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Kenya's ICT Policy in Practice: The Effectiveness of Tablets and E-readers in Improving Student Outcomes

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Abstract
Kenya is investing in information and communication technology (ICT) to improve children's learning outcomes. However, the literature on ICT is pessimistic about the ability of ICT alone to improve outcomes, and few ICT programs have created the instructional change necessary to increase learning. The Primary Math and Reading (PRIMR) Initiative implemented a randomized controlled trial of three ICT interventions to enhance learning outcomes: tablets for instructional supervisors, tablets for teachers, and e-readers for students. All three showed significant impacts in English and Kiswahili above the results of the control group. The impacts of the three interventions were not statistically significantly different from each other. Based on the findings, we recommend that Kenyan policy makers embed ICT interventions in a larger instructional reform, using ICT to support particular instructional improvement challenges. We also suggest that policy makers incorporate empirically derived cost-effectiveness analysis into investment decisions, to ensure that ICT provides value for money.

Keywords
Kenya; literacy; ICT; information communications technology; tablet; e-reader; coaching

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KENYA'S ICT POLICY IN PRACTICE: THE EFFECTIVENESS OF TABLETS AND E-READERS IN IMPROVING STUDENT OUTCOMES

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Policy makers in many sub-Saharan African countries see information and communication technology (ICT) as a catalyst to improve educational outcomes. However, few studies in this region have had the methodological rigor to produce empirical evidence that illustrates whether ICT increases student learning (Adomi & Kpangban, 2010; Mtebe & Raisamo, 2014; Tinio, 2003), improves access (Rubagiza, Were, & Sutherland, 2011), or prepares students for a globally competitive workforce (Beetham & Sharpe, 2013). Nevertheless, while this literature remains nascent, many countries in sub-Saharan Africa are investing heavily in ICT infrastructure (Igun, 2013). The Kenyan Ministry of Education, Science and Technology (MoEST) is focused on improving quality and on utilizing ICT to improve learning outcomes (MoEST, 2014). The Kenyan policy environment reflects this intent, with the development of a national ICT policy (Republic of Kenya, 2006), the notable focus on ICT in the National Education Sector Plan (NESP) (MoEST, 2014), and the inclusion of ICT in both the Education Act of 2013 (Republic of Kenya, 2013) and the Sessional Paper No. 14 of 2012 (Republic of Kenya, 2012), which is the guiding policy document for the sector.

As a result of this new emphasis on ICT in the education sector, the Kenyan government designed the Primary Math and Reading (PRIMR) Initiative to capitalize on the nexus between educational outcomes and ICT in the context of a program developed to improve the quality of literacy and numeracy outcomes for children in grades 1 and 2. This paper summarizes the findings of the effects of the ICT investments under PRIMR on the treatment groups' literacy outcomes, which are presented in full elsewhere (see Piper & Kwayumba, 2014; Piper, Zuilkowski, Strigel, & Kwayumba, 2015), and then examines how

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the impacts of ICT identified in the PRIMR study could inform the ICT policy environment in Kenya.

Literature Review

Our review of the literature on the interaction between ICT and policy issues in sub-Saharan Africa (with particular emphasis on Kenya, the location of this study) revealed that little is known about how ICT can improve learning outcomes in developing countries, and even less is known about how those findings can and should inform ICT policies in the education sector. Recent years have seen a rapid growth of ICT-in-education investments and activities in developing countries, even in the absence of further research on the likely impact of these investments (Wagner, 2014). The literature review below begins with an analysis of what the research says about ICT's impact on, and the interaction between, ICT investments and policy in sub-Saharan African education systems.

ICT in Education in Sub-Saharan Africa. Several authors have focused on the relationship between ICT in education and the education policy environment in sub-Saharan African education. Hudson (2013) argued that regular monitoring and investment in the ICT subsector is important for decision making. Thompson and Walsham (2010) identified four dimensions where ICTs could support development in Africa: (1) institutional infrastructure; (2) governance, accountability, and civil society; (3) service production and economic activity; and (4) access to global markets and resources. In the same vein, Nyagowa, Ocholla, and Mutula (2013) called for researchers in Africa to become more involved in the debate on ICT policy at the national and international levels, arguing that the pace of investment in ICT requires careful examination of the implications for education policy.

According to Iniesta-Bonillo, Sánchez-Fernández, and Schlesinger (2013), the spread of ICT in the education sector is a key component of the global educational reform agenda. Far too often, however, ICTs are isolated from broader policy change. In many countries, ICT is taught as a subject. Some scholars have argued that this approach to ICT in education contradicts patterns in the world outside school where ICT is not an isolated aspect of life but a ubiquitous economic, social, and cultural tool (Kessy, Kaemba, & Gachoka, 2006; Rubagiza, Were, & Sutherland, 2011). Burden and Shea (2013) noted that isolating ICT as a subject yields limited impacts on student learning outcomes.

Researchers, policy makers, and educators disagree on how to integrate ICT in education for maximum impact on learning outcomes as well as equity. Rubagiza, Were, and Sutherland (2011) opined that ICT's potential will not be realized by the mere introduction of ICT hardware and software in schools. They drew on Sen's (1992) capability approach as a framework for theorizing on issues of education policy and social justice and reported that some ICT policy initiatives can disadvantage girls and those living in rural communities. With specific reference to ICT policy in Namibia, Nglolo, Howie, and Plomp (2012) argued that acquisition and use of technology at various education levels is inequitable: Implementation was high to medium in higher levels of education, as compared to almost nil in lower levels of education (specifically basic education). In addressing such disadvantages, Mukuna (2013) argued that without a shift in practices of teaching and learning with ICT in schools, many young people are not likely to learn how to exploit the opportunities ICT provides. In effect, without clear policy direction, ICTs could exacerbate inequalities for particular populations.

ICTs were initially seen as tools to simplify administration processes (i.e., the official procedures of the school whereby records, enrollment data, and personnel information could efficiently be maintained) (Hennessy et al., 2010). Along these same lines, according to Ngololo et al. (2012), ICT implementation in most sub-Saharan African schools is still in its infancy, especially in rural areas. When used at all, typically it is for management. Kirimi (2013) stated that policy makers must realize the importance of technology in schools and,

more specifically, the teaching and learning environment. This argument implies that high-level policies must be reengineered to address how ICT is utilized in an education environment as a pedagogical tool.

Schools in sub-Saharan Africa encounter myriad challenges in the use of ICT to improve learning. Kozma, McGhee, Quellmalz, and Zalles (2004) evaluated ICT school programs in sub-Saharan Africa as well as South America with the objective of identifying barriers to ICT development. The research examined the impact of ICT on traditional pedagogy. In a study of constraints to ICT usage in teaching and learning environments in Kenya, Kamau (2012) established that few schools had adequate ICT facilities, making it impossible to incorporate ICT into the teaching and learning process. In addition, where ICT facilities were available, the facilities were not used efficiently, partly because of lack of capacity among staff, and partly because students seemed to engage in entertainment whenever they accessed computers, rather than use them for academic work. With regard to infrastructure, Kamau also found that most schools with computers had neither related educational programs nor Internet access.

According to Nchunge, Sakwa, and Mwangi (2012), although ICT plays a crucial role in effectiveness, efficiency, and service delivery in education, its adoption in schools in Kenya has remained limited. The authors reported that the pace of ICT adoption was slowed by a perception among users that ICT was complex, by the fact that many potential users had inadequate technological literacy, by the lack of psychological and technical readiness, and by insufficient policy guidelines. They argued that inadequate technical and psychological preparedness impeded attitudinal and behavior changes, which, in turn, has hampered technology use in schools. Similar to Kamau (2012), they posited that training and increased investment in ICT facilities were critical for the requisite psychological and technical skill readiness of teachers.

Some analysts have argued that new pedagogical models emphasizing ICT need to be explored and incorporated into the instructional process (Amutabi, 2004; Macharia & Pelser, 2012). In other words, the focus must shift from output-based ICT programs to outcomes-based programs that link ICT to improving teaching and learning. This change would have the advantage of preparing future citizens for lifelong learning. Although evidence suggests that active learning can be facilitated by ICT, little consensus exists as to which pedagogical models should be adopted. Furthermore, the supporting hardware has similar issues: Some educators have advocated for more versatile mobile devices, while others have argued for stationary equipment, such as desktop and laptop computers (Hennessy, Harrison, & Wamakote, 2010).

Various challenges have hindered the integration of instructional change and ICT. One difficulty is the personnel who ICT improvement would affect. While classroom teachers are the main agents of innovation and diffusion of skills and ideas at the school level, the role of head teachers in ICT program implementation cannot be underestimated (Njoroge & Kibaru, 2012). Ngololo, Howie, and Plomp (2012) reported teachers' negative attitudes regarding ICT and argued for the need to focus on pedagogical uses of ICT. Similarly, Buabeng-Andoh (2012) argued that the few schools with high pedagogical use of ICT showed an entrepreneurial leadership style and vision among science teachers. He strongly advocated for ICT implementation in rural schools. Buabeng-Andoh further argued that despite heavy investments in ICT infrastructure, equipment, and professional development to improve education in many countries, ICT adoption and integration in teaching and learning had been limited. Among the barriers to effective use of ICT for quality education that Buabeng-Andoh pointed out were lack of teacher ICT skills, lack of teacher confidence, lack of pedagogical teacher training, lack of suitable educational software, limited access to ICT, rigid structure of traditional education systems, and restrictive curricula. Additional research exploring the extent to which these factors impede

effective utilization of ICT for education would help in making policy decisions on how to address them.

Policy Opportunities for ICT in Education: The Case of Kenya. The section above focused on evidence regarding the effectiveness of ICT in education in sub-Saharan Africa generally, especially its impacts on learning outcomes. This section discusses what is known about the policy relationship between ICT and the Kenyan education sector specifically. As indicated above, Kenya is increasingly embedding ICT in its education policy documents. Kenya's National Education Sector Plan for 2013–2018 focuses heavily on ICT, including having ICT incorporated into instructional change (MoEST, 2014). This is despite the dearth of research in Kenya on the impact of ICT on learning improvement, and the NESP document refers primarily to activities that are currently pending or in place (such as an expected national laptop program; the digitization of school curriculum and learning materials; and training in ICT being offered by the Centre for Mathematics, Science and Technology Education in Africa [CEMASTEA]). In 2006, Kenya promulgated a national ICT policy applicable across sectors to improve the availability of accessible, efficient, reliable, and affordable ICT services (Farrell, 2007). The policy's key strategies with regard to ICT and education were to encourage the use of ICT in schools, colleges, universities, and other educational institutions in the country to improve the quality of teaching and learning (MoEST & Ministry of Information and Communication, 2006). Another aim of the policy is to improve the livelihoods of citizens through reliable, accessible, and affordable ICT services. In addition, the government is encouraging the use of ICT in all learning institutions so as to improve the quality of learning and teaching.

A great deal of the research cited above focused on barriers to successful ICT programs. There has been far less investigation of the relationships among ICT programs, learning outcomes, instructional change, and policy uptake. This is not an insignificant need in Kenya, as the initial budget for the recent Kenyan national laptop procurement was US$622 million (Waweru & Kihara, 2013). The incorporation of ICT into teaching and learning is a long-term research frontier. Methodologically, few studies have been conducted to estimate a causal impact of ICT programs. The literature also suffers from limited evidence to support education policies' emphasis on direct use of ICT in education. In the next subsection we delve further into the small but growing literature on the relationship between ICT and learning.

Impact of ICT on Learning Outcomes. Many researchers see the potential of ICT for improving quality of teaching and learning. Mobile devices are gaining prominence in the education space because of portability, low cost, and increasingly ubiquitous availability. Studies in this field often seek to arrive at a more precise understanding of the mechanisms by which ICT can affect classroom pedagogical practice. For example, Lehner and Nösekabel (2002) argued that use of mobile devices in education should not replace traditional educational models that depend on teachers, but instead should support both students and teachers by providing services that facilitate teaching and learning.

Wu and colleagues (2012) provided a comprehensive analysis and synthesis of 164 studies of mobile learning carried out from 2003 to 2010. Their meta-analysis found that most studies of mobile learning focused on effectiveness or the specifics of mobile learning system design. They also warned policy makers that the current mobile devices most widely used in the education sector inevitably will be replaced by other emerging technologies, so policy makers and investors should embed that factor in their decision-making. Lwoga's (2012) research in sub-Saharan Africa found that the adoption of e-learning technologies was still in its infancy, but there was increased enthusiasm for utilizing e-learning approaches and ICT tools in education. Wagner, Castillo, Murphy, Crofton, and Zahra (2014) argued that the emergence of low-cost digital and mobile devices has led to a recent increase in ICT interventions aimed at improving learning outcomes. Wagner's (2014)

suggested policy framework should help policy makers to consider the interaction of the aims of the intervention, the devices, the context, and the specifics of the users.

The work of Bhuasiri and colleagues (2012) extended beyond learning outcomes to focus on the relationship between ICT and curriculum design. Their study showed that technological awareness, the motivation of learners, and critical changes in day-to-day behavior of learners were prerequisites for successful ICT implementation. The importance of the context of the educational system was emphasized by Jere-Folotiya et al. (2014), who argued that applications can be effective for literacy if they are well aligned with a specific pedagogical intervention that the ICT can support. However, that study did not compare the relative effectiveness of various ICT applications and hardware choices that might be available for policy makers.

Within the ICT literature that directly addresses the impact on learning outcomes, results have been mixed. Several articles presented pessimistic findings. For example, Cristia, Ibarrarán, Cueto, Santiago, and Severín (2012) reported no statistically significant effects of ICT on math or language scores. On the other hand, a Ghanaian e-reader program showed positive effects on fourth-grade students' reading scores, especially if the student received support after school (ILC Africa & Worldreader, 2012). This study also showed that the e-reader program had a positive impact on family outcomes and those of non-school-going children as well. As discussed above, Jere-Folotiya et al. (2014) concluded that effectiveness of ICT in improving educational outcomes lies in embedding the ICT interventions in already effective pedagogical programs. Wagner's (2014) synthesis of results contended that the effectiveness of mobile learning approaches depends entirely on the fit of the approach into the context, the hardware, and the emphasis on a specific purpose, and therefore, the effectiveness of ICT depends heavily on non-ICT factors in the design. While the literature on the impact of ICT on learning outcomes is nascent, a recent study, described below, has shown that effectiveness increases if ICT is used as a support mechanism to help a well-designed instructional change program.

The PRIMR ICT Study

The results from the PRIMR ICT study discussed below were analyzed elsewhere (see Piper & Kwayumba, 2014; Piper et al., 2015). These papers presented the methods, research design, and cost effectiveness of the PRIMR ICT approach. Given the focus of this paper on the impact of ICT research on policy outcomes, the section below presents an overview of the methods of the PRIMR ICT study, points to the research design and findings of the previous work, and expands the previous work by fitting the findings specifically into the policy context of Kenya. The literature review presented above shows that few studies describe the impact of ICT interventions in terms of learning outcomes. Filling this gap in the literature was an essential part of the PRIMR ICT study for purposes of Kenya's immediate and long-term education policies. Even less work has been done evaluating the relationship between cost and effectiveness in ICT interventions so that policy makers are equipped with the data needed to make decisions. After a discussion of the impact of the PRIMR program on learning outcomes, we present findings on the cost-effectiveness of PRIMR and its implications for policy.

Methods. Given the lack of rigorously evaluated ICT programs focusing on student learning outcomes, the PRIMR program was designed by the MoEST and the United States Agency for International Development (USAID) in 2011 to address this need. PRIMR had several embedded randomized controlled trials within the larger research design organized to investigate the relative effectiveness and cost effectiveness of the investment. Among the experiments was a randomized controlled trial of three different ICT interventions implemented in Kisumu County in the western part of Kenya, situated on Lake Victoria. The three ICT interventions tested were e-readers for pupils, tablets for teachers, and tablets for Teachers' Advisory Centre (TAC) tutors. The fundamental

question that PRIMR's ICT study sought to answer was whether these three different ICT interventions would improve pupil outcomes in grade 2, and which of those three ICT interventions would be most cost-effective. Each of the three ICT interventions was compared against the other two interventions and the control group to measure effectiveness and cost-effectiveness (Piper & Kwayumba, 2014; Piper et al., 2015).

In order to determine whether ICT improves achievement in Kisumu County, Kenya, the three ICT treatment groups and a control group were given baseline (January 2013) and endline (October 2013) literacy assessments utilizing the Early Grade Reading Assessment instrument (Gove & Cvelich, 2011) in English and Kiswahili. Oral reading fluency was the Early Grade Reading Assessment measure primarily discussed in these papers and revisited in this policy analysis (Piper & Kwayumba, 2014; Piper et al, 2015).

Note that the mean scores of the four groups were not equivalent at the baseline. Given this non-equivalence of means at the baseline, the PRIMR team utilized differences-in-differences models. The models compare changes in a program's outcome variables at two different assessment points for treatment and control groups by removing the secular trend (the change in outcome for the control group over time). This allowed the researchers to analyze each program's impact with regard to changes not due to program impact (Murnane & Willett, 2011). In the case of PRIMR, the researchers were able to make causal inferences regarding the impact of the ICT interventions on learning achievement.

Research Design. The research team of PRIMR was interested in comparing the relative effectiveness and cost-effectiveness of ICT interventions at three different levels of the education system: the student level, the teacher level, and the instructional supervisor level. The three ICT treatment groups, executed across these three levels of the education system, implemented the full PRIMR literacy program in Kiswahili and English, which previous analyses had shown was successful at a low cost and in low-resourced environments (Piper, Zuilkowski, & Mugenda, 2014). The program utilized daily pupil activities in the five components of reading,[2] following the Kenyan syllabus, and supported teachers with teachers' guides related to the pupil books. In addition, the teachers in all three treatment groups received formative instructional support from the government's TAC tutors, who frequently visited the classrooms of teachers implementing the new PRIMR instructional approach. The teachers were trained for 10 days. Members of the PRIMR technical team supported the TAC tutors in similar ways. The research design utilized the existing zonal groupings of schools in Kisumu County. The PRIMR technical team randomly selected eight zones from across Kisumu and then randomly assigned the selected zones to three treatment groups and a control group. Each treatment group and the control group had a semi-urban and a rural zone. In PRIMR, this meant that the three interventions were assessed in 20 schools each, randomly selected and randomly assigned, stratified by urbanicity. A total of 1,580 pupils were assessed at the January 2013 baseline and 1,560 pupils at the October 2013 endline (Piper & Kwayumba, 2014; Piper et al., 2015). We describe the three treatment groups below.

PRIMR and Pupil E-Readers. Under this treatment, Kindle e-readers were provided to pupils and teachers. The e-readers contained the PRIMR reading textbooks in English and Kiswahili. Additionally included were books in the primary mother tongue in the area (i.e., Dholuo), relevant textbooks from Kenyan publishers, and hundreds of age-appropriate stories related to the Kenyan curriculum, as well as English and Kiswahili dictionaries. Teachers were provided 10 days of training to implement the base PRIMR intervention utilizing the pupil e-readers.

PRIMR and Teacher Tablet. In this treatment group, teachers were given a Google Nexus 7-inch tablet to supplement PRIMR instruction in English and Kiswahili.

[2] Phonemic awareness, alphabetic principle, reading fluency, vocabulary, and reading comprehension (National Institute of Child Health and Human Development, 2000).

The tablet contained multimedia lesson plans, supplementary pedagogical aids, virtual letter flashcards, and the Papaya™ software application, which had audio capabilities to practice letter sounds. The tablet also included the Tangerine:Class™ application, which contained a sophisticated continuous assessment program that allowed teachers to systematically investigate the quality of pupil learning and compare it with their instruction to determine which lessons they should reemphasize, based on pupil mastery of the content. Both programs were built using open-source software and were optimized for mobile devices. This enabled teachers to systematically collect, analyze, and use data to improve teaching and learning. Teachers were provided with 10 days of training to implement the PRIMR intervention, supported by the tablets.

PRIMR and TAC Tutor Tablet. In this treatment group, the TAC tutors were given a Google Nexus 7-inch tablet that contained educational materials on efficient and effective teacher support. This included the Papaya™ software application mentioned above, as well as an electronic version of the classroom observation tool. The TAC tutors were responsible for all of the teachers in a set of 10 schools. The tablets included PDF versions of the materials given to teachers and students. The TAC tutors trained the teachers for 10 days on implementing the basic PRIMR intervention.

Control Group. The control group did not experience any additional ICT interventions, including the base PRIMR treatment. Literacy instruction in the control group did not change as a result of the PRIMR experimental study. The control group was assessed at baseline and endline similar to the three treatment groups described above. Teachers in the control group were given materials, training, and support in the 2014 academic year, at the end of the PRIMR intervention.

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 MoEST 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 for scale-up. In addition, the PRIMR ICT study was organized to help the MoEST think through the policy implications of a program focused on the relationship between ICT and instructional change. Note that this paper focuses on the policy implications of the findings identified in the ICT PRIMR evaluation.

Results

The results of this study are presented in two categories of interest: Whether the technology treatments had any positive effects on student achievement, and whether any of the treatments were sufficiently cost effective to warrant further investigation or larger-scale application.

Does Technology Improve Achievement? The difference-in-difference models revealed that all three treatment groups had better performance on the key variables than did the control group, and that the differences were statistically significant (see Piper et al., 2015). The results showed that the TAC tutor tablet and teacher tablet interventions had larger impacts on these key measures than the e-reader interventions, although the e-reader group also saw an increase in the proportion of pupils reading at the appropriate benchmarks (Piper & Kwayumba, 2014).

The TAC tutor group consistently displayed higher effects compared to the other two groups. This could be explained by the effort made by various TAC tutors to supervise and support teachers as they undertook the ICT intervention. Comparative analysis of performance against the frequency of school visits during Term 1[3] made by the TAC tutors

[3] The Kenyan school year consists of three terms from January to November, with month-long breaks in April, August, and December.

revealed a noncausal relationship between visits and learning outcomes such that the more classroom visits the TAC tutors undertook, the higher the learning outcomes (see Piper & Kwayumba, 2014). This finding is similar to what was expected and identified in an analysis of the base PRIMR intervention (see Piper & Zuilkowski, 2015).

Apart from being an effect of possessing the tablet or ICT, the effect shown by the teacher tablet group could have been a result of efficient and effective use of the teacher tablet information. Apart from PRIMR lessons, pupil books, and other learning materials (e.g., tutor and teacher tip-sheets), the teacher tablets were loaded with applications that further aided teaching and learning in schools. These included Papaya™, which helped both teachers and pupils correctly sound out letters and construct letters and words, as well as Tangerine:Class™.

From another point of view, 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 simply to teach better, rather than required to utilize ICT, which for them proved a challenge. In any case, definitive answers about which ICT intervention was better for Kenya was impossible to determine from this experimental study given the similarity in pupil outcomes across the three treatment groups. As observed in other Early Grade Reading Assessment studies in Liberia and Kenya (Piper & Korda, 2011; Piper & Mugenda, 2013; Piper & Kwayumba, 2014), improvement in access to literacy materials was statistically significantly correlated with higher literacy outcomes. It was observed, however, that despite more reading materials being provided to pupils—and the associated greater expense—the gains in the e-reader treatment group were not larger than those in the other two groups. For example, as reported in Piper et al. (2015), gains in English oral reading fluency scores were 9.9 correct words per minute, 8.6 correct words per minute, and 6.1 correct words per minute for the TAC tutor tablet, teacher tablet, and pupil e-reader groups, respectively.

How Cost Effective Were the ICT Programs in PRIMR? In addition to estimating the effectiveness of the three ICT programs under PRIMR, the program was designed to estimate cost-effectiveness. PRIMR collected costs of the typical implementation of literacy programs in Kenya and compared those costs to the additional costs of the PRIMR program, including the ICT hardware, books, teacher training, and instructional support provided by the TAC tutors. Cost-effectiveness was then measured by dividing the PRIMR effect for each treatment group by the per-pupil, per-subject unit cost of each of the ICT tools.

This analysis revealed that an investment of US$100 translated into an additional 7.8 pupils reaching the emergent fluency level in English (30 correct words per minute) and 7.4 pupils in Kiswahili (17 correct words per minute), under the TAC tutor treatment (Piper & Kwayumba, 2014). A US$100 investment in the teacher tablet treatment increased the number of pupils reaching emergent reading fluency in English and Kiswahili by 4.3 and 4.2 pupils, respectively. Finally, for US$100 invested in the pupil e-reader treatment group, less than one additional student reached the emergent level in English or Kiswahili. This revealed that of the three ICT experiments, the TAC tutor tablet was by far the most cost-effective (Piper & Kwayumba, 2014). This is logical given that the funding share of the ICT hardware borne at the student level for the e-reader group and the teacher tablet group was very high. Understanding whether ICT can work is important, but it cannot be the only calculation provided for policy makers, as the hardware (and in some cases software) costs of ICT programs can be quite high.

Discussion

The Kenyan National ICT Policy of January 2006 emphasized incorporating ICTs in education. The current Kenyan government's Jubilee manifesto and Vision 2030 (Republic of Kenya, 2007), as well as the NESP, advocate for the integration of ICT into education as

part of a long-term quality improvement strategy. The ICT policy in education emphasizes the curriculum and professional development, and the investment program No. 25 in the National Education Sector Plan (MoEST, 2014) focuses heavily on improving learning outcomes through ICT. There is a growing awareness, however, that providing hardware is insufficient to yield the desired educational reforms. The government is now focusing on improving teacher skills and pedagogy as the key to effectively implementing ICT to enhance teaching and learning, and eventually improving quality of education.

Despite the recent policy reforms, use of ICT in education in Kenya is still limited, particularly in basic education. That said, the 2013 electoral pledge of the Jubilee Coalition government suggests that ICT will be closely integrated with instruction across the country. The PRIMR ICT intervention is an example of an attempt to mitigate the disadvantage experienced by girls and by children from rural schools, as those communities showed particular gains in the ICT interventions (Piper & Kwayumba, 2014). Critically, given that the majority of schools in Kenya are rural, PRIMR's ICT impact could be maintained at scale due to the relatively low cost of the TAC tutor tablet intervention.

In order to provide value for money, Kenya and other countries like it must undertake additional research to understand what conditions are necessary for successful ICT implementation. Some analysis about the durability of the hardware seems to favor more versatile handheld devices, such as tablets or smartphones, rather than personal computers. The trend away from personal desktop computers as an instructional support hardware yields the advantage of relatively lower cost and more compatibility with the daily activities of teachers and increased likelihood of the technology being used effectively. Even developed countries with high penetration of ICT in educational institutions are now moving away from the model of using ICT primarily in computer labs located far from classrooms. Location of equipment in a locked, gatekeeper-controlled lab some distance from the classroom, particularly the early primary classroom, is a deterrent to its use in the East African context, especially with large classes that are not easily or quickly relocated. Moreover, where computers are set aside for use only on special occasions, they remain viewed as objects of mystery, rather than as the enabling tools that they can be. The findings of PRIMR show that ICT can have a modest impact on learning in conditions where the use of ICT is embedded in a larger instructional reform model.

Creating a platform for sharing experiences and information on implemented initiatives, achievements, and lessons learned is an aspect that needs to be considered at a policy level. This would avoid unnecessary duplication and help large-scale initiatives to learn from both mistakes and successes of small-scale pilot projects. ICT integration in education could benefit from appropriate public-private partnerships between relevant stakeholders. The experiences of PRIMR in training teachers and dealing with issues of curriculum delivery and education reform indicate that this type of partnership presents the most successful models (Hawkins, 2002). Encouragingly, the MoEST is considering the PRIMR findings in its development of new initiatives, and the notion of using tablets to support instructional supervision has the potential for moving to national scale. A separate effort, the National Tablets Programme funded by the UK Department for International Development through June 2015, has used national-scale software and tablet hardware support to help all TAC tutors in the country better support teachers in improving instruction.

The Jubilee Coalition government manifesto, the NESP, and Vision 2030 explicitly state the need for integrating ICT into education. The PRIMR ICT study showed that ICT can have a notable, positive impact on learning outcomes in literacy, to the extent that it is integrated with an already effective instructional support program. Although the TAC tutor tablet program had the largest impact on the key variables, data suggests it was PRIMR's instructional approach augmenting the ICT, rather than ICT alone that was responsible for the improved outcomes. The TAC tutor tablet program was practically indistinguishable

from the basic PRIMR intervention without ICT. The integration of ICT is therefore not a panacea to instructional challenges but should be designed in ways that can support effective pedagogical improvement programs. In contrast, as mentioned in the literature review above, the current ICT de facto policy results in the teaching of computer science or information technology as discrete subjects both in secondary schools and in teacher training colleges, rather than embedding the use of ICT into larger reform processes.

The overall PRIMR study showed that a set of investments in teacher professional development, pupil reading materials, and ongoing instructional support could improve learning outcomes in Kenya (Piper et al., 2015). On the other hand, the embedded PRIMR ICT study showed that ICT investments did not improve learning outcomes significantly more than the basic education program. Without research to compare various ICT investments, a standalone study—for example, a study applying only one of the PRIMR ICT interventions—could have led policy makers to invest in ICT programming that, by itself, was not more effective than focused learning interventions.

The PRIMR ICT pilot study showed that ICT should be integrated with an instructional support program. There are many national ICT initiatives, such as the New Partnership for Africa's Development, Intel World Ahead, SchoolNET, One Laptop per Child, and Pan African Research Agenda, which span several countries across Africa but have yet to fully integrate ICT with instructional programs. We suggest that if such large ICT programs are not designed with a focus on effective educational reforms, it will be difficult for them to realize meaningful impacts on learning (see Ogutu, 2011). To fully integrate ICT, the policy in Kenya must address ICT as an instrument of teaching and learning rather than simply include ICT as an examined subject in the curriculum. Existing education approaches must be revised and rationalized to guarantee that the ICT education policy supports and is supported by corresponding education policies. Essential to this change is the design and implementation of high-quality professional development programs to ensure that educators are able to maximize the capacity of the technology to improve their classroom pedagogy.

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 hardware. The PRIMR team was struck by the length of time and amount of repetition needed to ensure that teachers and tutors successfully adopted the ICT components in classrooms. Any ICT integration program must consider the time needed to build the capacity of participants at all levels on the hardware, software, and implementation of instructional investments augmented by ICT. Training 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 (Piper & Kwayumba, 2014). These kinds of research-based capacity-building efforts could be a springboard for teacher education institutions and their leaders to develop pre-service teachers' competencies on embedding ICT in instructional improvement. The policy framework should be broad enough to provide space for research findings in capacity building for ICT integration.

Limitations

The ability of the research design to compare the impact of the three PRIMR ICT interventions with the base PRIMR program is lessened by the fact that the base PRIMR program was not included in the Kisumu County randomized controlled trial (Piper et al., 2015). Another limitation is the geographic coverage of the study. The results are externally valid to Kisumu County, but should not be generalized to Kenya at the national level or to other sub-Saharan African countries. However, the results identified in this study were quite similar to what was found in other counties in Kenya (Piper, Jepkemei, & Kibukho, 2015; Piper et al., 2015). Even so, policy makers utilizing the PRIMR evaluation

results should exercise caution in applying these results to other contexts, given the importance of context in determining the effectiveness of ICT programs.

Conclusion

The results of the PRIMR ICT study showed that the application of ICT at different levels of the education system did not change the impact of PRIMR noticeably (Piper & Kwayumba, 2014; Piper et al., 2015). What did vary was the cost-effectiveness of ICT. Providing the ICT at higher levels of the education system—that is, tablets for TAC tutors rather than for teachers or pupils—limits cost as well as targets the ICT on a more manageable instructional improvement problem. Kenya is already spending a very high proportion of its budget on education (MoEST, 2014), augmented by direct household expenditures on education as well as by development aid. Furthermore, while there has been some progress on developing appropriate education software in Kenya, most of the heavily used applications are still imported (Amutabi, 2012). Our research suggests that Kenyan policy makers must consider the cost of ICT options, their expected effectiveness, and their ability to directly target areas most likely to improve teaching and learning. We do not recommend that Kenyan policy makers ignore ICT and its ability to improve learning, but to make careful decisions about whether ICT should be best placed at the level of the student, of the teacher, or of those supporting teachers. In addition, we suggest that policy makers consider whether the outcomes they expect are improvements in learning or whether soft skills such as digital literacy or access to ICT should be measured alongside learning in the evaluation of ICT's effectiveness.

The PRIMR ICT results provide evidence as to the importance of embedding ICT interventions into broader instructional reform and providing policymakers with results. If policy makers were presented with evidence from any of the three ICT interventions that were effective on their own, the results would have suggested large-scale expansions of each of the three interventions. Instead, given that the intervention effects were not larger than a non-ICT base PRIMR program, policy makers in Kenya decided to scale up the instructional interventions with a light dosage of ICT. In the PRIMR program, ICT was more effective when it supported teachers to improve their instructional practice.

Further research should investigate whether cost-effective ICT program effects can be sustained at scale, and whether and how ICT can be effectively embedded in instructional reform. The National Tablets Programme is an opportunity to answer both of these questions within the context of the USAID Tusome Early Grade Reading Activity (2014–2018), which is a scale-up of the PRIMR instructional approach at a national level. This ICT research under PRIMR suggests that the success of the Kenya laptop initiative (or other similar projects) will depend largely on the integration of the initiative into the realities of classroom instruction, and, moreover, on the integration of ICT into the instructional reform required to improve learning outcomes in Kenya.

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