently. The results from the lower panel of Table 1 are from items that investigated how the coach implemented the resources. For coaches, 74.3% strongly agreed that they used Tangerine:Tutor during every observation, while only 16.9% agreed very strongly that they used instructional videos during each observation. Only 14.5% of coaches strongly agreed that they used the Papaya sound application in every observation. Despite the varying levels of usage of the tablet resources, 60.8% of coaches strongly agreed with the statement that they were comfortable using the tablet. Furthermore, 59.3% strongly agreed with the statement that they had improved over time at using the tablet.

Table 2 presents the results of questionnaire items examining the tablet program's ability to support coaches' work overall. We also organized these responses into the two additional tables that follow it: the preparation of coaches for instructional support, and the effects of that instructional support on teachers and students. With respect to supporting their work, more than 90% of coaches agreed or strongly agreed with each of the questionnaire items. More specifically, we found that 72.5% strongly agreed the tablet made them more alert and engaged, but only 47.9% strongly agreed that the tablets made them more able to visit teachers regularly. It appears that the tablet was helpful in their actual classroom feedback processes, which suggests that the tablets program was meeting its initial objective.

Table 2: Effectiveness of the tablets program: Supporting coaches' work overall

Questionnaire item	Agree	Strongly agree
The tablets help me have a better understanding of literacy instruction	38.0	60.2
Tablet has improved my ability to be a coach	29.8	68.5
The tablets help me to visit more teachers regularly	43.1	47.9
Tablet helps me feel more alert and engaged during lesson observation	26.0	72.5

Items in **Table 3** are related to the preparation that coaches received to help them support teachers better. The "strongly agree" responses again fell into a relatively narrow range, from the 64.3% who felt that the tablets showed them how to have engaging feedback sessions, to the 70.9% who concurred that the tablet enabled them to demonstrate a particular skill to a teacher. These results provide evidence that the tablets helped coaches to focus their classroom observation more

efficiently, and to provide higher quality classroom instructional support and feedback. In particular, the tablets program helped scaffold them on what to observe in the classroom, how to model specific skills, and how to give more engaging feedback.

Table 3: Effectiveness of instructional support in the tablets program: Preparation of coaches for teacher support

Questionnaire item	Agree	Strongly agree
Software facilitates my ability to have engaging feedback sessions	33.8	64.3
The tablets help me know what/how to observe when I visit a classroom	30.2	68.2
Tablet makes it easier to demonstrate appropriate teaching of a skill to a teacher	26.1	70.9

Beyond simply whether the coach was able to support teachers with better technical knowledge, we were interested in whether coaches would identify that the tablet would help them see improvements in Tusome implementation. **Table 4** results show that high percentages of coaches thought that the tablet was supporting their ability to track teacher and student progress, assess learner competencies in literacy, and improve their support to teachers. This area of instructional support has traditionally been an area of weakness (Piper & Zuilkowski, 2015) for coaches, and the tablet program was helping that relationship in meaningful ways, leading to more effective instructional support.

Table 4: Effectiveness of instructional support in the tablets program: Effect of instructional support on teachers and students

Questionnaire item	Agree	Strongly agree
The tablets help me to track teachers and student progress	44.6	50.7
Tablet helps me assess learner competencies in literacy	28.3	69.0
The teachers I support are improving because of my ability to better support them	40.2	58.9

To answer research question 2, we examined responses that would indicate whether the National Tablets Program was connected to the accountability structures within the Kenyan government system—that is, the County Directors’ oversight of CSOs (but not of APBET instructional coaches). The CSOs responded that more than 90% of the County Directors had seen and understood the data dashboard, as **Table 5** indicates. In addition to confirming whether the County Directors had access to the dashboard, we were interested in knowing what manner of feedback the County Directors were giving to CSOs as a result of seeing the data. We found that 83.8% of the CSO respondents noted that County Directors had given positive feedback based on the dashboard data, and 21.1% of CSOs reported that County Directors had given negative feedback based on

the dashboard. These figures suggest that a significant percentage of County Directors likely had used the data to hold CSOs accountable for their results, whether for good or poor performance. Serious consequences based on the data dashboard were identified by 13.9% of CSOs, noting that at least in some counties, the County Directors had used the Tusome data to push back on poorly performing CSOs. When the CSOs were asked how they felt about the feedback given by County Directors based on the dashboard results, 90.5% noted that it made them more effective in supporting teachers.

Table 5: CSOs' views of how County Directors used data dashboard for accountability (in %)

Questionnaire item	No	Yes
My county leadership understands the Tusome data dashboard	6.6	93.4
My county leadership has seen the Tusome data dashboard	8.2	91.8
My county leadership has given positive feedback to a CSO about the Tusome data dashboard	16.2	83.8
My county leadership has given negative feedback to a CSO about the Tusome data dashboard	78.9	21.1
My county leadership has given serious consequences to a CSO about the Tusome data dashboard	86.1	13.9
The feedback I have received helped me to be more effective in supporting teachers	9.5	90.5

To triangulate the findings from CSOs regarding how the dashboard data would be used for accountability, and to more fully answer research question 2 related to how the data were being used, we analyzed how County Directors dealt with the potential for increased accountability that the National Tablets Program data provided. In addition to the percentage responses given by the County Directors, **Table 6** compares the affirmative responses of the MoE and TSC County Directors, with *p*-values identifying whether the comparisons between the two types of County Directors' responses were statistically significantly different.

The majority of County Directors surveyed said they had been trained on the instructional aspects of the Tusome program (89.7%) and they had been issued a tablet (89.7%). The majority of County Directors also reported they had seen the data from the tablet tools (77.9%), and 79.4% noted that the data had affected their county. The ways in which the data had affected their accountability decisions were many and varied, as Table 6 shows. While we will not describe each item, it is interesting that the data affected supervisory visits (65.7%), methods to address student performance (31.3%), and—especially for some TSC County Directors—decisions to reassign or fire CSOs (36.1%). More than half (52.2%) of all the County Directors noted that access to tablet data had caused them to give negative feedback, and 50.7% said it had helped them share positive feedback. At the 0.10 significance level, TSC County Directors were more likely to give positive feedback (61.1%) than were MoE County Directors (38.7%).

In addition to investigating whether the data dashboard affected accountability decisions, for comparison, we were interested in whether the monthly emails with links to the dashboard issued by the Tusome program to the County Directors had an impact on accountability structures. Thus, we drew upon responses to questions about this type of communication that were incorporated into

their interview. Among all County Directors, 72.1% noted that access to that email affected their decisions. The downstream results from access to the email and access to the dashboard were similar. For example, 65.7% of the County Directors noted that access to the data dashboard affected decisions on supervisory visits, and 58.2% said that access to the email from Tusome affected decisions on supervisory visits. The results were nearly identical for several other items. Of interest is that TSC County Directors were more likely than MoE County Directors to use the Tusome email information to affect their decision to reassign or fire CSOs (36.1% vs. 9.7%; p -value .01) and to communicate negative feedback to CSOs (50.0% vs. 25.8%; p -value .04).

Table 6: Affirmative responses to ICT-based accountability measures, comparing MoE and TSC County Directors

Questionnaire item	County Director s overall	Director type comparison		
		MoE County Director	TSC County Director	Compara- son p - value
Have you been trained on Tusome?	89.7	87.1	91.9	.52
Has the Tusome program issued you with a tablet?	89.7	83.9	94.6	.15
Have you ever seen data collected from the CSOs' tablet-based tools?	77.9	71.0	83.8	.21
Has access to the data from CSOs on the dashboard affected your county?	79.4	77.4	81.1	.71
Has access to Tusome data affected your county's decisions on regular supervisory visits?	65.7	64.5	66.7	.86
Has access to Tusome data affected your county's decisions to address instructional materials shortages?	16.4	22.6	11.1	.21
Has access to Tusome data affected your county's decisions to address students' performance?	31.3	29.0	33.3	.71
Has access to Tusome data affected your county's decisions to change resource allocation for literacy?	11.9	9.7	13.9	.60
Has access to Tusome data affected your county's decisions to change time allocation for literacy?	10.4	9.7	11.1	.85
Has access to Tusome data affected your county's decisions to reassign or fire CSOs?	28.4	19.4	36.1	.13

Questionnaire item	County Director s overall	Director type comparison		
		MoE County Director	TSC County Director	Compari- son p- value
Has access to Tusome data affected your county's decisions to communicate negative feedback to CSOs?	52.2	41.9	61.1	.12
Has access to Tusome data affected your county's decisions to communicate positive feedback to CSOs?	50.7	38.7	61.1	.07~
Have you ever received an email with Tusome data?	77.9	77.4	78.4	.93
Has receiving emails with Tusome data affected your county's activities?	72.1	71.0	73.0	.86
Has receiving Tusome emails affected your county's decisions on regular supervisory visits?	58.2	54.8	61.1	.61
Has receiving Tusome emails affected your county's decisions to address instructional materials shortages?	16.4	19.4	13.9	.55
Has receiving Tusome emails affected your county's decisions to address students' performance?	26.7	32.3	22.2	.36
Has receiving Tusome emails affected your county's decisions to change resource allocation for literacy?	9.0	9.7	8.3	.85
Has receiving Tusome emails affected your county's decisions to change time allocation for literacy?	10.4	6.5	13.9	.33
Has receiving Tusome emails affected your county's decisions to reassign or fire CSOs?	23.9	9.7	36.1	.01*
Has receiving Tusome emails affected your county's decisions to communicate negative feedback to CSOs?	38.8	25.8	50.0	.04*
Has receiving Tusome emails affected your county's decisions to communicate positive feedback to CSOs?	50.7	48.4	52.8	.72

In order to answer research question 3, which investigated whether coaches utilized their time to support the Tusome national program using tablets, we utilized data from the Tusome external evaluation. The results came from a survey of 137 coaches sampled under the external evaluation. The results showed that 98% of the coaches had trained teachers on Tusome, and 94% of them

claimed to have visited classrooms regularly. **Table 7** presents the mean and standard deviation on four key outcomes from the coaches. First, 94.3% of coaches reported visiting a classroom in the last 30 days. On average, coaches reported making 13.2 school visits for the purposes of classroom observation in the previous month, and observing 18.2 different lessons. There is some variation around the mean on both of these items, with the standard deviation on the number of lessons observed at 9.3. Coaches claimed to have spent 59.8% of their time on classroom support in the last 30 days, which similarly has a relatively large standard deviation. These results match the data collected by the coaches and uploaded to the Tusome tablet-based data collection system, with 16,611 valid observations uploaded to the cloud in September 2016, the month before the data were collected.

Table 7: Coaches' responses to items investigating the utilization of their time for classroom support, as collected in the Tusome external evaluation (October 2016)

Response item	Mean	Standard deviation
Coach visited classroom in the last 30 days	94.3	23.3
Times visited a school in the last 30 days for classroom observation	13.2	8.7
Lessons observed in the last 30 days	18.2	9.3
Percentage of time spent on classroom support in the last 30 days	59.8	23.3

Understanding whether and how the National Tablets Program had an impact on learning outcomes is our fourth research question. Using data from the external evaluation implemented in 2015 and 2016 to measure learning outcomes, we found substantial improvements in learning outcomes in Kenya's classrooms implementing Tusome with support from coaches and the National Tablets Program.

Table 8 presents comparisons between the 2015 baseline and the 2016 midterm assessment, with statistical significance tests for each of the comparisons. The results show statistically significant differences between the baseline and midterm assessments for oral reading fluency and reading comprehension in English and Kiswahili, as well all of the other 14 tasks analyzed in the midterm evaluation (Freudenberger & Davis, 2017). In order to show the magnitude of the impact of Tusome on these outcome variables, we have included the effect sizes for each of these comparisons in the table. Effect sizes ranged from 0.40 to 0.94 standard deviations. If placed on a comparison with the effect sizes in international education programs cited in McEwan (2015) or Conn (2017), these results would be some of the largest in the international education field.

Table 8: Results from external evaluation of Tusome on Grade 1 and 2 Kiswahili and English fluency and comprehension rates

Subtask	Grade 1				Grade 2			
	Base-line	Mid-line	Difference	Effect Size	Base-line	Mid-line	Difference	Effect size
English Passage Reading (A)	10.6	22.3	11.7*	.67	23.8	43.6	19.9*	.72
English Reading Comprehension (A)	0.2	0.5	0.3*	.40	0.5	1.0	0.5*	.49
English Passage Reading (B)	9.7	22.0	12.4*	.73	21.8	44.2	22.5*	.86
English Reading Comprehension (B)	0.2	0.8	0.6*	.75	0.6	1.7	1.2*	.94
Kiswahili Passage Reading	4.9	12.2	7.3*	.75	13.5	24.5	11.0*	.71
Kiswahili Reading Comprehension	0.4	0.9	0.5*	.62	1.1	2.0	1.0*	.69

Adapted from Freudenberger & Davis (2017).

* $p < .01$.

DISCUSSION

The results we presented above showed that a large percentage of coaches and County Directors reported that they were successfully implementing the tablet-based instructional support tools in classrooms. The consistent increases over time in the numbers of classroom observations undertaken by coaches suggest that the accountability system is functional, and that the coaches see the classroom observational tasks as important.

More essential than simply knowing that the coaches were comfortable using the tablet, however, these results showed that they saw the tools available on the tablet—and their interactions with the teachers using the tools—as having increased the quality of their instructional support to teachers. Even without the frequency of ongoing support that some coaching programs in wealthy countries enjoy, the technology used in the National Tablets Program seems to have buttressed the quality of the instructional interaction. It remains for further research to determine whether the increased quality of the ICT-based instructional support to teachers will continue over time.

We were particularly interested in whether the tablet-based dashboard system and the availability of coaching data increased accountability. The results from both County Directors and coaches suggested a perception that the intervention made coaches more accountable. This was due not only to the existence of the dashboard data, but also to the events at the county level where the data were shared with County Directors and coaches present. The Tusome team were given information that some County Directors wrote warning letters to underperforming coaches. As of

2017, the Tusome program was expanding its support to County Directors and national education leaders in using the data and investigating the results of the dashboard, so further research will be necessary to determine whether that engagement improves the accountability system.⁶

The results showed that teachers claimed to be using more than half of their time providing instructional support to classrooms using the tablets in the National Tablets Program. Coaches had wide variations in how much time they spent in classroom observations, but Tusome's coaching system utilizing tablets seems to have meant that a significant amount of time was spent on classroom support using tablets, which was essential to improved learning outcomes. Unfortunately, there are no data on the prevalence of coaches undertaking classroom support prior to Tusome and the tablets program, but previous work suggests a much lower amount (Piper & Zuilkowski, 2015).

The Tusome tablet coaching model focuses on support from officers external to the school. At the same time, however, Tusome trained head teachers to provide feedback and support to teachers. Regression models that compared the performance of students in schools where head teachers claimed to have observed classrooms showed no difference in impact on any of the measures evaluated.

Finally, the results of the Tusome external evaluation of the impact of the entire package of Tusome's programming, including the National Tablets Program for coaches, showed significant impact on all outcomes. The percentage of that impact that was due to tablets themselves is impossible to determine from this data set, but future research will potentially be able to estimate the portion of Tusome's impact that is due to coaching and instructional support.

LIMITATIONS

This study had several limitations. First, given that the tablets program was implemented at a national scale, there was no counterfactual, and our analysis was not able to benefit from the causal nature of an experimental design. We argue, nonetheless, that the national-level results from before and after implementation of the tablets program suggest an effect of the ICT intervention on the quality of Tusome's implementation. First, Tusome is a fully national literacy program that capitalized on ICT provided to coaches, and is unique because of the magnitude of the impact (Freudenberger & Davis, 2017). Given that the design of Tusome's tablet program for coaches was based on rigorous results from an RCT (Piper, King, & Mugenda, 2016), we believe the results from our data analysis are indicative of a meaningful relationship between the tablets program and improved learning outcomes.

Second, neither Tusome nor its National Tablets Program allowed for a staggered implementation of the tablets intervention, such that the implementers could compare the coaching, support, and accountability systems of Tusome separately from the tablets intervention. We are therefore unable to ascertain whether and how a scaled program would have been implemented in Kenya without the technology component. However, the high level of uptake at the beginning of Tusome was due in part to coaches' and County Directors' excitement about the tablets.

Third, the consistently positive findings from coaches and County Directors could have occurred in part due to the perceived social desirability of positive responses. This likelihood is somewhat

⁶ The tablet system was not designed for teacher performance evaluation. In other words, Country Directors never saw teacher performance data or school-level learning outcomes, and no teacher was ever at risk of a negative consequence due to the tablet data.

lessened, however, by the fact that the coaches undertook their surveys alone, uploading their responses to the cloud without any assessor or supervisor reviewing them first.

Fourth, the data in this study were collected only one year after the tablets had been distributed. It is possible that the trend lines from the first year might differ from the subsequent years of the program, so further research is necessary to determine changes over time in usage of the tablets and the tablet program.

Finally, an important change took place from the first year to the second year: the beginning of the classroom-level implementation of the government's Primary Education Development (PRIEDE) mathematics program. PRIEDE was introduced roughly in parallel with Tusome to scale up the PRIMR numeracy intervention. In July 2016, the coaches were given a new software application to support the numeracy intervention, and the data dashboard was expanded to show results from numeracy assessments. The most recent month of the PRIEDE numeracy intervention for which data were available (June 2017) showed vastly fewer classroom observations for numeracy (2,573) than for literacy (21,269). Research is needed to determine whether the tablet-based support for numeracy will change over time and whether the PRIEDE mathematics program will affect Tusome's implementation.

CONCLUSION

The data that were collected to obtain feedback on Kenya's National Tablets Program represent one of the largest studies to date examining the implementation of national-scale ICT for school monitoring and accountability. Our analyses based on those data offer some indication that ICT investments in Kenya, when targeted at instructional support for teachers implementing a new instructional program, can change behavior and outcomes. This corroborates some of the other literature that has emphasized that technology must be applied in very deliberate ways (and its impact measured accordingly) to a specific instructional challenge in order to see positive results. That said, given the relatively modest relationships identified with improved learning outcomes as a result of increased visits, care should be taken to ensure that the ICT interventions undertaken at scale should consider scale. On the one hand, cheaper investments are not necessarily better if they do not support improved outcomes; but on the other, more costly investments have not been undertaken with full attention to the cost in environments like Kenya where there are scarce resources (Piper, Zuilkowski et al., 2016).

Finally, we offer a point about accountability. Education systems in sub-Saharan Africa are typically unable to create structures that regularly provide access to data on whether civil servants are consistently doing their jobs appropriately. Several recent developments, however, have suggested that many people within the Kenyan education system see the ongoing tablets program under Tusome as an effective way to create accountability. First, the MoE asked Tusome in late 2016 to develop tools on the tablets for its Quality Assurance and Standards Officers,⁷ 500 of whom work at a somewhat higher level of instructional support than coaches. In addition, the Tusome implementing team worked with the MoE in early 2016 to develop tools specifically for the use of the 290 Sub-County Directors of Education. After these tools were developed and the officers were using them for data collection, the MoE asked Tusome to include their results on the dashboard as well. The MoE's most current accountability-related request to Tusome was to allow the MoE to use the data for purposes far beyond Tusome and PRIEDE, so that other programs could be

⁷ Quality Assurance and Standards Officers are responsible for ensuring quality in government schools, including in instructional delivery. Visits from these officers are usually accompanied by a higher level of concern and worry than visits from CSOs, whom teachers typically see as somewhat more supportive and less likely to cause someone to be fired for poor performance or instructional methods.

similarly supported, including activities funded by school improvement grants issued under the PRIEDE program.

We posit that the effect of the National Tablets Program can be attributed to the program's focus on the educational problem most prevalent in Kenya: poor instructional quality (Piper, Jepkemei et al., 2016). In addition, the National Tablets Program was able to invigorate an accountability structure for better monitoring the educational officer cadre. The tablets made it possible not only to carry out school-based inspections, but also to provide targeted instructional improvement support to teachers.

In summary, ICT programs that are designed to solve particular instructional quality and accountability concerns are potentially more effective than those that expect access to ICT alone to create improved teaching quality. The National Tablets Program in Kenya has been a relatively inexpensive intervention focused on the quality of instructional feedback and increased accountability built on top of an effective instructional intervention (Piper, Zuilkowski et al., 2016). We suggest that future large-scale ICT interventions narrow their interest to specific aspects of instructional quality improvement that, to date, have not been solvable through traditional means.

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