Background Paper

Information and Communications Technologies in Secondary Education in Sub-Saharan Africa

Policies, Practices, Trends, and Recommendations

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Secondary Education in Africa:

PREPARING YOUTH FOR THE FUTURE OF WORK

INFORMATION AND COMMUNICATIONS TECHNOLOGIES IN SECONDARY EDUCATION IN SUB-SAHARAN AFRICA

Policies, Practices, Trends, and Recommendations

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Information and Communications Technologies and Secondary Education in Sub-Saharan Africa: Policies, Practices, Trends and Recommendations

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Part I: ICTS and Secondary Education in Sub-Saharan Africa

A. About This Report

The following report discusses the use of Information Communications Technologies (ICTs) to improve access to, quality of, and delivery of secondary education within sub-Saharan Africa. It discusses the policy environment for ICTs in sub-Saharan Africa, their successes, challenges, and lessons learned, and it concludes with a broad and detailed set of recommendations for policy makers, donors, the private sector, designers, and implementers of ICTs in education programs. The report seeks to generally answer the question of how sub-Saharan African (SSA) governments can best use technology to improve access to secondary education, improve learning, strengthen management of schools and the education system, and foster innovation.

This report was commissioned by the MasterCard Foundation (MCF) in in July, 2018 to be completed by December 2018. It was funded by the Bill and Melinda Gates Foundation.

Before continuing, it is important to note what this study is and what it is not. It is a descriptive landscape review of technology use in sub-Saharan Africa at the secondary level—*where this exists in the sub-Saharan African context.* MCF asked researchers to examine 17 questions, including sub-questions (See Appendix 1), that focused on topics ranging from government investments in technology to the role of teacher unions to the types of technology used in secondary education for the research team to examine. The unit of focus was all countries in sub-Saharan Africa with a specific focus on four unique case study sites.

The landscape review is not an analytical study, though many sections may involve some degree of analysis.

B. Methodology

This report is primarily qualitative in nature, utilizing interviews, focus groups, a literature review, and observational data. Together these data collection methods allow for in-depth inquiry, individual and organizational perspectives, context-based analysis, and careful review of primary and secondary documents. All data presented here are empirical and evidence-based, drawn directly from interviews with stakeholders, observations, and published research.

The report consists of two broad sources of evidence and data. The first is a literature review, along with interviews of 121 key informants working in education in sub-Saharan Africa. The second consists of four case studies developed over visits to South Africa, Mauritius, Botswana, and Cape Verde. The methodology for each is described below.

1. Literature Review

The methodology employed was a systematic literature review approach. It began with a main research question: *How can SSA governments best use technology to improve access to secondary education, improve learning, strengthen management of schools and the education system, and foster innovation?* As mentioned previously, an additional 17 subtopics that were identified by the MasterCard Foundation guided responses to this question.

The research team conducted an extensive literature review of (primarily) English, Portuguese, and French-language research on ICTs in education in sub-Saharan Africa. Researchers accessed available research on ICTs in sub-Saharan Africa at the secondary level, as well as "gray literature"—organizational and government reports, policy documents, and websites, culminating in a synthesis of available evidence.

As part of the literature review, researchers also interviewed 15 ICT in education specialists all of whom work in some capacity in sub-Saharan Africa (See Appendix 2). Interviews were transcribed and returned to interviewees so they could authenticate the veracity and accuracy of each transcript. These transcripts form the basis of much of the broader, non-case study specific, information in this report.

2. Case Studies

A major component of this qualitative approach is a multi-case study approach. A case study is a detailed examination of a "case"—a setting, subject, event, or a bounded system involving detailed, in-depth data collection involving multiple sources of information (Creswell, 2007). Case studies are holistic and involve purposive sampling, which aims to provide insights about the phenomenon being studied, not empirical generalizations from a sample to a population as is the case with random samples (Patton, 2002).

The four cases (countries)—South Africa, Mauritius, Botswana and Cape Verde—were selected for numerous reasons. First, within the sub-Saharan Africa context, many countries lack a developed secondary education sector and the funding, finance and resources to support ICT infrastructure and equipment, thus were not suitable sites for a study on ICT in the secondary education system.

Second, concurrent with this study, the MasterCard Foundation was undertaking a number of other studies that focused on Rwanda, Kenya and Tanzania, three countries with large populations, developed secondary education systems, and robust ICT in education efforts. This situation, combined with the above-mentioned constraint, narrowed the pool of prospective country case study sites.

Third, the four case sites conform to the MasterCard Foundation's desire to explore the use of ICT in secondary systems in countries that do not normally receive a good deal of attention in this area, particularly Lusophone Africa. This multiple-case approach of four geographically, linguistically, and economically distinct countries provides a diverse prism that allows researchers to do multiple comparisons. This contributes to understanding what, if any, contextual differences exist between countries and their policies, practices, and programs regarding educational technology.

Fourth, government officials and policy makers in the four countries responded affirmatively to research requests. Researchers contacted a number of other potential country sites but these Ministries of Education did not respond to such solicitations. Given the compressed timeline of the study, researchers moved ahead with case study sites that expressed a willingness to be part of the study.

Finally, and most important, South Africa, Mauritius, Botswana and Cape Verde all have fully developed secondary education systems and long-term, documented efforts to integrate ICTs within the secondary system in order to improve access to, quality of, and delivery of education. These four countries have furthermore achieved more than 80% enrollment in lower secondary schools (Bashir et al 2018). Further, these four countries were ranked 1, 3, 4 and 5, respectively, within Africa by the ICT Development Index (IDI), a composite index that measures countries on 11 indicators (ITU, 2017). Thus, their ICT environments are considered sufficiently developed, within an African context, to warrant further examination.

2A. Data Collection: Case Studies

Case study data collection involved initial exploratory phone calls, email communications, and document review to identify potential cases.

Once identified, case study research was conducted via further document review, classroom and teacher professional development observations and site visits, and interviews with 105 Ministries of Education, secondary schools, universities, advocacy groups, foundations, provincial heads of government, and departments of education (in the case of South Africa) (See Annex 1).

As Appendix 1 shows, there were 17 interview questions based on the topics about which MCF requested information. Thus, interviews took some time—between 1 and 2 hours. All interview data were transcribed and sent to interviewees for a final data check and verification of information.[1]

2B. Data Analysis: Case Studies

All qualitative data—interview transcripts and field notes—were entered into the qualitative research program *NVivo* and coded. In qualitative research, a code is a “word or short phrase that symbolically assigns a summative, salient, essence-capturing attribute to a portion of language-based data” (Saldaña, 2015, p.3). Since the MasterCard Foundation had previously identified

[1] Though not all interviewees took advantage of this, the majority did.

specific research topics and questions of interest, researchers utilized a deductive coding frame with a pre-developed set of codes based on these previously identified topics. When new themes or issues emerged within the coding process, researchers carried out “in-vivo” coding.

The analytical approach utilized for this report thus moved through the following process. The first was *coding*—naming constructs or key terms within the narratives. The author coded the number of instances within an interview. For example, if an interviewee spoke about the need for teacher professional development, his/her statement was coded as one instance. If later in the interview, as part of another question, he/she again noted the importance of teacher professional development, this was again coded as a second instance. This coding of instances allowed for the surfacing of major themes and/or needs that were then prioritized and ranked and used to inform the “Recommendations” section of this report. Following coding, the author eliminated and condensed redundant codes and split more general codes into more specific ones.

Collating codes based on a set of commonalities allowed for translating/identifying these codes as a larger *concept.* These concepts were further collated, based on commonalities, to create *categories. Categories* were further organized into a set of larger ideas to generate a *theory*—essentially an explanation of ideas or statements. Because so much of the data in this report is primary-source (that is, in the very words of participants themselves), this process relied less on author interpretation and more on utilizing the words and reactions of participants themselves.

3. Limitations of This Study

As with any document, this study suffers from a number of limitations. First, time and budget constraints made for a condensed research window and the study was carried out in less than six months.

Second, as mentioned previously, the potential pool of case study site candidates was constrained by the lack of secondary education sector and ICT infrastructure and by MCF studies on other potential case study sites.

Third, the timeline for the study and case study visits to South Africa and Botswana coincided with national examination preparation for the National Qualifications Framework exam in South Africa and the General Certificate of Secondary Education (GCSE) in Botswana, thus making students and teachers unavailable for interviews. Since many of the classes observed by researchers were focused on examination preparation, those observations may not fully capture the diversity of instructional methods that would be normally deployed at other points of the academic year.

Fourth, the array of questions, combined with a short study timeline, made answering all questions difficult. For example, researchers were unable to make contact with teacher union representatives. Similarly, government officials and private sector representatives were often unable or unwilling to answer questions around finance. Thus, it was not always possible to find answers to all of the questions in Appendix 1.

Fifth, the government approval process for research permits and granting interviews did not coincide with the study timeline of six months. Thus, in the case of South Africa, there is an over-representation on nongovernmental ICT in education stakeholders and much less on relevant stakeholders in the Department of Basic Education. On the other hand, in Botswana and Cape Verde, given the absence of a large, diverse private sector, there is an over-representation of government ICT in education stakeholders.

Sixth, all case study school and classroom visits and interviews with government officials were arranged by governments in each case study site (The same is not true for private sector company visits). Given this, it is not clear whether these classrooms were representative of all schools and classrooms or exemplars.

Finally, ICT in sub-Sahara Africa in general, and in the secondary education context in particular, suffers from a dearth of research. The research team attempted as much as possible to adhere to baseline criteria for rigor in quantitative and qualitative research (e.g., peer-reviewed studies; non-peer reviewed studies consulted had to meet certain standards, including clear research questions, sufficient data to answer questions and make reasonable inferences, transparent and adequate statistical or qualitative coding scheme, and warranted conclusions). However, it was often difficult to find rigorous high-quality research with substantial coverage of the sub-Saharan Africa context.

The remaining sections of this report focus on the policy environment, implementation of ICT in secondary education contexts, trends, and recommendations for ICT in secondary education in sub-Saharan Africa.

Part II: Policy Environment

A. Secondary Education

Secondary education enrollment rates and completion in African countries are a threat to meeting the Sustainable Development Goals and competing in a highly globalized world. While progress has been made since the year 2000 in secondary education completion, significant problems remain in the sub-Saharan Africa secondary education sector (GEM 2016). The key problem, according to data from the UNESCO Institute for Statistics, is the secondary education dropout rate. In sub-Saharan Africa, at least 50% of adolescents aged 15–17 are not in school. While countries such as Madagascar, Ethiopia, and Tanzania have made progress in lower secondary schools, others, like Malawi, Uganda, and Zimbabwe still struggle to make progress at the lower secondary school level (GEM 2016).

Major inequalities in secondary school enrollment and access are attributed to geography, poverty and gender. Many secondary-school-age adolescents live in poverty in rural areas, and many girls never receive a basic primary-school education. Child marriage and adolescent pregnancy are leading cause for girls to abandon secondary education prematurely in Africa and nations like Sierra Leone and Tanzania make it difficult for pregnant girls to stay in school (Woodon et al., 2017). Conflicts in a number of sub-Saharan countries deprive millions of students of basic and secondary education. In a number of sub-Saharan African countries, compulsory education is less than six years, as compared to nine years of compulsory education in more successful countries. The biggest challenge in many sub-Saharan countries is access and outreach, yet some countries are not even able to meet the educational needs of those who are relatively easy to reach (GEM, 2016).

Secondary education systems in sub-Saharan Africa suffer from a lack of qualified teachers. This is due to conflicts, a “brain drain” caused by poor working conditions, low pay, a lack of professional development, and other pressing issues like AIDS and famine (Educational International, 2018; Appleton et al., 2006). It is clear that approaches that focus mainly on brick-and-mortar institutional models for teacher training will not be sufficient and effective to address the lack of qualified teachers in sub-Saharan Africa.

Teaching practices in sub-Saharan Africa are highly traditional and many who are teaching have not been prepared in either their content area or in pedagogy. According to Bashir et al. (2018), most teachers in sub-Saharan Africa receive no continuous professional development or support. Other issues related to secondary education and teachers in sub-Saharan Africa are linked to teacher deployment across countries, teacher-to-student ratios, teacher management, and the need for specialized teachers in secondary education. Kenya, Mauritius, and Zimbabwe are countries that have achieved consistency in teacher deployment in secondary schools.

Primary and secondary education systems in sub-Saharan Africa generally suffer from a lack of financing at all levels, from teaching to infrastructure, which adversely affects educational quality. In general, more public funds are allocated to primary education systems versus secondary and tertiary level by governments in sub-Saharan Africa. Most educational expenditures go toward teacher salaries. For example, in 2013, Ghana and Zambia spent, respectively, 97% and 89% of their gross education budget on teacher salaries (Darvas & Balwanz, 2014). According to World Bank (2015), in Zambia only 0.2 % was allocated for textbooks. An issue in sub-Saharan Africa is poor planning and implementation of budgetary measures, especially non-salary spending measures and capital expenditures. Most low-income countries in the region rely heavily on donors to finance textbooks, teacher training, and grants to schools; this overdependence raises serious concerns of sustainability when aid is stopped (Bashir et al., 2018).

National examinations are still a problematic component of the secondary education system. Secondary education enrollment is increasing across sub-Saharan Africa but its examination focus creates bottlenecks and barriers in terms of access to secondary school and student development within the secondary system. National examinations often present an opportunity cost for preparing students for the world of work. For example, in the classrooms visited for this study in South Africa and Botswana, none focused on helping students develop work-readiness skills. Instead, students prepared for examinations. This is true where high-stakes examination systems, like the Cambridge examinations and the Baccalaureate, prevail.

In Mauritius, for example, despite doing well in terms of primary and secondary educational enrollment, policy makers realized that national examinations (apart from producing inequalities) also hinder the emotional and psychological development of children. Thus Mauritius shifted to the nine-year basic schooling system with a focus on soft skills development and continuous assessment.[2]

Eliminating certain types of examinations or making them less rigorous has also created problems. By 1987, Botswana had eliminated the lower-secondary-school entrance examinations that were given at the end of primary school; this quickly led to an increased enrollment in lower secondary school, from 50% to 90% by 1994 and pressure on resources (Bashir et al., 2018). South Africa has continued to lower the passing "cut scores" for its "Matric" with the result that many students graduate from secondary school and enter university with limited literacy and numeracy skills.

Curricula in African countries are outdated and deemed inefficient for the developmental needs of Africa. In the past two decades, there have been ambitious curriculum "big idea" reforms efforts in sub-Saharan African countries such as South Africa, Rwanda and Kenya. Fleisch at al. (2019) define these "big idea" curricula reforms as competency-based curriculum, competence-based pedagogy, outcome-based education, learner-centered education, a focus on work readiness and 21st century skills (p. x). Specific country enactments of such curricula include South Africa's effort to introduced outcome-based education in 1998 and Kenya's 2016 competency-based curriculum

[2] Education and Training in Mauritius–Human Resource Development Council. See http://www.hrdc.mu

reforms. However, many of the "big idea" reforms have limited impact on teaching and learning (Fleisch et al. 2019, pp. vii, x).

The reality remains that those who finish school in many sub-Saharan African countries are ill prepared for the world of work, further learning, and skills acquisition. Curriculum reform is an important element for a successful transition to secondary education in sub-Saharan Africa (World Bank, 2008).

ICTs and educational technologies can play an important role in addressing some of these pressing issues and challenges faced in sub-Saharan Africa. With the right policies and implementation, policy makers and governments can leverage the potential of ICTs to address some of the more vexing issues facing secondary education. These include issues surrounding access to education, curriculum reform, improvement of the quality of teaching and learning, achievement of learning outcomes, capacity building and teacher training, and reducing inequality in the girls' education.

In terms of the latter, two externally funded programs have attempted to help girls and young women in Africa benefit academically and vocationally from the potential of the digital transformation.

The first, the Girls' Education Challenge, funded by the UK Department for International Development (DFID), aims to improve the education of marginalized girls in part through access to ICTs. Girls' caregivers reported that the quality of teaching, teaching materials and learning aids improved and that ICT equipment created a more interesting environment for teaching and learning, which improved teachers' confidence and the teaching and learning process overall. However, data reporting also found that teachers and schools faced serious practical challenges, which limited the usefulness of the equipment and the learning content, making them less effective (Coffey International, n.d., p.1).

The second, #eSkills4Girls, an initiative started under the German G20[3] presidency, attempts to tackle the existing gender digital divide in low-income and developing countries. Launched at the annual G20 summit in Hamburg in 2017, the Heads of State and Government of the G20 member states agreed to take action to close the gender digital divide. The initiative has promoted such activities as #eSkills4Girls Hackathon, Code Week, and #eSkills4Girls meet ups in Kigali and Accra.[4]

Technology has the potential to provide education to students in conflict and crisis settings: Conflicts across much of sub-Saharan Africa have prevented many secondary age students from attending school. For example, UNICEF (2017) estimates that 68%, 60% and 55% of lower-secondary age students in Niger, South Sudan and the Central African Republic are out of school as a result of conflict in these countries. In Niger, an estimated 75% of lower-secondary age girls do not attend school (UNICEF, 2017). While it cannot replace a functioning educational system,

[3] The G20 (or Group of Twenty) is an international forum for the governments and central bank governors from 19 countries and the European Union

[4] For more information, see https://www.eskills4girls.org/

technology is increasingly being utilized to provide educational opportunities to these youth and their teachers.

Most of these initiatives are driven by humanitarian organizations or donors. For instance, WarChild Holland's *Can't Wait to Learn Sudan* project (to be discussed later in this report) delivers the Sudan mathematics curriculum to out-of-school children through a self-paced, interactive, tablet-based program that children access in community spaces (Dahya, 2016). In Burundi, Ideas Box, in partnership with the United Nations High Commission on Refugees and the International Rescue Committee, uses tablets, e-readers, the Internet, and a generator to provide educational opportunities to 4000 Congolese refugees in Burundi's Kavumu and Musasa camps (Dahya, 2016; Libraries without Borders, n.d.[5]). In the Dadaab refugee camp, in northern Kenya, InZone, the Center for Interpreting in Conflict Zones at the University of Geneva, offers Massively Open Online Courses (MOOCs) for Somali refugees, including "Foundations of Teaching and Learning" for current and prospective teachers.[6]

B. Technology in Education: Policy Environment

> *You have to have a very strong management imperative of what the future looks like.*
>
> Paul Mayers, Associate Principal of Innovation in Learning and Teaching, Parklands School, Cape Town, South Africa

Most sub-Saharan African countries have some kind of Information and Communications Technology (ICT) plan or policy. For the most part, such plans or policies are driven by imperatives for social and economic development, or digital inclusion, that are often tied to "national vision" policies. For example, Kenya's key policy documents guiding the ICT and Science, Technology and Innovation (STI) sector[7] all focus on achieving its Vision 2030 objectives (IST Africa, 2016).

South Africa's National Development Plan 2030 aims to utilize ICTs to build a more inclusive society in order to eliminate poverty and reduce inequality, stating that "by 2030, ICT will underpin the development of a dynamic and connected information society and a vibrant knowledge economy that is more inclusive and prosperous." (Department of Telecommunications and Postal Services Republic of South Africa, 2016, p. 9).

Mauritius's National Development Plan 2013–2017 aims to support entrepreneurship as a foundation for sustainable development. In this context, the government took measures to promote private investment, the development of micro-, small-, and medium-sized enterprises, and

[5] For more information, see https://www.librarieswithoutborders.org/countries/
[6] For more information, see http://www.unige.ch/inzone/who-we-are/
[7] These are Kenya ICT Policy 2006 (under review), eGovernment Strategy, Kenya ICT National Master Plan 2017, the National Broadband Strategy and Kenya Science, Technology and Innovation (STI) Policy 2012.

entrepreneurship. Botswana's *Maitlamo*, the National Policy for ICT Development, was approved in 2007 to "position Botswana for sustained growth in the digital age by serving as a key catalyst in achieving social, economic, political and cultural transformation within the country" (Government of Botswana, 2007, p. 1).

Many African countries have complementary or supplementary plans or policies that support ICTs in education. For example, Benin, Botswana, Burundi, Cameroon, Cape Verde, Central Africa Republic, Comoros, Côte d'Ivoire, Djibouti, DRC Congo, Gambia, Ghana, Guinea, Lesotho, Madagascar, and South Africa have national broadband policies (Broadband Commission for Sustainable Development, 2018). In Mauritius, the National Broadband Policy 2012–2020 emphasizes the importance of ensuring that all three educational levels in Mauritius (primary, secondary, and tertiary) have adequate access to broadband facilities to enable teaching and learning.

Of the 48 sub-Saharan African countries that have a national ICT policy in place, 39 have education sector ICT policies and implementation plans, in one form or another.[8] Figure 1 outlines these countries:

Figure 1: Countries in sub-Saharan Africa and policies on ICT in education. (UIS Statistical Database, 2015)

<table>
<tr><th>Country has a policy on ICT in education</th><th>Only for upper secondary education</th><th>No ICT in education policy</th><th>No information</th></tr>
<tr><td>Angola, Botswana, Côte d'Ivoire, Eritrea, Gambia, Mauritius, Rwanda, São Tomé and Principe, South Africa[9], Uganda, and Zambia</td><td>Ethiopia, Djibouti, and Togo</td><td rowspan="3">Cameroon, Comoros, Congo, Guinea, Lesotho and Madagascar</td><td rowspan="3">Benin, Burundi, Central African Republic, Chad, Equatorial Guinea, Gabon, Guinea Bissau, Malawi, Mali, Namibia, Nigeria, Senegal, Sierra Leone, Somalia, Swaziland, United Republic of Tanzania, and Zimbabwe</td></tr>
<tr><th colspan="2">Country has a national plan for ICT in education</th></tr>
<tr><td colspan="2">Burkina Faso, Côte d'Ivoire, Gambia, Kenya, Liberia, Mozambique, Niger, São Tomé and Principe, Uganda, and Zambia</td></tr>
</table>

The quality and coherence of national educational technology plans varies widely because the policy environment and educational reality across countries varies widely. Many sub-Saharan African countries are still focused on getting students into and out of primary school in order to meet the Universal Primary Enrollment goals of the Millennium Development Goals (MDG) and Education for All (EFA); therefore, the secondary sector is undeveloped and has not yet become a

[8] The figure of 48 sub-Saharan African countries comes from the World Bank. See https://data.worldbank.org/region/sub-saharan-africa

[9] In South Africa, ICT in schools technically falls under a provincial mandate so each province has its own plan. However, *Education White Paper 7 focuses on* the use of ICT to accelerate the achievement of national education goals and the Department of Basic Education's five year strategic plan features ICT as an important component.

focus of national efforts. Many African countries, such as Sudan and Burundi, have a strong interest in integrating ICTs into the formal and informal education sectors, but have a nascent policy environment (Radford, personal communication, October 15, 2018).

Like national ICT policies themselves, the foci of these national ICTs in education, though broadly similar, vary greatly in ambition and scope. For instance, Ghana's ICT in education policy focuses on education management, capacity building, infrastructure, e-readiness, and access. It includes ICTs for curricula, content development, technical support and maintenance, and monitoring and evaluation. The educational strategy ICT of Mauritius (launched in January 2018) encompasses the pre-primary, primary, secondary, and tertiary education subsectors. It focuses on infrastructure and connectivity, enhanced teaching/learning, pedagogical content development, education management, capacity building, and professional development (GOVMU, 2018). As Figure 2 notes, South Africa has a number of ICTs for education-related policies that focus on skills, training, teacher professional development, intersectoral engagement, opening learning, and open education resources.

Figure 2: Supporting policies for ICT in education. (Janet Thomson, SchoolNet South Africa)

Policy	Date
The National Curriculum Framework for children birth to four years	2018
Professional Development Framework for Digital Learning	2017
Policy on the minimum requirements for qualifications for ECD educators	2017
Revised policy on the minimum requirements for teacher education qualifications	2015
Action Plan to 2019: Towards the Realization of Schooling	2015
National Strategy for Learner Attainment	2015
Operation Phakisa: ICT in Education	2015
The National Development Plan: A vision for 2030	2012
Integrated Strategic Planning Framework for Teacher Education and Development	2011
The National Qualifications Framework	2008
Guidelines for Teacher Training and professional development in ICT	2007
e-Education White Paper: Transforming Learning and Teaching through ICTs	2004

Sub-Saharan African policy makers are very open toward ICTs for education. All interview data suggest that national and provincial governments are receptive toward and enthusiastic about ICTs in education. This openness results from the confluence of a number of beliefs—a belief that ICT can improve educational quality; that it can serve, in the words of one donor, as "a magic formula" to remedy shortcomings of an education system; that technology represents modernity and progress; and a recognition that that digital literacy and ICT skills are important for youth employment and for higher education. This openness may not necessarily translate into deep understanding of the benefits and drawbacks of educational technology.

ICTs have a powerful political appeal for many politicians, since the physical presence of tablets in schools or computer labs ostensibly signifies a tangible and visual demonstration that a government (or a certain political party) is, in the words of one government official interviewed for this study, "doing something" for youth.

There are numerous organizations driving and influencing ICTs in education. ICTs in education policies are often directly or indirectly influenced and supported by numerous stakeholders. Stakeholders may include the following:

- Private sector companies: Huawei, Microsoft, Intel
- Government-owned or private sector telecommunications companies: Mascom, Orange, MTN
- State or provincial governments: Gauteng and Western Cape provinces in South Africa or Edo State in Nigeria
- National government or ministries: the President of Kenya; ministries of telecommunications
- National research networks: MAREN,[10] TENET,[11] KENET[12]
- International donor community: UNECA,[13] USAID,[14] UNDP,[15] AfDB,[16] IDRC[17]
- Faith-based networks: Catholic schools; Adventist church schools; Strathmore University
- Research and development organizations: Council for Scientific and Industrial Research (CSIR) in South Africa
- Development and humanitarian non-governmental organizations: UNESCO, WarChild NL, International Rescue Committee
- Low-cost and high-cost private schools: SPARK in South Africa; Bridge Academies in Kenya, Liberia, Uganda, and Nigeria
- Technology hubs: (iHub in Kenya or Injini in South Africa

[10] Malawi's Research and Education Network
[11] Tanzania's Research and Education Network
[12] Kenya's Education Network (KENET) is the National Research and Education Network (NREN) of Kenya
[13] United Nations Economic Commission for Africa

[14] United States Agency for International Development
[15] United Nations Development Program
[16] African Development Bank
[17] International Development Research Centre

Box 1. South Africa's infrastructure environment

South Africa enjoys a robust ICT environment. As of 2013, South Africa was served by five submarine communication cables, SAT-2, SAT-3/WASC/SAFE, SEACOM, EASSy,and WACS. Another five cables, Main One, SAex, ACE, BRICS, and WASACE, have been proposed or are under construction. The national backbone and backhaul networks are relatively well extended across the country by the Telkom, MTN, Vodacom and other network providers. The Independent Communications Authority of South Africa is an independent regulatory body that regulated the telecommunications sector. South Africa's mobile and fixed broadband markets are mature and competitive, resulting in a continuous drop in subscription prices and the fastest Internet speeds in sub-Saharan Africa. The South African National Research and Education Network (SANReN) provides dedicated bandwidth capacity to more than 100 university campuses, research institutes, museums and scientific organizations in South Africa to facilitate collaborative research with academics and scientists across Africa and across the globe.

Telecommunications is one of the fastest growing sectors of South Africa's economy, driven by explosive growth in mobile telephony and broadband connectivity. With a network that is 99.9% digital and includes the latest in fixed-line, wireless, and satellite communication, the country has the best developed and most modern telecoms network in Africa. As of 2015, 52% of South Africans were Internet users, the highest in sub-Saharan Africa.

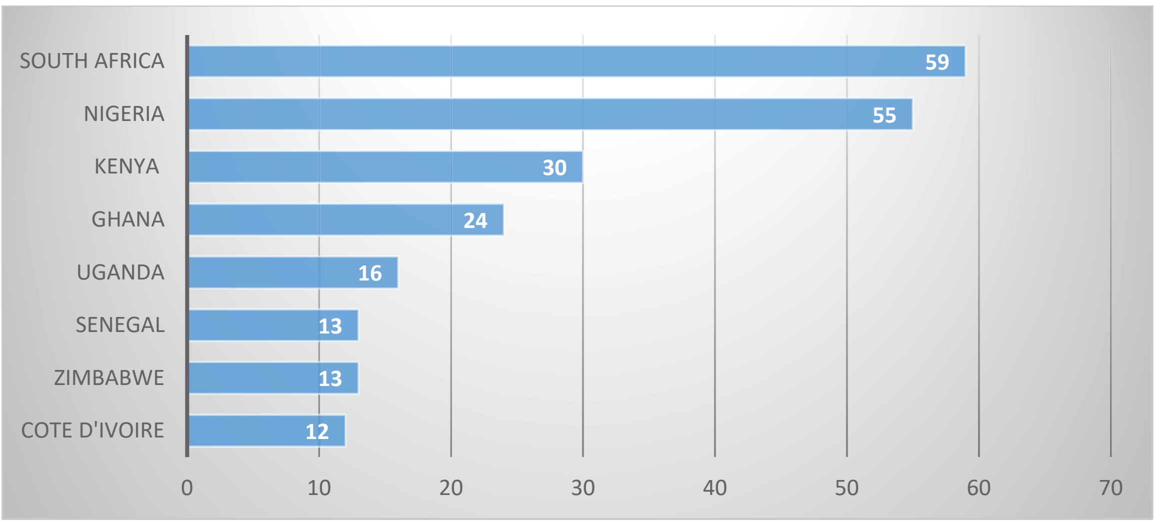
Sources: GESCI, 2017; ITU (2017), Wikipedia (n.d.), IT Web (2018)

Not surprisingly for a country with such a large population and economy, South Africa enjoys a constellation of actors who both drive and participate in education efforts. These include:

- **Government ministries:** Department of Basic Education (DBE), the Department of Posts and Telecommunications, the Department of Higher Education and Training (DHET), the Department of Science and Technology (DST)
- **Telecommunications:** Telkom, Vodacom, MTN
- **Provinces:** Western Cape province, Gauteng province
- **University partners and stakeholders:** University of Cape Town, University of Witwatersrand, University of Fort Hare, Stellenbosch University
- **National organizations:** Council for Scientific and Industrial Research (CSIR), National Advisory Council on Innovation (NACI), National Research Foundation (NSF), Technology Innovation Agency (TIA) (GESCI, 2017)

However, in many sub-Saharan countries, the government is still the primary driver of ICTs in education. Given the small private sectors and limited private school networks of many sub-Saharan African nations, national governments are often still the main drivers of ICTs in secondary education. This is certainly the case, for example, in Botswana and Cape Verde, where the government drives the demand for ICTs in education. However, in addition to promoting the supply and demand of ICTs to secondary schools via direct financing, many governments are using policy to diversify supply and demand for technology in schools. They are doing this by developing public-private partnerships, partnerships with donors, or creating their own "innovation hubs" or technology incubators, which, as Figure 3 notes, have dramatically increased in number across several African countries.[18]

Figure 3: Sub-Saharan African countries leading in number of technology hubs. (Atlas, 2018)



As a case in point, the Government of Botswana launched the Botswana Innovation Hub (BIH) in 2008 along with development of Botswana's ICT infrastructure and Botswana Excellence Strategy to support economic diversification, job creation, and the transition to a knowledge economy. BIH was developed to inspire and assist start-ups, provide an enabling environment for technology investors, and manage Botswana's first Science and Technology Park (Botswana National Commission for UNESCO, 2016). BIH's success in such endeavors has been limited because it is underfunded (Chilisa, personal communication, November 22, 2018).

In Cape Verde, the Ministers Council developed the Núcleo Operacional para a Sociedade de Informação *(*NOSI) in 2003 to become the operational unit of the inter-ministerial commission for an "Innovation and Information Society," chaired by the Prime Minister of Cape Verde. NOSI developed the State Technology Private Network (RTPE), a technological platform that hosts the Internet and electronic mail, government databases for all government entities, and all data for all Cape Verdean public institutions, including the country's 454 schools. NOSI also provides training, technical assistance, management information, and support to all Cape Verdean public institutions.

[18] It is important to clarify that many technology hubs are privately, not publicly, created.

The government of Cape Verde is in the process of connecting a technology park with NOSI as the anchor, and at this point, only, tenant. In 2014, NOSI became a corporate public entity and now operates as a quasi-private agency. NOSI has developed a number of private partnerships and educational technology programs, including the WebLab program, which will be discussed in the next section of this report.

The absence or presence of an ICT in Education policy, *per se*, is not necessarily correlated to ICT in secondary education programs. Even without an official ICT in education policy, many countries have moved ahead on ICT in education initiatives at the secondary level. For instance, Cape Verde launched a national ICT in education initiative, Mundu Novo (2009), which provided computers, Internet, and teacher training at all Cape Verdean schools. Botswana launched the online content repository Thutonet and placed computers, tablets, and Internet access in all secondary schools. Though South Africa does not have an official ICT in education policy, it has numerous cross-sectoral and mutually supportive policies across several public entities and agencies that are focused on ICTs in education, as well as a national commission to advise on ICT development in the country (Souter et al., 2014, p. 9).

In contrast, though ICT in education is a component of Guinea-Bissau's national education sector plan, technology and the Internet, apart from a few private religious schools in Bissau, is nonexistent (Barreto and Santos, personal communication, 2018) though the Government of Portugal did provide ICT-related assistance in the early 2000s. Similarly, the government of the Democratic Republic of Congo (DRC) has a national education policy advocating the use of ICTs in education (Kapena, September 30, personal communication, 2018) but at this point in time, based on interviews with DFID and the Ministry of Education in Congo, there appear to be no government ICT in education initiatives.

ICT in secondary education initiatives are funded by a number of different actors. Although the average public expenditure on education as a percentage of GDP increased from 4.2% to 4.9% between 2000 and 2012 in sub-Saharan Africa (UNECA, 2015), for most low-income sub-Saharan African countries, an ICT for education is simply a luxury they cannot afford. Where technology exists in low-income sub-Saharan Africa, it may be refurbished/donated equipment, used in private schools, or donor funded (Otto, Bloome, & Trucano, personal communications, September 4 and October 11, 2018). There are some exceptions to this. For instance, the JP Group, a Portuguese-based hardware manufacturer, who is a major partner in Kenya's *DigiSchools* laptop program, has plans to move production of all of its laptops for the program to Kenya and Rwanda is engaging in the domestic manufacture of laptops (Castilho, personal communication, November 7, 2018).

In Mauritius, the government began to adopt ICT in schools during the mid-1990s, based on the implementation of computer labs in secondary schools. A public investment program was put in place with the goal of having all primary schools equipped with computer rooms and all secondary schools with computer labs. Successive governments maintained the momentum within an evolving and adaptable policy environment for ICTs, as per the table below. The government education budget of Mauritius in 2017 was 5.082% of the country's GDP as per World Bank figures. Forty-one percent of the education budget is dedicated to public secondary education funding, including the private secondary schools receiving government grants. As Figure 4 below denotes, since the 1990s, there has been a shift in the policy with respect to the development of ICTs in education, with more government openness toward public-private partnerships and government-to-government initiatives.

Figure 4: ICT initiatives in Mauritius since the 1990s.

Year	Actions/policies
1990s	Building of ICT infrastructure
2000–2010	Consolidation of ICT infrastructure and computer equipment through school IT projects
2012–2016	Digital learning initiatives at the national level under public-private partnerships (World Bank, Commonwealth of Learning, Sankore, Microsoft, etc.)
2018	The development of ICT in education strategy

Middle-income countries, like Botswana, South Africa, Mauritius, and Cape Verde, attempt to fund the majority of their own ICT in education efforts with varying degrees of support and success. In Botswana, for example, the government finances educational technology but amounts are often limited. Schools submit a budget through a regional office, and all budgets are consolidated within each ministry. Each minister requests recurrent and capital funds from the government. While the Ministry of Education and Basic Skills (MEBS) gets the largest share of the government's budget, its largest outlay is in teacher salaries, so it is left with little surplus funding (Motlotle, September 18, personal communication, 2018). The MEBS allocates a set amount of funding to each school in Botswana. Government schools have no budget for technology repair and maintenance, since student fees (which are often prorated or eliminated based on family income) are typically used for other needs.

The Ministry of Education and Basic Skills is open to partnerships and has a number of public-private partnerships with Microsoft, Intel, Orange, MASCOM, and Dimensions Data to provide training, materials, and Internet access to secondary schools across Botswana. The Government of Botswana also has partnerships with the Government of South Korea to provide 50 tablets to a number of secondary schools, along with school-based Korean interns, who help teachers and students with technology.

In Cape Verde, the Ministry of Education and Sports (MES) also receives a set amount of funds, based on national revenue, from the national budget. In turn, it distributes a portion of funding to each *delegação* (delegation or region) which in turn distributes funding to each school. Like schools in Botswana, Cape Verdean government schools have no budget for technology repair or maintenance, nor do *delegações* provide technology repair, maintenance or support (Andrade, personal communication, November 22, 2018).

Despite its small economy, Cape Verde has embarked upon the development of a strategic plan for ICTs in education as part of an overall education reform program. It has provided 4000 Samsung tablets for students at a cost of approximately 280,000 Euros (Marques, personal communication, November 19, 2018). The Government of Cape Verde has undertaken financing for this effort as well as school connectivity (Delgado, personal communication, November 19, 2018) but is leveraging this funding with United Nations and World Bank financing for more equipment and technology in schools. Like Botswana, the Government of Cape Verde receives education funding via bilateral aid (from the Governments of Portugal and Luxembourg) and support for the construction of its telecommunication infrastructure from international private-sector partners like the Huawei Corporation. The Cape Verdean government also participates in public partnerships with Cabo Verde Telecom. Cape Verde Telecom and EllaLink have entered an agreement to begin the implementation of the EllaLink submarine cable system from Brazil to Cape Verde and onto the European mainland. This submarine cable system is expected to be operational by 2020 (Tobor, 2018).

In South Africa, money from the national budget allocation funds government departments such as the Department of Basic Education (DBE), while money from the provincial allocation funds the Provincial Departments of Education (PDEs). Funding for educational technology comes from a central national budget and is disbursed to provinces on a per pupil basis so that provinces can carry out national policy priorities. Schools have no budgets for technology per se, but they often use money from the Learning and Teaching Supplementary Materials (LTSM) fund—one of the largest education budget items—to cover the cost of printer ink, paper, and other recurrent technology-related expenses. District offices within provinces take care of technology repair, and South African secondary schools that have technology generally have an on-site technology support person or administrator (Mabena and Kikine, personal communication, September 10, 2018).

While South Africa has limited bilateral donor support from global aid agencies, it has numerous partnerships with the private sector. Essentially, if businesses want to do business with government or to increase their Broad Based Black Economic Empowerment (BBBEE) rating, they can give 6–10% of their profits to social investment schemes, which qualify as Corporate Social Investment (CSI). There are multiple aggregators of this CSI, including (but not limited to) the National Education Collaboration Trust (NECT), the Kagiso Shanduka Trust, and the Tshikululu Trust, which partner with businesses, not-for-profit (NPO) organizations, private sector organizations, and others to promote innovation around systemic change like ICTs for education and post-industrial education (Varady, personal communication, September 11, 2018).

To avoid corruption, South Africa and Mauritius have very stringent procurement rules that make innovation difficult. While a number of technology companies are often invited to present their solutions to the government in Mauritius, in terms of procurement, they have to abide by the Procurement Act and tendering procedures. As a result, companies are often reluctant to spend time and effort and disclose the potential of their technologies, considering the real risk of not being awarded a contract (or for other business-related reasons).

Procurement rules in South Africa require, for example, that a provincial education department (PDE) know exactly what it needs before issuing a call for tenders. Because technology evolves so rapidly, this makes the tendering process difficult. Procurements must be extremely specific, and it is difficult to promote innovation within the education system because ill-defined or exploratory ideas testing or proof-of-concepts cannot get through the procurement system (Schäfer, Walker, Schreuder, & Zille, personal communication, September 17, 2018).

The uneven policy environment and uneven funding to support ICT in education policy initiatives often results in uneven implementation across the across the continent. The policy environment around ICTs in secondary education in many sub-Saharan African countries is uneven, not fully developed, and often lacks linkages to other sectors. This results in a number of implementation challenges. Even South Africa, noted for innovative, comprehensive, and coherent policies, struggles with uneven implementation of ICT in secondary schools. In Mauritius there is the difficulty of maintaining an equilibrium between public government schools and government-funded private secondary schools. Patterns, successes, and failures of implementation are the focus of the next section of this report.

Part III: Implementation

Sometimes, you've already done 70% of the work. But the remaining 30% is important from an implementation point of view, otherwise you just get stuck.

Yamal Matabadul, CEO of Polytechnics Mauritius Ltd

How is technology being used in secondary schools in sub-Saharan Africa? In secondary schools, computer labs predominate, but there are also other types of technology.

Figure 5: A computer lab built by the Government of Luxembourg. Escola Secundária António Silva Pinto Ribeiradas Patas, Santo Antão, Cape Verde. (Photo: Mary Burns)

Computer labs with desktops or laptops are still the most common configuration of ICTs in secondary education. Every principal's office visited across the four case study sites contained a laptop, typically for communication and administrative purposes (attendance data in EMIS, etc.), a printer, and Internet connectivity.

In Cape Verde, faculty rooms contained desktops for teacher use in researching topics or lesson planning. In Mauritius, many teachers have their own devices—tablets, or laptops. Across the four case-study sites, almost all teachers appear to own a smartphone. Despite the fact that the smartphone offers teacher access to professional development opportunities, researchers saw little evidence that this was happening.

The South African government-school classrooms visited for this study, especially those in Gauteng Province, were equipped with interactive whiteboards, a projector, and a laptop (as part of the provincial initiative Gauteng Online). Apart from these, or a teacher laptop connected to a projector, researchers saw no evidence of computers in the classroom. In several classes, the teacher used the interactive white board, mainly to display exam papers and go through math problems (in preparation for upcoming exams). In one class, the teacher projected videos onto the interactive whiteboard.

The situation was completely different in the one South African private school visited by researchers. Parklands College, in Cape Town, is an Apple Distinguished School (2016-2017) and had some of the most innovative uses of technology seen by researchers anywhere, not simply Africa. Here, in this well-resourced environment, where every student and teacher have laptops, technology was ubiquitous, with students using Computer Aided Drawing programs and three-dimensional printers to create models of a proposed new school campus. Students made their own apps (some of which are sold by Apple), developed videos explaining certain mathematical operations, and created professional-quality music videos.

Cape Verdean secondary schools often had computer labs and WebLabs (see Section IV of this report). Some classrooms had projectors but no classrooms (unless they were being used as a computer lab) contained desktops or laptops. Computer labs in Cape Verde were typically built by donors (such as the Government of Luxembourg), were used for Information Technology classes and were not available to students after school or on a drop-in basis for homework or research.

However, Cape Verdean technical schools were particularly well equipped with technology—with, in many cases, plotters, 3-D printers, and such computer applications as computer-aided drawing, mechanical drawing, and graphics design software for related technical arts classes. In some cases, however, the technology was not functional or was outdated.

In South Africa, “regular” computer labs (for non-technical subjects) appeared to be in great demand. In the Cape Verdean and Botswanan schools visited, computer labs often sat empty and unused, with the exception of technical high schools, where demand is great and teachers talked about the need for more technology and more computer lab space. In South Africa, computer labs were often full after school for remediation and exam-preparation programs (see the next section of this report).

In Mauritius, all secondary schools are connected to the Internet with a 10 MB connectivity line. While there are at least two computer labs and one audio-visual room per secondary school, each school has a local learning content management system (LMS) (Moodle). The LMS is centrally backed up at the Government Online Centre. However, computer labs in schools are still mainly used and controlled by ICT subject teachers, while the audio-visual room educational technology is mostly used by teachers (especially for video projections). Some teachers, who either have a passion for ICT in education or have obtained formal training at their own expense, are quite active in the use of ICTs and social media (such as Facebook and WhatsApp groups) for enhanced communication with students via mobile phones. Others have created their own educational websites through free hosting services to share educational resources with their students.

The most common technology in secondary schools is that which is not used for teaching and learning: mobile phones.

Some countries are using educational TV to complement or supplement the Internet. A number of secondary schools across sub-Saharan Africa employ educational television at the secondary level. For instance, South Africa’s Department of Basic Education has provided 1600 schools[19] with educational television programming. These include free-to-air channel “e.tv” (an entertainment channel), the 24-hour news channel eNCA, educational content produced by the South African educational TV content provider, Mindset, and on-demand educational broadcasting that teachers can use (Faulmann, Tihabane, & Mothobi, personal communication, September 13, 2019). Schools

[19] Data showing the breakdown between primary and secondary schools was unavailable.

pay for the TV and decoder and receive OpenView High Definition (OVHD) free-to-view direct broadcast satellite television. No usage data for educational television was available.

Botswana's educational television broadcasting focuses primarily on math and science programming that appears on Botswana Television (BTV) in two-hour three days per week. This programming supplements the secondary school curriculum and attempts to provide interactive and experimental content. BTV does not provide audience ratings for its educational programming (Sennye, personal communication, September 21, 2018) so no data on audience or satisfaction with these courses are available nor have external evaluations been conducted.

Educational radio is still used throughout the continent to provide access to learning, though to varying degrees. Radio is the most widely used communications technology in many of the poorest countries of the world (Burns, Montalvo, & Rhodes, 2010). The cost of a radio or audio player is often low enough to be affordable for most schools and using the equipment requires little to no training. Teachers simply "tune in" (where programs are broadcast during the school day) or "turn on" (a CD player with pre-recorded audio programming) and play the educational program in class (Burns, Montalvo, & Rhodes, 2010).

Box 2: Educational Radio in Cape Verde

Cape Verde, an archipelago of ten sparsely-populated islands off the west coast of Africa, has relied on educational radio for decades. All Cape Verdeans have access to radio, and it is a popular medium in the country.

One of the first Interactive Radio Instruction (IRI) programs was the Portuguese-funded Projeto PALOP (2001-2007) which provided Portuguese-language and mathematics instruction to Grade 4-8 students and teachers. Radio segments were twenty minutes in length and highly interactive, involving games, physical movement, and music. Teachers printed learning guides for the radio programs. Evaluation data showed that children who had access to IRI tested better in Portuguese and math than children who did not.

Radio Escola (School Radio) offers radio classes for secondary-school-age students who have left school. Students are sent printed materials to use with the radio programs to learn secondary-school subjects. Funding for Radio Escola has been somewhat uneven.

In addition to IRI and Radio Escola, Cape Verde has often used radio broadcasts to support teacher professional development, as well as helping the general population with Portuguese skills, environmental education, etc. Weekend morning educational radio programming, complete with stories and songs, is offered for children, and is (at least for this author) highly engaging.

Sources: Eufemia Mascarenhas, Radio Educativa do Cabo Verde (personal communication, November 21, 2018); Hanemann, 2014.

A number of governments have capitalized on radio to provide educational opportunities to teachers and students through educational broadcast radio. For example, the Government of Botswana broadcasts educational radio programming to primary-age students several times per week.

Where radio (and audio) become particularly powerful is through Interactive Radio Instruction (IRI) or Interactive Audio Instruction (IAI). IRI is an instructional approach that uses one-way radio to reach two audiences: students and their in-class teachers. In this dual-audience, direct-instruction approach, all lessons are prerecorded. IAI uses narrowcasting—pre-recorded audio programs delivered via cellphones or MP3 players connected to a speaker or CD players.

Once the in-class teachers turn on the radio or MP3 player, the radio or audio “teacher” delivers content and directs the in-class teachers to apply a variety of interactive instructional approaches within their classrooms. Both the content and activities of the program are based on the national curriculum and use a series of structured learning episodes in which students are prompted to sing songs, participate in individual and group work, answer questions, and perform certain learning tasks (Burns, 2011, p. 21). IRI and IA have been used to help students and teachers learn content in sub-Saharan locations (Guinea, Liberia, Somalia, Cape Verde, Angola, Mozambique, Guinea-Bissau, Zanzibar, São Tomé e Principé, Mali, South Africa, and the DRC, among other countries).

Startup costs for IRI and IAI programming represent a large initial investment on the part of governments, but once programs are operating at scale, recurring costs are usually very low. Because IRI and IAI are largely broadcast media that can be used over multiple years, users (such as teachers or students) can be added for very low marginal cost (typically pennies per user) (Christina & Louge, 2015).[20] Because of the behaviorist aspect of IRI and IAI, where teachers repeat the same words and do the same activities over years, teachers tend to internalize the learner-centered practices promoted by IAI and IRI and are able to carry them out even when the radio program has ended (Burns, 2011).

Despite numerous types of technology, uses of technology appear quite non-differentiated. Classroom observations by researchers suggest that there is little diversity in how technology is used in secondary schools. Computers are used for IT classes, after-school remediation and test preparation (the South African National Qualifications Framework and the General Certificate of Secondary Education (GCSE) in Botswana), tutoring, research, and “show and tell” by teachers (more accurately described as “tell and show,” as teachers often use projectors or interactive whiteboards to support lectures). Classroom observations in schools across four countries revealed nothing approximating real-world uses of technology (for example, using word processing software to write a letter-to-the editor of a local newspaper or news station about a local problem, using spreadsheets to develop a household budget). Nor was technology used to support more innovative pedagogies like collaborative or project-based learning which prepare students for the types of professional situations they will invariable encounter in the formal employment sector.[21]

ICTs are increasingly used for data collection and management. Although ministries of education and schools often struggle to successfully use technology for instruction and assessment, many governments and educational organizations are using technology to address the lack of systematic data collection and management and to improve educational planning. For instance, the Open EMIS Initiative funded by UNESCO in partnership with the Community Systems Foundation is an open-source Education Management Information System (EMIS) developed to help education systems collect, analyze, and report data related to the management of educational activities (Barry & Newby, 2018). FHI360, a US-based NGO, documented the number of teachers, schools, and the state of school infrastructure in Sudan and Sierra Leone, mapping educational offerings in eleven of twelve UNHCR-supported countries (Dhaya, 2016, p. 13) and USAID’s All Children Reading Grand Challenge along with OpenEMIS is tracking textbooks from warehouse to the schools (Bloome, personal communication, October 18, 2018). Mobile technologies and the use of mobile payments are also increasingly used to pay teachers. However, this was not a focus of this report.

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[20] The cost of starting up an IRI/IAI program differs by context, scale, program, etc. However two good, though older resources for learning more about IRI and IAI, and in particular the costs of developing such programs are: (1) Adkins, Douglas. 1999. “Cost and Finance” in Alan Dock and John Helwig, eds., “Interactive Radio Instruction: Impact, Sustainability, and Future Directions.” Education and Technology Technical Notes Series 4 (1). World Bank, Washington, D.C. (2) Anzalone, Stephen, and Andrea Bosch. 2005. “Improving Educational Quality through Interactive Radio Instruction.” World Bank, Washington, DC.

[21] Again, it must be noted that classroom observations in Botswana and South Africa coincided with the examination preparation period, so the patterns of instruction and assessment observed may contain many exceptions. Globally, however, secondary instruction is noted for a focus on lecture-based practices.

A. Promising Practices

Sub-Saharan African schools have growing access to hardware, software, and digital content. This will be explored in greater detail in the "Trends" section of this report. In South Africa, 65%–70% of schools have some basic ICT infrastructure and connectivity for teaching and learning (Kuvuma, personal communication, October 2, 2018; Faulmann, Tihabane, & Mothobi, personal communication, September 15, 2018). In Cape Verde, all secondary schools have technology and some form of Internet access; in Botswana, the majority of junior and senior secondary schools have technology and Internet access (Chilisa, personal communication, September 19, 2018). In Mauritius, all secondary schools have two computer labs per school with Internet connectivity, and tablets were recently distributed to students in grades 10 and 11. All four countries are in various stages of finalizing a platform of curriculum-linked educational content. While these are promising figures, access to technology is just the foundation of a successful educational technology initiative. Furthermore, this reveals nothing about the adequacy and quality of technology infrastructure. Far more important are the learning outcomes related to the use of teaching and learning with and through technology.

Many governments are making efforts at bridging the digital divide. The digital divide will also be explored in greater detail in the Trends section of this report. One of the greatest challenges faced by many sub-Saharan African countries is the digital divide, or a lack of digital equity, between urban and rural regions. Policy makers have aimed to address this divide in a number of ways.

Box 3: The Cyber Caravans and mass computer literacy project in Mauritius

The National Computer Board operates two "Cyber Caravans," which are used to democratize access to ICTs by providing basic ICT trainings to various segments of the community on a regional basis. The Cyber Caravans are equipped with laptops and broadband Internet, and training is provided to the community at large according to need, regardless of age, educational background, or profession.

The NCB training program includes offerings such as Internet and Computing Core Certification (IC3), Microsoft Office Package (MOP), ICT Literacy Program (ICTLP), Initiation to Coding for the Community, and ICT Awareness for Senior Citizens.

As of December 24, 2018, 217,588 persons have followed the above training courses. 8,796 persons (including, children, adolescents, students, women and unemployed people) have been initiated for the period July 2017 to date

Source: National Computer Board – http://ncb.intnet.mu

For example, educational broadcast radio and television (as discussed above) can provide access to educational resources to teachers and students in remote areas. Botswana Television, which offers daily educational programming, reaches 90% of the country through its terrestrial transmitter and 100% of the country through satellite. Because not everyone in Botswana has the set top boxes and decoder needed for digital television, BTV still uses analog transmission (Sennye, personal communication, September 20, 2018).

In addition to broadcast technologies, governments have also collaborated with private companies (e.g., game parks in South Africa and mining companies in Botswana) to provide Internet access to those in rural areas. Governments have also encouraged the use of "telecenters," or learning centers (in many cases, government built) where students and teachers can access computers, the Internet, some form of training, and digital content, often provided by partners such as Vodacom or the MTN Foundation. Similarly, the Botswana Open University (BOU) currently makes open schooling (secondary-school and tertiary-level education) available to 16,000 learners[22] in Internet-equipped learning centers in villages across Botswana.

Some governments appear to have specifically addressed this urban-rural divide through specific educational initiatives targeted at rural schools. One example is Technology for Rural Education Development (TECH4RED). The project is run by South Africa's Council for Scientific and Industrial Research (CSIR) as a joint initiative between the Department of Science and Technology (DST), the Department of Basic Education (DBE), the Eastern Cape Department of Education (ECDoE) and the Department of Rural Development and Land Reform (DRDLR). Its aim is to improve rural education in the Eastern Cape province of South Africa through technology-led innovation. As component of this program is ICT4Red (ICT for Rural Education) which has provided tablets, training, and connectivity to 143 schools. Teacher ICT courses include techniques for integrating ICTs via "flipped learning": teachers are given tablets but only allowed to retain them if they complete training, that is, "earn while you learn" (Ostrowick, 2018).

[22] Because of the nature of open universities, these numbers are variable. The figure of 16,000 was the enrollment figure as of September 2018 (Tau, personal communication, September 20, 2018).

Samsung and UNESCO have partnered with Kenya, Tanzania, and South Africa to help set up mobile solar-powered computer laboratories to connect rural schools in sub-Saharan Africa.[23] This project, the Digital Village Initiative, aims to provide an alternative to the problem of unreliable or inexistent electrical supplies. Mobile Internet Schools are equipped with digital whiteboards, broadband connection, solar-powered notebooks, tablets, and cameras.

Box 4: Interactive Radio Instruction (IRI)

IRI is one example of programming that offers low-cost, widely available opportunities for education for many internally displaced persons (IDP), particularly children and youth. The Somali Interactive Radio Instruction Program (SIRIP, 2005–2012), funded by USAID and implemented by Education Development Center (EDC), worked with local community educators and leaders to develop instructional content and supplement formal education in math and reading for approximately 330,000 IDP students in the outskirts of Mogadishu, out-of-school students, and those in alternative schools (e.g., Qu'ran and community schools) across Somalia. Books and other teaching materials incorporating Somali history, language, and cultural norms were produced to supplement radio broadcasts. Radio broadcasts included prompts that invited teachers and students to participate in activities that enriched the learning process (e.g., song, question-and-answer, or other physical movements).

Research has shown that IRI is an effective tool to breach the digital divide and reach school age students who are in and out of the formal education system. IRI is by nature less susceptible to interruption and unrest as content can be regularly delivered via broadcast. While IRI content is most effective with a facilitator or teacher who conducts pre- and post-broadcast sessions, small radios are widespread in Somalia and students are able to take advantage of the programs outside of a classroom setting. IRI programs are also effective; a recent study showed that children in IRI schools performed significantly better than students without IRI in mathematics and Somali literacy.

Sources: Dhaya, 2016, p. 19; Anzalone & Bosch, 2005.

Technology is being used in many parts of Africa to provide Internally Displaced people (IDPs) and refugees with access to education. The Vodafone Foundation and the United Nations High Commissioner for Refugees (UNHCR) have collaborated to establish thirty-six "Instant Network Schools" in seven refugee camps in Kenya, Tanzania, South Sudan, and the Democratic Republic of Congo (DRC). Instant Network Schools connect classrooms to the Internet, providing hardware, software, and teacher training to deliver digital educational content to around 50,000 students each month in low-resource learning environments within refugee camps.

War Child Holland's *Can't Wait to Learn*, mentioned earlier in this report, is a tablet-based gaming application for refugees, internally displaced persons, and out-of-school youth and teachers in Sudan and Uganda. The games' interactive learning activities are based on the Sudanese and Ugandan national curricula. Although the games target primary-school competencies, secondary-

[23] See "Samsung harnesses solar power to build digital villages in Africa" at https://news.samsung.com/global/samsung-harnesses-solar-power-to-build-digital-villages-in-africa

age youth (particularly in Uganda) are also eager users of these self-paced games (Radford, personal communication, October 15, 2018). The games, which contain three to five years of educational content in math, literacy and psychosocial supports, has also proved popular with teachers (many of whom received little or no preparation in teaching). *Can't Wait to Learn* is one of the few educational technology initiatives that enjoys rigorous research and has been successfully scaled to Sudan, Uganda, Chad, Jordan and Lebanon (Radford, personal communication, October 15, 2018).

As a final example, Coursera, the online consortia of universities (that includes Stanford, Penn, Johns Hopkins and others) with its own MOOC platform, has recently launched a free online MOOC for refugees: https://www.coursera.org/refugees.

There's a strong link between mobile phones and youth workforce development programs: Young people in sub-Saharan Africa, like young people across the globe, are using mobile phones for job-related and workforce related purposes. For example, via mobile technologies, youth can access relevant job-related education and training content. They can access career information and job-matching services (through platforms such as Harambee and Souktel), build their own businesses, access potential funding opportunities and financial services, and overcome social constraints to employment (Raftree, 2013).

B. Challenges

The greatest challenge facing technology use in secondary schools in sub-Saharan Africa is a comprehensive lack of readiness. ICTs reside in an ecosystem and can only provide value when all parts of the ecosystem are established and functional. Simply put, many national education systems, regional education systems, and secondary schools are simply not ready to use technology to support access to education, improve educational quality, or manage information. Readiness comprises physical and human capacities, as well as technical and educational aspects. Discretely and together, these qualities adversely influence policy.

1. **Physical readiness.** Across the continent, many secondary schools lack electricity (or fuel to run generators, or updated electrical systems), particularly in rural areas and in slum communities in urban areas. Schools lack plugs. They lack a physical space for computers. They lack security (a huge issue in South Africa and Cape Verde). They lack clean environments where laptops or desktops will not be damaged by dust, debris, heat, or water. In short, even if they wanted to use technology, many schools simply do not have the physical infrastructure to do so. That said, the next section explores a number of initiatives designed to address these physical plant and power issues.
2. **Human readiness.** Despite their general openness to using technology, teachers often lack the skills to use technology, most fundamentally keyboarding skills. Beyond this most basic set of skills, many teachers lack an understanding of how to integrate technology into their subject areas—for example, how to have students use concept maps to analyze a short story; how to use spreadsheets to model simple phenomenon (like rainfall); or how to allow

students to use technology to learn basic facts (like multiplication tables) while freeing up the teacher to focus on designing and facilitating more higher-level learning activities. It is critical to emphasize that this is not the fault of teachers. Governments have placed technology in schools with either little or no basic technology skills training. More critically, governments have not trained teachers how to teach with technology.

This lack of readiness extends across actors in the education systems. Although countries like South Africa provide professional development for principals in instructional leadership, these efforts are often sporadic. Moreover, in most countries, there is no effort to help principals or head teachers become instructional leaders. Thus, those school principals who do use technology understand it as an administrative tool, not as a teaching and learning one. In district and regional education offices, education officials (whose job it is to supervise and support teachers) do little more than assure compliance and complete administrative tasks. Their knowledge of good teaching and assessment with and through technology is limited.

Students, too, suffer from ICT readiness issues. Studies of student technology use in the United States and United Kingdom suggest that student skills and attitudes can help to either inhibit or facilitate technology use in schools (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010; Hennessy, Ruthven, & Brindley, 2005). Research also reports that students, despite being facile users of technology outside of school, often struggle with "academic" technologies for subject-specific purposes or resist the increased autonomy and responsibility for learning that comes with using technology in school (Hennessy, Ruthven, & Brindley, 2005).

Finally, many policy makers, including some interviewed for this study, lack a real comprehension of the affordances and drawbacks of technology and of what it can and cannot do. There is often a lack of understanding of what a high-quality secondary system that uses technology to promote twenty-first-century learning looks like and what it requires. This lack of vision reduces technology efforts to building computer labs in schools and holding IT classes. Many policy makers have never seen models of quality teaching that incorporate technology, and therefore they cannot articulate a vision or motivate an education system to adopt such a vision. This leads to the result that goals and success are both determined by the number of devices in schools, not by a high-quality educational outcome and how technology can promote such an outcome.

When the bulb of a projector is faulty, because of internal procedures, it can take weeks. If a few computers are faulty and parts need replacement, there is a need to notify the Ministry and then sometimes they wait for a threshold of such requests before making bulk purchases. Simple technology can take up to six months to procure in some cases.

Rector, Secondary School, Mauritius

3. **Technical readiness:** Across the continent, secondary schools lack the robust and reliable infrastructure required to support the use of ICT in education. Internet access is limited, slow, and unreliable. Technology is old and outdated for many reasons; it was donated secondhand or never maintained; it suffers from the tragedy of the commons; or it is simply obsolete and there is no money to update it.

As a case in point, Mauritius, after initially distributing tablets to secondary school students in grades 10 and 11, the government had to rethink its strategy due to poor device quality, poor/lacking school connectivity, a lack of digital materials and relevant learning resources, theft and hacking of the devices, and a lack of utilization strategy (Jugee & Santally, 2016).

African youth want to work vs. feeling frustrated and humiliated. Our governments are unable to harness or use opportunities to create proper quality education and provisions to equip youth adequately for the modern workplace.

African policy maker

The key thing is the legacy of a lost generation of kids. They are leaving school with poor levels of reading ability, without being able to engage the world, with massive consequences for the whole country. If we can't close the opportunity gap, it means the survival of South Africa.

Penny Tainton, Delivery Support Union, Western Cape Government, Cape Town South Africa

Many schools openly use pirated software; in the candid words of one principal, "If we didn't use pirated versions, we wouldn't have any software at all." Often, there is no budget for technology beyond the actual desktop computer itself. Software is not updated because there is no available technology support staff in schools (South Africa being an exception) or because there is no budget for maintenance or no maintenance plan. The denigrated state of infrastructure is more than a technical issue; when technology fails to work or fails to work reliably, teachers begin to distrust it, and they may choose not to use it.

4. **System readiness:** Many or even most education systems in sub-Saharan Africa are simply not set up to incorporate and capitalize on the affordances of technology. Even a curriculum like South Africa's Curriculum Assessment Policy Statements (CAPS), which promotes more higher-level, learner-centered approaches, is overly circumscribed and focuses on far too many topics. Though the research for this report did not involve examination of national curricula, it is well within the realm of reality, based on classroom observations, to suggest that many

national curricula at the secondary level focus on knowledge versus skills and are geared toward having students show mastery of facts and understanding concepts for a high-stakes examination (such as the baccalaureate in French West Africa, the GSCE in Botswana, or the "Matric" in South Africa).

Where technology is included in many of these systems, it is included as an examined subject, which downgrades ICT skills to mere knowledge of ICTs—or it is often, in the words of one teacher, in the "wrong place." For example, in Cape Verde, grade 11 students must choose between chemistry and IT. Chemistry is a necessary prerequisite to studying sciences at the university level; IT is not. Furthermore, IT classes, which focus on how to use (typically) Microsoft Office software applications, are an elective, not a required course, and they are offered only at the secondary level—not at the primary level. However, many of the teachers and principals interviewed for this report believe the courses should be offered at the primary level.

In South Africa, Gauteng Online, a Gauteng Department of Education initiative initiated in 2009 to provide hardware and software to all Gauteng province secondary schools, has begun tablet distribution beginning at grade 12 and then moving down the secondary system year by year.[24] However, many grade 12 students have not taken IT classes; this situation exists in part because IT classes are not obligatory, and in part because students have not had much prior access to technology and do not know how to use the devices.

> *I don't know whether we can term it as a failure, but it is a fact that the tablet PC program in secondary schools in Mauritius [in its] initial form was discontinued. It is not just about having tablets. These are just devices. There is a need for relevant content and trained teachers, including the appropriate pedagogy and educational framework to make it work. So it's not necessarily a failure but a rethink[ing] of the whole concept from a policy perspective at the level of policy-makers.*
>
> Rajnish Hawabhay, Chief Technical Officer, Ministry of Technology, Communication and Innovation, Mauritius

There are numerous other educational constraints that point to a lack of readiness—a lack of high-quality digital content and adequately trained educators; a lack of data to assist in educational planning and decision-making; a lack of online assessments that automate testing and provide timely feedback, and a lack of operating systems and digital content in languages that students speak. Far from bridging the digital divide, the dominance of English, French, and Portuguese content and operating systems exacerbates language inequities in the many parts of sub-Saharan Africa where students do not speak these languages (Santos, Barreto, & Barradas, personal communication, November 7, 9, and 15, 2018).

5. **Policy environment:** Taken together, the above issues both contribute to and are compounded by a weak policy environment. Where policy documents exist, there is often disparity in what they advocate ("the fourth Industrial Revolution," "information societies," "twenty-first-century learning") and what they can support. Educational

[24] Gauteng Online has suffered from funding issues and has struggled to meet its targets.

technology policies may not be connected to or supported by comprehensive and enabling telecommunications; teacher education policies that support ICTs in education may or may not be in place (Ponelis & Holmner, 2015). Policies may only exist in the aspirational realm, without supporting clearly defined and resourced implementation strategies at the national, regional, school, or individual educator levels.

Part IV: Trends and Opportunities

There are numerous trends—general direction in which something is developing or changing—and opportunities in ICT in secondary education across sub-Saharan Africa. The most salient of these trends and opportunities are outlined here.

Governments recognize that ICTs need to be part of any education reform efforts. Technology is regarded as an essential tool to scale innovations, provide educational services that might be otherwise unavailable, and automate administrative functions. Thus, for example, education systems in sub-Saharan Africa are increasingly turning to cloud-based services (Amazon data storage; Google Classrooms; online portals of educational content, curriculum supports, and digital textbooks such as DBE Cloud in South Africa and Thutonet in Botswana; and education management information systems). The South African government, for example, is investing in the development of state-owned digital textbooks and resources to reduce dependence on proprietary resources and thereby reduce costs (Kavuma, personal communication, October 2, 2018). In Mauritius, the Mauritius Institute of Education has set up the Centre for Open Distance Learning, with a team dedicated to developing interactive materials and digitizing the educational textbooks available to schools and teachers. A national Open Education Resources (OER) policy is being prepared with the support of the Commonwealth of Learning to release such materials as OERs.

Box 5: Promoting open content in South Africa

Like many countries, South Africa has suffered from problems associated with developing and distributing print textbooks. Despite advances in both areas, printing and distribution of printed textbooks is enormously expensive, and many textbooks never reach intended schools and students. For the past several years, working with the South African company, Siyavula, South Africa's Department of Basic Education (DBE) DBE has printed open-source science and math textbooks for every grade 10, 11, and 12 student in South Africa. This dramatically reduces the costs of development, updating, and distribution, and it is one of the first sub-Saharan African examples of open-licensed materials from a nontraditional publisher on a massive scale.

Source: Attwell, 2012.

Donor support for secondary education and ICTs in education can be uneven. As noted earlier, and throughout this report, multilateral and bilateral donors remain funders of ICT in education initiatives. Some of the largest bilateral donors have shifted funding focus to primary education and away from technology in education or technology in education at the secondary level. Interviews with in-country stakeholders reveal a concern there may be a lack of support for secondary education and a lack of understanding among some donor agencies about how technology can support meaningful education reform at the secondary level.

In contrast to this perception, there are donors, obviously, who fund secondary education and the use of technology within secondary education (the Millennium Challenge Corporation being one example). Additionally, the United Kingdom's Department for International Development (DFID) is planning the launch of its EdTech Research and Innovation Hub, a multi-year initiative, to bring together experts in technology, education, research and innovation. Their focus will be to examine the kinds of educational technologies and practices that deliver better learning outcomes for students, to determine which technologies hold the most promise for teaching and learning in developing countries, and research which educational technology interventions hold the greatest value for money and social return on investment.

While there is more awareness in governments about the role ICTs can play in education, this awareness does not always translate into well-directed or well-funded implementation plans. School-based observations, interviews, and a review of the research reveal that far too many sub-Saharan African secondary schools suffer from a lack of vision about how technology can enrich teaching and learning. This translates into the inability to integrate technologies into subject area teaching in meaningful ways. Similarly, secondary schools are often not provided with the resources and funding for needed maintenance, technical support, and software licensing (which results in software piracy). Generally, schools suffer from a lack of funding for training and supporting teachers in how to use technology and funds to cover maintenance and refresh of technology devices. These gaps continue to harm technology adoption and implementation programs across sub-Saharan Africa.

More attention is being paid to last-mile electricity needs and electricity may be another area where sub-Saharan Africa can leapfrog from fixed to mobile provision. As of 2016, six hundred million Africans still lacked access to the electrical grid (Coren, 2018). These are disproportionately rural inhabitants; access to technology and the Internet is especially difficult for rural students.

This lack of access to electricity and Internet has spawned numerous innovations across the sub-Saharan region that should directly benefit schools and the schools' communities. For example, as the cost of solar-plus-battery systems continue to drop dramatically, a number of governments (Botswana and Cape Verde are but two) have outfitted secondary schools with solar panels, thereby reducing the cost of providing electricity to schools. The mobile telecommunications company Orange offers "solar kits" to residents in the Democratic Republic of Congo (DRC), Madagascar, Burkina Faso, Senegal, Mali, Guinea, and Côte d'Ivoire[25] so that residents can have electricity without relying on unstable electrical grids. Households can choose daily, weekly, monthly, or quarterly subscriptions. Monthly subscriptions in the DRC, for example, start at US$15 and can be paid for via "mobile money" (Kenning, 2018).

In rural areas with little or no infrastructure, the British company, Bboxx, has used a pay-as-you-go system to install cheap batteries and solar panels on buildings without selling any equipment. For the equivalent of a few US dollars per month, customers can lease solar panels, batteries, and high-

[25] The Orange Energie solar kit includes solar panel, battery and accessories (lightbulbs, switches, a moving torch, sour, four switches, a USB charger for five phones, and an optional TV.

efficiency appliances. The service operates like a pay-as-you-go cellular package service. A remote cellular connection (with 2G or SMS backup connectivity) turns the system on or off based on mobile payments (Core, 2018). In Botswana and Cape Verde, the government has provided schools with solar panels.

There has been an upsurge in offline "solutions" to address the lack of (affordable) Internet. For example, Instant Schools is a free digital learning platform with no data charges for anyone on the Vodafone/Vodacom network. Instant Schools is available in the DRC, Tanzania, Ghana, and South Africa (where it is known as "eSchool"). It hosts quality digital educational content in local languages and reaches over 750,000 learners. The Vodafone Foundation aims to support five million learners through Instant Schools in countries where Vodafone operates by 2025 (Jigsaw Consult, 2019).

In South Africa, Vodacom has launched its eSchool,[26] a free-to-access educational site that provides access to curriculum-based content. The site includes video lessons, homework questions, and interactive quizzes, along with tools for evaluating and rewarding progress. (Felton, personal communication, December 14, 2018).

Learning Equality, a US-based nonprofit organization, has developed two open-source platforms, Kolibri and KA Lite. Both Kolibri and KA Lite were designed for use in low-resource and low-connectivity contexts, providing offline access to a curated library of open-licensed educational content with tools for pedagogical support.

In Kenya, the BRCK Education project provides students with a rugged tablet devices (KioKits) as well as hardware, software and connectivity. e-Limu, another educational technology initiative from Kenya, offers offline educational resources, such as examination preparation and lessons based on the Kenyan curriculum as colorful easy-to-digest exercises without the need to incur expensive data costs (Shapshak, 2015). eKitabu, an e-book provider, has built a digital library (including e-Limu materials) which can be accessed online or offline. The library contains thousands of free books and an application (also accessible offline) that reads ebooks aloud to children who are blind or have a vision impairment (Secorun, 2017).

In Zambia, SteppingStone, a content management system developed by Education Development Center, allows users to create multi-language application-based content in Drupal (including video, practice activities, and assessment activities) without the need for coding. Once downloaded to a SteppingStone application on an Android tablet, all learner content can be run offline in the application, and a user's progress can be stored on the device.

[26] See https://www.vodacom.co.za/vodacom/services/vodacom-e-school

Mobile penetration continues to grow in sub-Saharan Africa. Mobile phone subscriptions are more common than electrical grid connections in sub-Saharan Africa (The Economist, 2017), with an estimated 700 million mobile phone owners. From 2000–2013, mobile phone use in South Africa surged by 822% (Institute of Race Relations, as cited in GESCI, 2017, p. 19). South Africa has LTE access in 80% of the country.

Box 6: Mobile Growth in Botswana
Since 2009, Botswana has experienced a phenomenal growth in its mobile sector. As of March 2014, there were 3.2 million mobile subscriptions in this nation of 2.2 million people. As subscriptions continue to grow, the price of prepaid and post-paid mobile services continues to drop. This, along with the increase of smartphone ownership, has particularly benefitted young Botswanans. The use of smartphones has led to increased numbers of people with access to the Internet, especially youth. As of March 2017, mobile Internet penetration in Botswana was 69%, with 1.4 million subscribers.
Source: Botswana National Commission for UNESCO, 2016, pp. 174–179.

While considerable progress has been made in Internet connectivity, access to the Internet is still an issue. Many countries, like Mauritius, with its National Broadband Policy 2012–2020, emphasize the importance of all educational levels (primary, secondary, and tertiary) having adequate access to broadband facilities to enable teaching and learning. However, despite national broadband policy statements, the International Telecommunications Unit (ITU) reports that only 25% of the African population has Internet access. Internet access has not been provided systematically to advance education and learning at individual and institutional levels (ITU, 2018). Even where national plans emphasize connectivity, providing Internet access, especially in rural areas, is expensive and/or beyond what governments can realistically expend. For example, South Africa's plans to provide broadband Internet connectivity to all schools in the country via the implementation of the national broadband policy (Ford & Herselman, 2017) has been stalled by budget shortfalls.

The cost of the Internet continues to drop in many parts of Africa. For example, South Africa is experiencing a boom in Internet access with 22.5 million online users (2017 projected data) (Shapshak, 2017). This increase in Internet users has resulted in decreased Internet costs, which benefits all schools but particularly South Africa's private and blended public-private schools, which often pay for their own Internet access. Telcom, South Africa's national telephone provider, is moving away from landline to digital, reflecting the changing demands of its customer base. All South African metro areas have 4G or higher, and most towns have 3G broadband (Mays, personal communication, September 23, 2018). Broadband costs have dropped from 20,000–40,000 ZAR per month to 5,000–10,000 ZAR per month, and small private schools can get by with residential fiber-based connections that cost 2000–3000 ZAR per month (Lee, personal communication, October 18, 2018). Additionally, private Internet companies are offering incentives to schools to connect to the Internet. In Johannesburg, for example, many Internet providers will provide fiber-based Internet connections "at cost" (that is, at no extra cost) to schools when cabling nearby businesses (Lee, personal communication, October 18, 2018), and business cellular providers have also provided broadband access to schools at cost.

The increase in mobile devices, and commensurate decreases in prices for devices and mobile broadband, has enormous potential benefits for educational content design and delivery, data collection, distance learning, and support and coaching for teachers and students through text messaging (SMS) and VoIP applications like FaceTime and Skype. Digital content developers like IdeasSolution in South Africa are providing interactive mobile educational resources for students at the cost of a few ZAR cents per day.

The emergence and expansion of National Research and Education Networks (NRENs) has helped to extend affordable noncommercial broadband to educational institutions. A NREN is a physical high-performance communications network operated for and by the educational and research community of a country. It is also the organization that operates that network, constituted either as a consortium of members, a dedicated agency, a company, a non-governmental organization (NGO), or other type of body (Foley, 2016, p. 5). Across sub-Saharan Africa, Ethiopia, Rwanda, Mozambique, Uganda, Somalia, Sudan, Namibia, Zambia, Malawi, Tanzania, South Africa, Nigeria, Ghana, Mali, Niger, Senegal, Côte d'Ivoire, and Kenya all have NRENs. These are organized into regional backbone networks (e.g., the West and Central African Research and Education Network and the UbuntuNet Alliance for Research and Education Networking). Souter et al. (2014) point to South Africa and Kenya as "examples where a combination of sector liberalization and government investment in connectivity to education, working with NRENs, has led to prices falling to less than 10 per cent" from 2011–2014 (p. 11). Kenya's NREN, the Kenya Education Network Trust (KENET), has been connecting all schools in Nairobi to its network and providing them with an educational portal (Foley, 2016, p. 8).

Yet, in spite of falling costs, Internet affordability is still an issue. Even as Internet subscription prices fall, the Internet is still unaffordable for many. At the same time, South African telecommunications providers have found that demand for calls is down and demand for data is up. A 2017 study in South Africa[27] reported that over a quarter of South Africa's 29 million smartphone users (approximately eight million people) cannot afford the cost of data. While higher-income South Africans want faster Internet access and can pay for it, those at the bottom of the market want cheap Internet access (Shapshak, 2017). The risk is that designers of educational content will target the higher end of the market while neglecting the lower end, further exacerbating the digital divide between wealthy and poor students.

Ministries of Education, schools, parents, and educators continue to grapple with how to integrate mobile phones into education. Mobile phones are a true bottom-up technology, but many questions remain. Given what appears to be very high rates of phone ownership among secondary-school-age students in sub-Saharan Africa, how can mobile phones be transformed from a distraction into a learning asset? How can schools leverage mobile phone ownership to reduce the burden of

[27] See the World Wide Worx study at http://www.worldwideworx.com/wp-content/uploads/2017/07/Exec-Summary-Internet-Access-in-SA-2017.pdf

providing equipment and Internet access to students? What kinds of acceptable use policies should be designed and implemented to potentially govern the use of phones in classrooms? Unfortunately, policy makers have not addressed mobile phones except to ban them in classrooms. At many schools, students must turn in phones for the duration of the school day; in some, students may bring them to class for research when sanctioned by the teacher. While more schools (in South Africa, for example) take an interactive view of mobile phones in classrooms, these tend to be private schools (Lee, personal communication, October 18, 2018).

Low-cost private schools across sub-Saharan Africa are using ICTs as a central part of their model. Bridge International Academies, a private-for-profit education company based in Cambridge, Massachusetts, provides primary school teachers in Liberia, Kenya, Nigeria, and Uganda with tablets that include scripted activities that they follow to standardize instruction across their country's primary schools. These tablets are also used to assess student learning and feed information back to the main office in Cambridge (via 2G cellular connections) so Bridge can analyze its instructional model and make appropriate adjustments. Bridge is in the process of providing tablets to students and smartphones to all principals in the countries in which it works (Geraghty, personal communication, October 17, 2018).

The SPARK school chain of twelve low-cost private primary schools in South Africa employs two blended learning models—a lab rotations and a "flex" model in which students spend 40–80 minutes a day in learning labs. Nova Pioneer Schools, which operate primary and high schools in Kenya and South Africa, also use a blended learning approach. SPARK will open its first high school in South Africa in January 2019 (Dick, personal communication, September 11, 2018).

Figure 6: An after-school remediation program in Eldorado Park Township outside of Johannesburg, South Africa. (Photo: Mary Burns)

Students are taking advantage of the Internet for additional tutoring, remediation and exam preparation. One of the biggest technology-related growth areas in secondary education is taking place in after-school and at-home online tutoring, remediation, and exam preparation services. In South Africa, numerous NGOs run after-school tutoring programs using secondary school labs and providers such as EDR's Edutrac. Online fee-based tutoring programs like BrightSparkz or PaperVideo proliferate in order to meet demand from those families who can afford to pay. In the Western Cape Province of South Africa, one of the seven priority projects known as Game Changers (a provincial initiative) provides quality after-school programming, with and without technology, to learners in no- and low-fee schools (defined as those that cost between 0 and 1,140 ZAR per year). The goal is to ensure that at least 20% of all learners in these schools attend regularly and consistently, that is, two times weekly for at least 70% of the available time (Tainton, personal communication, September 16, 2018).

Though not an after-school program *per se*, the Kenyan company Eneza delivers educational resources to remote schools through low-cost mobile technology (Asego, 2013). The platform runs mainly as a revision and learner scaffolding platform to better prepare students. Data suggests that students using the platform improved their performance on the Kenyan national exam by about 5%, while the most active participants performed 15% better overall. Students using the online platform spend an average additional four hours per day studying after school (Asego, 2013).

Figure 7: Training inside the Cyber Caravan in Mauritius. (Photo: National Computer Board)

In Mauritius, the Ministry of Education set up the Student Support Programme (SSP) (http://ssp.moemu.org). It is an initiative of the Ministry of Education and Human Resources, Tertiary Education, and Scientific Research in collaboration with the Open University of Mauritius (OU), the Mauritius Institute of Education (MIE), and the Mahatma Gandhi Institute (MGI). The SSP is being developed with the assistance of the Government of India through the National Council of Educational Research and Training (NCERT). Students are provided free additional support via interactive learning materials, instructional videos, and e-presentations through a web portal. This supplementary instruction provides all students with the opportunity to consolidate their learning.

Tablet programs are proliferating across the continent. Many policy makers and educators appear to have settled on tablets as a compromise between mobile phones and laptops, and the growth in tablets and tablet-based initiatives across sub-Saharan Africa is indeed striking. Tablet-based programs are often externally driven. For example, Worldreader distributes digital books to schools and libraries in 47 countries (mostly in sub-Saharan Africa) via tablets. The Portuguese company JP Group furnishes the tablets and laptops for Kenya's DigiSchools program (and has promoted in-country device manufacturing). The Chinese technology company Huawei has donated tablets to high schools in Botswana, including the Moshupa Senior Secondary School. At a much larger scale, Huawei has built most, if not all, of Cape Verde's telecommunications and Internet infrastructure and provided tablets and necessary connectivity to the Ministry of Education of Cape Verde to support its WebLab program and its tablet distribution to teachers.[28]

The Government of South Korea has provided tablets and technical support (in the form of school-based South Korean interns), to support tablet-based learning for a number of high schools in Botswana. OneBillion provides tablets to young children in Malawi to promote local-language literacy and numeracy via its OneCourse application. Kenya's national literacy program, Tusome (implemented by the US-based organization, Research Triangle, Inc.) is a USAID-funded project that provides tablets for literacy coaches so they can provide instructional support to primary school reading teachers (Piper et al., 2017).

There are also a number of government-funded tablet programs, such as Gauteng Online (which distributes tablets beginning in grade 12, moving down the secondary system) and the Government of Mauritius's 2013 tablet pilot program. Gauteng Online has subsequently run into funding difficulties, while the Government of Mauritius has shifted its tablet program from the secondary school level to the primary school level.

The private educational technology sector in sub-Saharan Africa continues to grow. The educational technology sector is not present in all countries, and it is not large (Martin, personal communication, October 8, 2018) but there are promising patterns. For example, educational technology hubs are growing in many countries like Nigeria, Kenya, South Africa, and Ghana (theatlas.com, 2017). Injini, a South Africa-based educational technology incubator, has funded and provided management and technical assistance to educational technology start-ups in South Africa, Kenya, Tanzania, South Sudan, Ethiopia, and Nigeria (Martin, personal communication, October 8, 2018).

Educational technology initiatives, many of them targeting the secondary level and scaling all income levels, can be found across sub-Saharan Africa. Initiatives like LightBulb (in South Africa) links high school students to tutors for single and group tutoring. Mtabe ("Smart Student" in Swahili) is an offline Artificial Intelligence (AI)-powered text message-based search engine. Students can text messages about the Tanzanian curriculum and take curriculum-aligned quizzes.

In South Africa and South Sudan, respectively, Siyavula and Yobooks provide digital textbooks to students. Siyavula is an education technology company, initially funded by the Shuttleworth Foundation, and an Open Educational Resource (OER) publisher that provides open textbooks and learning materials for all grades and subjects within South Africa. Released under Creative Commons licenses (Creative Commons, n.d.), these resources are free for users to print and adapt as needed, depending on the license chosen. Siyavula has successfully partnered with South Africa's Department of Basic Education (DBE) (see Box 10) to review and endorse the open textbooks produced by Siyavula, as well as to enable the printing and distribution of free-to-the-user copies of their textbooks (Attwell, 2012).

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[28] For more information, see Huawei's report, Cape Verde Goes Digital: https://www-file.huawei.com/-/media/corporate/pdf/publications/winwin/31/11-en.pdf?source=corp_comm

Finally, angel investors, some of whom are based in sub-Saharan Africa, are funding low-cost private school initiatives like Nova Pioneer Schools and SPARK Schools.

Teacher openness toward technology and their understanding of the potential of ICTs continues to grow. Interviews with stakeholders across the case-study-country sites confirmed a growing general acceptance of and understanding about technology among secondary school teachers. This openness may not translate into proficiency or actual use for planning or teaching, but it is a positive development.

More teachers have access to technology at home or at school and younger teachers understand technology (though not always Office software). More teachers report knowing far more about ICTs than they did five years ago; they are more likely to use technology as part of their professional work; they are more likely to undertake some form of interactive teaching, however modest; and they more likely to express enthusiasm about ICTs (Montjane and Mohlala, personal communication, September 10, 2018; Bright and Merafhe, personal communication, September 18, 2018; Marques, personal communication, November 19, 2018). New teachers in South Africa, Botswana and Cape Verde who graduate from university and begin their teaching career in junior and senior secondary schools know how to use ICTs, although many Internet, hardware, and software constraints in schools often inhibit their use.

Educational technology in sub-Saharan African schools is still largely driven by technological (rather than) pedagogical decisions. Governments still focus on providing Internet access, digital content, and equipment to schools, and pay far less attention to helping teachers enhance and transform teaching through technology. Such an omission in turn fails to provide students with the mindset and skills to prepare them for jobs in the formal sector.

This overemphasis on technology, with its corresponding under-emphasis on pedagogy, accounts for uneven teacher skills in using technology and digital content, uneven pedagogical practices with technology, and uneven (or even a lack of) professional development to help teachers design, teach, and assess using technology. There appears to be little recognition of models of teaching with and designing for technology that show pedagogical transformation, such as Puentedura's SAMR model or TPACK (Roos, personal communication, September 14, 2018).

Secondary education systems lag behind in making the connection between technology skills and work readiness. In school visits, researchers saw little evidence of explicitly using or emphasizing the use of technology to prepare students for jobs and careers. We use the term, "explicitly" because certainly IT classes teach students to use word processing, spreadsheet and presentation software that form a part of professional environments. And certainly IT classes provide students with important keyboarding and file management skills. Students themselves do not need to be convinced of the importance of learning technology—they see it in the world around them, but there was no empirical evidence that schools were making that connection.

Cape Verde's WebLab program provides a dramatic exception to this pattern, however. WebLab is an after-school program in Cape Verde funded by Huawei and overseen by Cape Verde's Nucleo de Operação de Sistema de Informação (NOSI) in partnership with the Ministry of Education and Sports.

Figure 8: WebLab students and teacher at Liçeu Ramos, Praia, Cape Verde. (Photo: Mary Burns)

The program, launched in September 2018, operates in 43 of Cape Verde's 44 secondary schools. WebLab activities are held in a secure solar-paneled shipping container on the school grounds. Containers have high-speed Internet activity and are outfitted with a smartboard, laptops, tablets, technology repair kits, technology components (e.g., motherboards), and other materials. Each container accommodates twelve students and one facilitator, a teacher trained by NOSI).

WebLab consists of fifteen problem- or challenge-based modules. Within these modules, students learn how to use the programming language Makeblock to create robots, learn about mobile and web application programming, White Hat hacking, web page and graphic design, networking, and building and repairing laptops and mobile phones. WebLab is designed for 12–16 year-olds and aims to target an equal number of girls and boys.

Sub-Saharan Africa's digital divide is transversal and persistent. The digital divide, present everywhere, is particularly complex in sub-Saharan Africa, and transects geography, gender, economics, demography, ability, and pedagogy. It is a *digital equity divide*; students in secondary schools in sub-Saharan Africa continue to have less access to technology than secondary school students in the rest of the globe. It is a *gender divide*—more boys than girls have access to technology in schools. It is a *regional divide* between parts of Africa beset by conflict and crisis—northern Nigeria, Somalia, South Sudan, northern Mali, the DRC—and areas without conflict. It is an urban-rural divide (see Box 8). It is an *economic divide* between students in government and private schools (discussed below). It is a *home-school* divide, whereby students without home Internet access or a computer lack access to the educational content, resources for homework, and tutoring that students with a home computer and Internet access

Box 7: Bridging the Gender Digital Divide

The digital divide in sub-Saharan Africa is gendered, in part because more boys than girls attend junior and senior secondary school. As noted on page 10 of this report, organizations such as GESCI, UKAID's Girls Education Challenge and the German development agency, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) program, eSkills4girls, are attempting to bridge this divide enjoy. The biggest divide may be between those students who have access to teachers with sufficient digital, pedagogical, and content knowledge to create meaningful and engaging learning activities via technology, and those who do not (Thomson, personal communication, September 4, 2018).

This digital divide will exacerbate existing inequalities, resulting inevitably in further exclusion of those left behind as employers require digital skills of employees and as opportunities for digital financial inclusion, "gig work" and entrepreneurship through technology platforms become more prevalent.

Box 8: The Rural-Urban Digital Divide

Globally, people living in rural areas are significantly less likely to incorporate digital technology into their lives than their urban counterparts. This is also true for sub-Saharan Africa. A 2018 Microsoft report on the digital divide in rural America essentially encapsulates the rural-urban divide in sub-Saharan Africa.

First, fewer customers living longer distances apart means less revenue and higher installation costs for telecommunications companies. Installing fiber-optic cable—the gold standard of broadband service—can cost US $30,000 per mile. This means that delivering sufficient broadband to remote parts of the US would cost billions of dollars, an expense the private sector has not yet been willing to pay.

Second, the development of alternatives to fiber-optic cable has been slow and uneven. While mobile telecommunications technologies such as 4G LTE have given customers broadband-like speed through mobile devices such as smartphones, the cellular model of this technology is designed for densely populated areas and faces the same connectivity and capacity gaps as traditional broadband. There is a perception that weak demand for broadband in rural areas cannot support private investment.

Source: Microsoft. (2018). *A rural broadband strategy: Connecting rural America to new opportunities,* p. 8

The digital divide between many government and private schools continues to grow. Research for this study presents stark differences between the amount, quality of, and access to technology in private and government schools. However, the biggest divide may be in how technology is used for teaching and learning—a function of differences in access to working technology, teachers' instructional abilities, the nature of the examinations system, and curriculum constraints.

For example, in the South African township schools visited for this study, despite the presence of projectors, Internet and interactive whiteboards, the dominant mode of technology use involved students quietly copying notes from interactive whiteboards, which effectively functioned as chalkboards. In contrast, as mentioned previously, in private schools like Parklands College in Cape Town, students engage with technology in higher-level ways—developing learning apps for sale in Apple's iTunes store, constructing Sketchpad models of proposed school buildings for a new campus, and using Virtual Reality[29] and Augmented Reality.[30] In the SPARK schools, technology is used to provide students with personalized content-specific remediation and enrichment. This frees up teachers to focus more on learner-centered, project-based activities in classrooms.

[29] Virtual reality (VR) can be used in classrooms to enhance student learning and engagement. VR can transform the way educational content is delivered; it works on the premise of creating a virtual world, real or imagined and allows users to interact with it. Being immersed in what the student is learning gives motivation to fully understand it. It requires less cognitive load to process the information. In the era of digital devices, we have an opportunity to enable better learning with technology. Virtual Reality (VR) seems to be the natural next step for the evolution of education. VR is a powerful educational technology. It is immersive, easy to use, meaningful, adaptable and measurable.

[30] Augmented Reality (AR) has the potential to encourage learners to explore learning materials from a totally new perspective. Besides, the advancements made in information technology further broaden the scope for educational AR applications. The proliferation of wireless mobile devices such as Smartphones and tablets has made AR mobile. Most of these systems are GPS-enabled, location-aware, and provide wireless access to the Internet. High quality video cameras and audio functions provide the basis for future learning and instruction.

Part V: Recommendations

The recommendations offered here, to policy makers, the private sector and donors, draw heavily from interviews conducted for this report. As can be seen in Appendix 1, all interviewees were asked to recommend actions, strategies, etc. to best help governments best use technology to improve access to secondary education, improve learning, strengthen management of schools and the education system, and foster innovation.

> *Planning is important. There has to be a common vision.*
> Teacher union representative, Cape Verde
>
> *Governments need clear vision that is aligned with uses (implementation, evidence-based).*
> Donor
>
> *Be visionary.*
> School leader, South Africa
>
> *Policy makers lack the basic understanding of [what] technology is all about, how it can be used to improve learning.*
> Government official, Botswana

As explained on page 6 of this report, all narrative information (interviews and observation notes) was coded in the qualitative software program, *NVivo*.
Codes were collated based on commonalities (for example, "digital content" was joined with "digital resources") to create concepts and *categories,*

Thus, in examining these recommendations, it is important to bear in mind that they represent the number of *instances* of a concept. The ranking of the recommendations here is not the author's decision but rather reflective of running frequency counts in NVivo. Thus, the recommendations are presented in order of prioritization by interviewees based on this process.

A. Policy Makers

Recommendation 1: Have a vision for ICTs in education.

Technology's potential to improve and transform teaching and learning at the secondary education level, under the right conditions, is enormous. Interactive digital content can engage learners and make difficult-to-understand concepts more accessible to learners. It can offer learning opportunities to young men and women who are internally displaced or who are outside the formal education sector. It can connect students to after-school learning opportunities. Project-based learning that employs real-world uses of technology can engage learners in real-world tasks and activities, thus preparing them for the world of work. Students are excited by technology, and—at least in these case-study countries—most teachers are open to using technology, provided that it works and that they have been trained and are supported in doing so.

Despite this potential, and despite general enthusiasm about ICTs at the highest levels of government, the most striking theme that emerges from this data analysis is a lack of vision for how technology can impact and transform secondary education (South Africa and Mauritius excepted). This lack of vision is pervasive throughout the secondary education system in many of the national education systems examined for this report. It is evident in the marginalized role that ICTs play in schools: confined to skills training or relegated to an elective or examined subject in the national syllabus. It is evident in the lack of professional development for teachers, apart from skills training. It is evident in the difficulty of articulating what technology integration looks like in classrooms. It is evident in the adoption of technology tools like interactive whiteboards with little consideration or understanding of how such a tool can paradoxically promote a highly passive model of instruction. Finally, it is evident in the common practice of giving teachers devices and Wi-Fi—without requiring and supporting corresponding changes in instructional styles.

An actionable vision for ICTs should be part aspiration-oriented (a vision of a model of secondary education supported by technology) and part needs-based (based on identifying the most pressing needs within the secondary education systems involved and considering whether and how technology can address such needs). A vision for ICTs in schools should be part of any national planning or policy framework (discussed in the second recommendation, below). Policy makers should have a vision of the kind of teaching and learning they want to develop, as well as the knowledge and skills students should exhibit when they leave the secondary school system. This can help guide purchasing and procurement decisions, help policy makers determine which changes should be introduced to the system (and how such changes should be managed), help determine the best balance for schools between accountability and autonomy, and focus on teacher capacity, educational management, and how educational technology can result in school improvement.

> *Countries may want something but have no goals apart from wanting ICTs. We have to guide (governments).*
> Private sector partner
>
> *Organization is an issue, communication is an issue, there is no planning. For a company this is a cost. These projects are expensive. The TCO is really crazy because of these logistics and communications cost.*
> Private sector partner
>
> *Parents see new technology and want it used immediately. Schools feel pressure around adoption when they don't know what they are going to use it for. This is especially true for tablets—schools bought hundreds of tablets before thinking about, what will we use them for? There's lots of hardware schools could not use.*
> South African educator

Recommendation 2: Develop an enabling and integrated policy environment for ICTs. Implementation of ICTs in secondary education systems often falls victim to an absent or incoherent policy environment. Countries may have no ICT in education plan; an umbrella national technology plan (with no developed explicit, comprehensive linkages to education); or a national educational technology plan that lacks coherence, supports, specificity, and funding). Within such environments, attempts to use ICTs in a coherent systematic fashion often fail.

For technology initiatives to succeed within the secondary education system, countries need a robust and integrated policy environment that involves the following:

- **Political will and prioritization.** Technology must be a priority within the education system, with vocal and visible support from the highest levels of government (as in the case of Kenya or the Western Cape province in South Africa)
- **Planning and plans.** The planning process includes all stakeholders (teachers, parents, business leaders, students, policy makers, etc.) and creates national actionable plans that take into account local constraints and address the most salient educational needs. Governments need to go “slowly on planning so that they can go more quickly on implementation” (Schäfer, personal communication, September 17, 2018)
- **Vision.** An agreed-upon vision for what excellent teaching and learning with technology looks like in practice so that everyone knows what they are working toward
- **Metrics.** Measurable goals, methods to assess student learning outcomes, teacher performance and progress, realistic guidelines and timelines for implementation and use
- **Support.** Maintenance, repair, replacing old equipment, training, security, support
- **Capacity building.** For key educational actors: district officials, supervisors, subject specialists, head teachers or principals, teachers, and students
- **Internet connectivity.** Fiber-optic, satellite, and or Wi-Fi installations in classrooms, not just the principal’s office
- **Educational supports.** Digital content in local languages, digital textbooks, online assessments
- **Curriculum.** Technology should be integrated across all content areas (not be treated as a stand-alone subject)
- **Budget.** ICT initiatives that are fully costed and funded with a ring-fenced budget that targets not just technology purchases but training, coaching, maintenance, content, etc. Since African governments often face revenue shortfalls, it will be necessary to devise solutions for long-term funding, limit the scope of technology initiatives, or explore options that minimize cost (such as open education resources)
- **Partnerships.** Take advantage of synergies with non-governmental partners to improve the system. Policy makers need partnerships that are well structured, with committed partners and shared goals, but governments should ensure that private-sector initiatives are addressing government secondary-school educational technology priorities; they should direct all funding and donations from the private-sector and donors into a ring-fenced trust to be used for educational technology initiatives (similar to South Africa’s National Education Collaboration Trust)

The above policy and planning process cannot be the responsibility of education ministries alone. It will also involve engaging ministries of planning, finance, telecommunications, infrastructure, etc., as well as business partners, universities, teacher unions, parent groups, and schools. It critical that these stakeholders work together, since the absence of broad participation, coherent policy frameworks, supportive institutional arrangements, and interlinkages will impact the scope and quality of implementation. This coordination and collaboration among ministries will most likely necessitate central-level coordination and mandates from the highest levels of government.

Within Ministries of Education, too, various departments must work together in the development of national educational technology policy and accompanying plans. Interviews with stakeholders suggest that curriculum departments, assessment departments, teacher education departments, and e-learning departments operate in silos and do not interact with one another. Within a policy development framework or activity these departments need to collaborate.

Recommendation 3: Focus on human resource development.

Teacher attitude is key.

Happy Jelelti, Hulwazi Secondary School, Daveyton Township, Gauteng Province, South Africa

Though responsibility for successfully using technology to improve the quality and delivery of learning often falls disproportionately on teachers, it is in fact a responsibility shared among all actors in the education system. Education officials, school leaders (principals), and teachers need ongoing professional development and support in how to use technology to fulfill their professional tasks. More importantly, they need professional development and support to help them fulfill their professional roles of supporting the integration of technology into teaching and learning.

Education officials and principals must understand how to support and evaluate teachers as they use technology to promote more learner-centered environments, and teachers themselves must know how to incorporate technology into lesson design, instruction, and assessment. This support could take the following forms:

Professional development for education officials within the system, particularly those who are supposed to supervise, monitor, support, or evaluate teachers. Often education staff in the lower echelons of the education system (at district or municipal levels) are expected to support and train teachers. Instead, their primary responsibilities are often administrative and accountability-focused. Furthermore, many lack practical teaching experience and thus lack lived experience of the daily responsibilities and challenges of teaching. This is a layer of the education system that, if developed, trained, and supported, could potentially provide needed support for teachers attempting to use technology to shift instructional and assessment practices.

Professional development for school leaders. Leadership is a critical ingredient in school improvement. School leaders/ principals establish the school-based climate and make decisions about the values and culture of the school. They need to be good resource managers as well as inspirational and motivational leaders, and they should support good instruction with and without technology. The connection between supportive and facilitative leadership and teacher development is well established in educational research (McCann et al, 2005).

Professional development for teachers. This should help teachers develop competencies in integrating digital tools and resources into their teaching (such as those outlined in the UNESCO framework, which South Africa has adopted) and embody characteristics of high-quality professional development by:

- **Focusing on the core areas of teaching**—content, curriculum, assessment, and instruction, and how technology can support each
- **Addressing teacher and student needs** via approaches that are appropriate for conditions in schools
- **Being long-term, ongoing, sequenced, and cumulative**, providing teachers opportunities to gain new knowledge and skills, reflect on changes in their teaching practice, and increase their abilities over time
- **Focusing on student learning outcomes** in ways that enable teachers to use their new knowledge and skills
- **Modeling learner-centered instruction** so that teachers experience and reflect on the learning activities that they will lead
- **Using formative and summative evaluation** for program improvement, being highly practice-based, and allowing teachers to see models of intended practice (Gaible & Burns, 2005, pp. 16–17)
- **Providing teachers with ongoing school-based** supervision, support, and follow-up
- **Incorporating change management strategies** so that teachers understand the changes wrought by new innovations, why change is necessary, why individuals resist change, and the stages of the change process

Box 9: Leadership in Digital Learning

SchoolNet South Africa's Change Leadership for Digital Learning is a series of professional development courses in ICT Integration based on teacher needs. It uses a peer coaching program to sustain the professional development after the intervention.

Ongoing support and coaching for teachers. Without ongoing classroom-based support to help them internalize what they have learned in professional development, teachers will fail either to implement or abandon new instructional methods, particularly in the face of difficulties such as a lack of resources, an examination system misaligned with instructional practices, or a lack of principal or colleague support. To unlearn less-than-optimal practices and learn approaches more amenable to student learning, teachers need the assistance of a *highly competent* school-based or district-based support person who understands how to help teachers get from point A to point Z.

It is critical that those providing professional development and support to teachers have practical experience in teaching secondary-school-age students. This is often not the case in universities, where instructors may lack practical teaching experience with younger students. This in turn results in pre- and in-service instruction for future and current teachers that is overly theoretical and that lacks modeling of intended practices.

Recommendation 4: Provide schools with Internet access. Internet connectivity is still a mixed bag in sub-Saharan African schools. The good news is that Africa has demonstrated some of the world's highest growth in fixed broadband (ITU, 2018, p. 20) and access to mobile broadband has increased in urban areas.

> **Box 10: Broadband in Rwanda**
>
> The Government of Rwanda has made significant progress toward affordable broadband for all. In 2008, the Government of Rwanda (GoR) embarked on a nationwide roll-out of fiber-optic cable as a backbone infrastructure for broadband. This cable connected different parts of the country and provided high-capacity cross-border links with onward connectivity to submarine cables. In 2013, GoR published a new broadband policy aimed at restructuring the broadband market under an infrastructure-sharing regime and by putting in place a 4G LTE wholesale open-access network as a means to accelerate roll-out of broadband network services and reduce overall infrastructure investment costs. The network currently provides access to 90% of the national population, though the majority of the population is not using 4GLTE.
>
> **Source:** ITU, 2018, p. 34.

The bad news is that reliable Internet is still unavailable and unaffordable to many sub-Saharan African teachers and students. With about half of the continent's population located more than 25 kilometers from the nearest fiber connection, broadband connection in rural areas remains very low. With over 70 percent of the population living in rural areas, the majority of those who need the Internet the most, such as rural schools, do not have it due to access challenges. The variation in regulations and the strong market concentration around a few players also makes the cost of access high. Existing Internet providers tend to have outdated low-quality networks that are not optimally connected to national, regional, and international Internet exchanges, nor are they resilient against failures and outages (Internet Society, 2017). Further, telecommunication operators still face considerable technical and financial challenges in expanding networks into more remote regions, making it difficult to deliver truly universal and affordable broadband service to communities (ITU, 2018, p. 9).

The problematic state of the Internet for schools must be addressed. While there is no simple solution or one solution, governments can employ policy and technical solutions to address this. They can invest in satellite-based Internet,[31] lease unused strands of dark fiber, build government-owned networks, incentivize telecommunications providers to provide subsidized access to rural areas, tax Universal Service Funds,[32] and/or use "white spaces"—wireless technology that leverages

[31] Satellite coverage is considered to be the most cost-effective solution for most areas with a population density of less than two people per square mile (Microsoft, 2018, p. 2). However, satellite-based Internet often suffers from high latency, lack of significant bandwidth, and high data costs.
[32] Though unexplored and potentially promising, Groupe Spéciale Mobile Association (GSMA) outlines some of the financial, legal and regulatory challenges associated with this. See GSMA (2014). *Sub-Saharan Africa: Universal Service Fund Study.* Retrieved from https://www.gsma.com/publicpolicy/wp-content/uploads/2016/09/GSMA2014_Report_SubSaharanAfricaUniversalServiceFundStudy.pdf

unused television and radio frequencies to create wireless broadband connections while protecting broadcasters and other licensees from harmful interference. This "dynamic spectrum alliance" has been used to varying degrees in Botswana, the Democratic Republic of Congo, Malawi, South Africa, Namibia, Ghana, Kenya, Nigeria, Tanzania, and Zambia (Microsoft, 2018, p. 21).

Recommendation 5: Capitalize on the potential of mobile technologies. As Ministries of Education wrestle with providing equipment and connectivity to schools, they overlook one technology that many people own and know how to use—mobile phones. Sub-Saharan Africa has extremely high mobile phone penetration among teachers, and as smartphones drop in price, this penetration will continue to increase.

Figure 9: Cape Verdean students with mobile phones during school break. Despite high rates of ownership among many secondary school-age students in South Africa, Botswana, and Cape Verde, mobile phones are not allowed in classrooms. (Photo: Mary Burns)

Yet despite the ubiquity of smartphones, mobile phones are not allowed in classrooms in South Africa, Botswana and Cape Verdean schools unless specifically sanctioned by a teacher on a per-activity basis. There are valid reasons for limiting mobile phone use in class, but further exploration of leveraging smartphones for teaching and learning purposes should be explored. Potentially, smartphones could allow schools to institute Bring Your Own Device (BYOD) programs that reduce the amount of equipment governments must purchase. It could alleviate pressures on the Internet by having students use more reliable cellular networks. It could jumpstart greater development of mobile-based educational content for anywhere, anytime access. [33]

Recommendation 6: Use ICTs to address language issues.

[33] IDEA Digital Education, which has developed the digital content for South Africa's national curriculum to be hosted on Department of Basic Education servers ("DBE Cloud"), has created core curriculum content for device-agnostic (mobile, tablet, and computer) delivery that students can access for a per user price of 60 South African Rand ZAR60 (US$4.30) per year. The mobile telecommunications provider, MTN, charges the equivalent of two South African cents per day to access its content.

Language is a complex issue in many parts of Africa. As a case in point, in Lusophone Africa—Guinea-Bissau, Mozambique, Angola, São Tomé e Principé, and Cape Verde—only a minority of people in Lusophone countries are proficient in the official language of Portuguese, with the exception of Angola and Cape Verde (Barreto, personal communication, November 5, 2018).

ICTs can exacerbate language issues because operating systems, software, and resources are predominantly available in languages that many African students and teachers do not understand or understand well. However, ICTs can assist greatly in addressing language issues. Teaching and learning resources can be developed in commonly spoken and local languages (for example, Kiswahili); ICTs can be used to preserve African and Creole languages; and they can be capitalized upon to improve teaching in the official education system languages of English, French, Portuguese, and Arabic.

Recommendation 7: Invest in ICTS to gather and use data for decision-making and planning. One of the biggest successes in terms of education-related technology in sub-Saharan Africa has been the use of ICTs for data collection and management. In Kenya, the Ministry of Education, Science and Technology releases national exam results via the World Wide Web. The Kenya School Mapping project uses Geographic Information Systems (GIS) to collect data on such attributes as the location and physical condition of facilities, enrollment, and the number of teachers. These data are made available to educational planners, other professional users, and average citizens. GIS has also been used for school planning in Mali and Nigeria and in South Africa to identify and map isolated rural schools to take part in the Primary School Nutrition Programme (PSNP).

> **Box 11: Data collection tools in South Africa**
>
> South Africa uses a number of data tools for planning, management and decision making such as the Annual School Survey (ASS), which determines coverage, enrollment, and repetition and dropout rates by gender and province.
>
> The SNAP Survey of Ordinary Schools collects annual data from all schools in South Africa. The data forms part of the national Education Management Information Systems (EMIS) database used to inform education policy makers and managers in the Department of Basic Education (DBE) and provincial education departments for planning purposes
>
> The South Africa SAMS system tracks government school data records throughout academic career of learner. These data are made available to schools by DBE via data dashboards, though DBE does not allow direct access to data.
>
> **Source:** Department of Basic Education (2016)

While it is not a secondary education provider, Bridge International Academies, which operates schools in Liberia, Kenya, Uganda and Nigeria, uses teacher tablets not just for scripted teaching but also for data collection as mentioned earlier in this report. The use of tablets allows for centralized data collection and analysis. Bridge is able to collect assessment data, monitor teacher absenteeism, and track the impact of its model on the effectiveness of individual schools for planning, teaching, and even procurement decisions. The use of tablets for automated data collection frees up teachers from manual data collection tasks so they can focus more time on instruction (Geraghty, personal communication, October 15, 2018).

At national, district/regional, and school levels, education officials, principals, and teachers (and perhaps department heads) should be provided with appropriate hardware, software, and professional development so they know how to collect, disseminate, analyze, and use data for continuous improvement. At a national level, such data collection could assist with more efficient and equitable allocation of resources and improved education planning. Ministries of Education could make these data available on their websites in accessible file formats so that donors, the private sector, universities, and NGOs could target their programming to the greatest national needs. The use of visual and intuitive data dashboards (via free and easy-to-use web-based tools or apps) that allow for fine-grained data modeling would allow Ministries of Education to track the performance of the overall education system.

At the school level, the use of simplified digital data collection tools, along with school-based "data conversations," can improve monitoring and attainment of student learning outcomes.

B. Private Sector

While schools and governments are grateful for equipment donations from private sector companies, interviews for this study reveal concern around this involvement. The following recommendations, compiled from interviews (see Appendix 1), provide a set of prioritized recommendations to address such concerns.

Recommendation 1: Focus on long-term, national imperatives.

No sub-Saharan African government can develop a robust, quality-based ICT in education program without the support of private-sector partners. However, numerous government officials expressed concern, gratitude notwithstanding, that local and international private sector companies often "do their own thing." Examples include circumventing national or provincial governments to work directly with a set of schools; providing certain types of hardware that may not yet be trialed, researched, or educationally feasible, but that companies want to showcase; or marketing new technologies to parents, who then pressure schools to purchase devices whose success and robustness is still undetermined. Such actions often countermand national or provincial ICT in education initiatives, causing disruption, waste, and confusion in schools. Small isolated technology initiatives lack impact and sustainability.

> *We don't want equipment dumped on us.*
>
> School directors, South Africa, Botswana, Cape Verde
>
> *We don't want refurbished computers. We want technology that is educationally relevant and durable for students.*
>
> Government official, South Africa

Therefore, the private sector should consult government before conceptualizing and deploying any technology solution into the education sector in order to work in concert with government to focus on priority areas or initiatives and to do so in an organized, collaborative, and reciprocal manner. In working with government, the private sector should ensure that its digital projects are guided by an integrated and consolidated vision and a set of shared goals that involve using technology as a tool to reform and improve teaching, learning, and management of information. Public-private partnerships aligned with government educational priorities and strategies can then hopefully make digital learning a deeper, more relevant, and more meaningful endeavor than has often been the case.

Recommendation 2: Move beyond the device to the ecosystem. When educational technology initiatives have failed, which, as outlined in this report, is far too often, they have done so because stakeholders—governments, private sector companies, and schools—have focused on the device to the exclusion of more important inputs. Certainly, secondary schools must have access to appropriate *educational* technology that is simple, easy to use, and has proper filters (so that students don't access inappropriate content—a major issue with devices such as tablets in many of the schools visited by researchers). But any initiative that places technology in computer labs (or tablets in the hands of students) with no attention to critical human, infrastructural, and educational supports is bound to fail.

Technology companies in many countries in sub-Saharan Africa drive many ICT in education initiatives, so there is often a disproportionate focus on the cost of equipment. Yet successful educational technology initiatives focus on a "whole systems" approach. Before putting technology in schools, private sector companies must—on their own or in concert with policy makers—ensure that the following are in place and addressed:

> *If we want to see the benefit[s] and positive impact of technology in schools, we have to invest in pedagogy; understand the learning required for Fourth Industrial Revolution; and identify the affordances of tech that will support learners for this.*
>
> Government official, South Africa
>
> *Policy makers lack the basic understanding of [what] technology is all about, how it can be used to improve learning. I can use my phone, but I do not know how to use beyond what I need. We need teacher-training models. We need school-based in-service supports. Connect us to schools we can partner with. Show us good models of ICT in action.*
>
> Government official, Botswana

- **Basic physical infrastructure.** Portugal's JP Group, which provides the tablets for Kenya's DigiSchool program, recommends that before technology companies agree to provide technology to schools, they first help schools with basic physical infrastructure electricity, solar power (instead of electricity) plugs, a clean space for equipment, security, storage space, and reliable connectivity. Device security is a very salient issue in Cape Verde and South Africa, and policy makers explicitly requested that technology companies help governments ensure that devices are branded and can be tracked and disabled in the event of theft in order to depress their retail value.
- **Human capital infrastructure.** Teachers, students, and principals need to have keyboarding skills and know how to use devices and software
- **Digital content.** Relevant, standards-based content and online textbooks need to be available to students wherever they are. Technology companies should provide zero-rate data costs so learners can use devices to access educational content (as Vodacom has done

with its content for teachers). Given that intellectual property violation (in the form of pirated software)[34] appears common, private sector companies may wish to look at more affordable and flexible software licensing arrangements for schools, including a mix of proprietary and open source digital content which would allow for greater opportunities for local language versioning.

- **Technology for teaching and learning.** Policy makers, principals, and teachers need standards for and models of quality teaching with technology and ongoing professional development and support to help teachers use technology to improve teaching and learning.
- **Systems and supports to maintain, repair and refresh technologies.** Private sector companies should help national and provincial Ministries of Education and schools to develop maintenance plans, budgets for maintenance (perhaps putting a percentage of funds for donation into an escrow account for maintenance and repair)and replacement of old equipment.

C. Donors

"Donors" in this report refer to both bilateral donors, for example, UKAID or USAID, as well as multilateral donors such as UN agencies and the World Bank.

> *Invest in projects with an ICT dimension within capacity development with a degree of sustainability. Project approaches don't work.*
> University researcher, Portugal

Recommendation 1: Ensure that donor-funded initiatives contribute to national policies and objectives. As is the case with the private sector, donor-funded ICT in education projects often have their own agenda, their own timeline, and their own focus. This is problematic for a number of reasons. First, the project-based focus of donor investments may mean that initiatives occur independently of national ministries of education and are not aligned with broader national policies and objectives. Next, the short-term nature of projects means that such initiatives typically end when donor funding ends. Third, these short-term projects that are independent of and disconnected from government frameworks and policies can create unhealthy tensions and fragmentation within educational systems and put undue pressure on schools (because schools cannot make policy decisions).

Donors, like the private-sector companies mentioned in the previous section, must ensure that their funded initiatives contribute to national policies and objectives, and they must do so in ways that focus on sustainability. This can only occur when donors move from short-term, project-based approaches to more systems-based, long-term ones. This may involve working with policy makers to ensure that ICT in education policies are more coherent and integrated, both in and of themselves and in terms of donor policies. Or, if national strategies are unclear, donors can help to

[34] Based on researcher interviews in Cape Verde, Botswana and South Africa. Schools openly admit using pirated software since they need the software, especially for TVET classes, and in many locations (Cape Verde and Botswana), government does not provide software budgets.

"develop the policy environment, including expert support, financing and capacity building at both national and regional levels" (Souter et al., 2014, p. 83).

Recommendation 2: Stimulate and support innovative uses of technology. Given their reach, resources, and networks, donors can promote and fund innovation and experimentation in educational technology. They can bring together private and government schools to collaborate and share resources (as South Africa is currently doing with its "twinning" project between wealthy schools and township schools), prototype new technologies, and sponsor and trial technology "use cases" or pilots to address issues related to secondary education. They can then ensure that these relationships, prototypes, and pilots are rigorously evaluated; that a Total Cost of Ownership (TCO) is established; that the potential benefits and tradeoffs are well understood and disseminated; and that any developed technology tools or content are made available at no cost to government agencies, schools, teachers, and students.

Recommendation 3: Focus on high-quality research and evaluations and utilize that evidence for funding and program design.

Donors are distracted by photo opportunities in the one school with educational technology. They need to think about the other 99 schools.
Donor agency representative

Put more money into evidence gathering. It's not as attractive—but have a series of trials. We are quite interested in partnering for evidence gathering.
Donor agency representative

Demand clear and transparent results. Anyone who wants your money should show proof. If they can't, why are you funding them?
South African educator

One of the most troubling patterns around educational technology is the degree and frequency of poor implementation in secondary schools. Known poor practices—placing interactive whiteboards in classes and hoping for instructional transformation; the failure to provide teachers with ongoing professional development in instructional methodologies; the lack of planning—are endemic. This points to research failures—an absence of research on ICTs in the sub-Saharan context; the lack of dissemination among educators and policy makers of the research that does exist; and, most importantly, the failure to incorporate research findings in national and regional educational technology initiatives.

Donors, too, have not been able to make available adequate funding for evidence-based ICT in education research. The decentralization of donor funding and programming at the country level means missed opportunities for identifying and funding a global ICT in education research agenda, which could help move the field forward. For implementers, unless research is an explicit, funded mandate in their donor-funded project, it is often not possible for them financially, logistically or programmatically to carry out research on their initiatives (apart from required external evaluations).

Technology investments by donors and Requests for Proposals (RFPs) for implementing agencies, NGOs, and development to design and deliver such initiatives should focus on research-based evidence, proven theories of change, and evaluation findings that (Rose, 2018) demonstrate conditions in which educational technology can improve the quality of education for secondary-school students. Donors must require that educational technology program designers demonstrate that their proposed interventions are grounded in evidence. They should also promote high-quality research on what works in educational technology in low-resource sub-Saharan contexts (rather than simple program evaluations for the purposes of accountability). Such an approach would shift the focus from access to the quality of teaching and learning, the learner's experience in the classroom (Ngware et al., 2010), and academic performance and the role of technology in all of these.

As Rose (2016) notes, where the evidence base is weak or and the implementation context more fluid, donors should identify more flexible procurement mechanisms and program designs that allow adaptations. Where randomized controlled trials are not necessary or not financially or logistically feasible, donors should sponsor other types of carefully designed, utilization-focused observational or quasi-experimental research.

Recommendation 4: Invest in technologies and in instructional uses of technology that have demonstrated success. Two of the more successful technologies in sub-Saharan Africa are interactive radio instruction/interactive audio instruction (IRI/IAI) and mobile phones. One, IRI/IAI, has a proven forty-year history of educational success in sub-Saharan Africa. The other—mobile phones—offers tremendous promise as an educational tool. Most African countries have both radio and cellular network infrastructure, and radio and phones are technologies that people own and know how to use.

Yet, as part of this study, interviews with policy makers suggest that they are either unaware of IRI/IAI or consider it to be an "old" technology. Similarly, they regard mobile phones as too new, as not being expressly educational tools, and as too disruptive for classrooms (as evidenced by mobile phone bans in classrooms). Yet radio and phones are "bottom up" technologies, widely used and valued by their owners. They have the kind of reach that computers and the Internet do not, particularly in remote geographic areas or areas of conflict where the digital divide is most stark and where IRI and phones could potentially provide access to greater learning opportunities.

IRI and IAI have already been used in ways to enhance educational quality in sub-Saharan Africa, especially among girls and in rural areas (Anzalone & Bosch, 2005). South Africa's Open Learning Systems Educational Trust (OLSET)'s English in Action helped 52,000 teachers and nearly two million primary school students in nine South African provinces improve their English-language speaking and writing through radio-scaffolded active learning, games, and group work (Potter & Naidoo, 2009, as cited in Burns, 2011, p. 21). During 2014–2015, when an Ebola virus outbreak in Liberia resulted in national school closure, the Education Development Center, with World Bank funding, designed IRI programs that were broadcast throughout Liberia so students could continue their education.

In the African context, mobile phones have provided tutoring support to learners through Nokia Mobile Mathematics in South Africa and (now defunct) programs like Ask Dr. Maths and MxIt, as well as through access to educational apps and digital content (for example through World Reader).

They have promoted literacy and numeracy in Niger (Aker et al., 2012). In addition to their potential as tools for student learning, mobile phones have been used successfully to provide teachers in Africa with access to curriculum, language instruction, lesson plans, SMS support, content delivery, virtual coaching, and even their salaries. As a model of pre- and in-service distance-based education for teachers, IRI exhibits many best practices that provide demonstrable teaching and learning benefits (Burns, 2011).

Recommendation 5: Support educational-technology initiatives in middle-income sub-Saharan countries. The four case study sites—Mauritius, South Africa, Botswana, and Cape Verde—are all middle-income countries, as are most sub-Saharan African countries that have a developed secondary education sector (both "regular" education and technology and vocational education and training) and that utilize technology within that sector. All have fully developed secondary education systems, have made documented efforts to integrate ICTs within the secondary system, enjoy high secondary school enrollment, and ranked high in the ICT Development Index. Three of the four also have relatively small populations so represent a smaller fraction of the overall current/possible secondary student population in Africa.

Policy makers in all four expressed the challenges associated with their middle-income status. Many noted that "middle-income" is an overly broad designation that results in limited funding for needed projects. In interviews, many noted that Gross Domestic Product (GDP) is a deceptive statistic that obscures large urban-rural divides and regional economic disparities. They reported that they face similar funding constraints to those of their poorer African counterparts, since 75–90 percent of their budget is dedicated to salaries, leaving little funding for technology.

In such environments, technology stands a better chance of being integrated across the curriculum and into teaching and learning (versus being treated as a stand-alone subject). Furthermore, it is in these environments that technology has a better chance of being utilized in ways that will prepare sub-Saharan African secondary students for further education and for the rapidly evolving world of work. However, strengthening opportunities to support secondary school education in the lower resource context found in many other African countries is also a worthwhile endeavor, since without secondary education youth will be unable to participate in either higher education or in the formal employment sector.

A final recommendation: Start with education, not with technology. A constant question for researchers in conducting this study was this: *What technologies should African policymakers invest in?* This is an understandable question, but it is the wrong question. Technology programs that begin with such a question are bound to fail. As anyone familiar with ICT in education initiatives knows, most educational technology initiatives have indeed begun with this question, and as a result many (most?) have also failed.

The question instead for sub-Saharan Africa policymakers (indeed all policymakers) is this: *What are your goals for the education system? What needs are you trying to address?* Once these answers are determined, the next question should be, *Can technology help you attain these goals and/or* *address these needs and if so, how?* At this point, policymakers can begin to investigate which technologies may (or may not) help in this endeavor and how.

Appendix 1: Interview Questions

Main Question: *How can SSA governments best use technology to improve access to secondary education, improve learning, strengthen management of schools and the education system, and foster innovation?*
Focus: ICTs for secondary education and secondary-age students

1. **Policy:** Could you tell me about the ICT for education policy environment in [Country]?
   a. Does the government have a national ICT in education policy?
   b. What is the vison for educational technology?
   c. What are priority areas around technology use?
   d. Who is driving ICTs for education in secondary schools? National or regional authority?
   e. *If it exists,* how is the government implementing its ICT in education policy?

2. **Your organization's work:** How does your organization's work carry out this policy vision?
   a. How much coordination and interaction with the government do you have?
   b. What is your organization doing exactly? Audience? Reach?
   c. Successes/challenges?

3. **Types of technology:** What kinds of ICTs are being used for secondary education and for what purposes? How are they being used by and for:
   a. Students?
   b. Teachers?
   c. School directors?

4. **Trends:** What trends do you see in ICT use in [country] at the secondary level?
   a. What is different now from 5 or 10 years ago?
   b. How does what is happening here differ from what is happening in neighboring countries?

5. **Entities to promote technology**: Are there government-created entities that are promoting technology adoption in secondary schools in particular or educational technology in general?
   a. **For example, outside government**: SchoolNets, Innovation Labs, regional organizations, NGOs, universities, donors?
   b. **Inside government**: Chief innovation Officer, special offices within Ministry of Education, Ministry of Telecommunications, Ministry of Labor, etc. to oversee and manage new technologies before they are rolled out? Do such organizations have authority?

6. **Technology companies:** How active is the private sector in educational technology or technology in general here?
   a. How involved is the private sector in technology in [Country]?

   b. How much interaction and coordination is there between technology companies and the government
   c. How are educational technology pilots and initiatives developed?
   d. Who are the big educational technology/technology companies here?

7. **Openness to ICTs:** How open is the Ministry (Education, Telecommunications, Labor, etc.) to ICTs in education?
   a. How open are teacher unions?
   b. How open are teachers?
   c. What are concerns that you've heard or know of?

8. **Capacity to understand and use ICTs:** How well do policymakers understand the potential benefits and drawbacks of ICTs?
   a. How about regional education staff?
   b. Teacher educators?
   c. Teachers?
   d. Students?
   e. School directors?

9. **Finance:** How is educational technology financed? By whom?
   a. Fixed budget?
   b. Donor funded?
   c. Public-private partnerships?
   d. Are there any successful models of finance to promote investment into innovative education technologies?

10. **Teacher Pre-and In-service Training:** How are ICTs being used for teacher pre-and in-service training?
    a. What technologies specifically are being used and how?
    b. Descriptions of the professional development—topics? Types of technologies used? Who is supporting this?
    c. What successes and challenges do you face?
    d. Results?

11. **Implementation:** What percentage of secondary schools have ICTs? Classroom based? Labs? BYOD?

    a. If we walked into a junior or senior secondary school (that had technology), what would we see in terms of technology use?
    b. What would teachers be doing? What would students be doing?
    c. How would principals be supporting ICTs?

    d. How does technology adoption happen in schools?
    e. What is teachers' receptivity to teaching with ICTs?

12. **Digital divide:** How is the government using technology to provide educational access to:
    a. Rural youth?
    b. Girls?
    c. Street kids?
    d. Children with disabilities?
    e. Out-of-school youth?
    f. Migrants (IDPs, refugees)
    g. Remote geographic areas?
    h. What kinds of technologies is the government (or other actors) using?

13. **Success:** Are there examples of successful ICTs in education programs in [Country]?
    a. What makes them successful?
    b. How is success determined?
    c. Are there evaluations and data on these programs?
    d. Who is evaluating them and collecting data?

14. **Failures:** Why have ICT in education projects failed in [Country]?
    a. Where are the gaps?
    b. What mistakes have been made? By whom?
    c. Is there evidence that stakeholders are attempting to learn from failure?

15. **Scale:** Are there examples of successful and large ICT for education projects in [Country]?
    a. Describe project/initiative.
    b. Why are these projects scalable?
    c. How have these projects been incentivized?
    d. How have they been taken up—where? By whom and how?
    e. Why this project versus another ICT in education project?

16. **Lessons Learned:** Based on your experience, what factors influence success or failure of successful ICT for secondary education projects?
    a. What pre-requisites are necessary for investments in ICT to generate promised educational returns?
    b. What supports etc. need to be in place?
    c. Where are the evidence gaps? Research gaps?

17. **Recommendations:** Since this report is geared for a wide audience, what recommendations would you have for the following stakeholders in order to help governments best use technology to improve access to secondary education, improve learning, strengthen management of schools and the education system, and foster innovation?

a. Policymakers
b. Donors
c. Implementers
d. Private sector

Appendix 2: Interviews

Botswana

1. Allen Mubu Makanye, Senior Teacher and Department Head, Mathematics, Shakawe Senior Secondary School, Shakawe
2. Daniel Tau, Vice-Chancellor, Botswana Open University, Gaborone
3. Dineo Bosa Modimakwane, Executive Manager, Botswana National Commission for UNESCO, Gaborone
4. Fancy Amey, Director, Center for Distance Education, Botswana Open University, Gaborone
5. Gosego Mareka, Librarian and Math Teacher, Matatla Junior Secondary School, Gaborone
6. Hellen Chilisa, Deputy Permanent Secretary of Education, Ministry of Education and Basic Skills (MEBS), Gaborone
7. Kgomotso Motlotle, former Director, Department of Teacher Training and Development, Ministry of Education and Skills Development, Gaborone
8. Lenah Bright, Strategic Manager, Department of E-Learning, Ministry of Education and Skills Development, Gaborone
9. Nicodemus Merafhe, E-Education Coordinator, Department of E-Learning, Ministry of Education and Skills Development, Gaborone
10. Patrick Phiri, Head of the School, Moshupa Senior Secondary School, Moshupa
11. Robert Dikole, Principal Computer Programmer, Kgale Hill Community Junior Secondary School, Gaborone
12. Shima Sennye, Principal Education Officer and Head of Operations, Office of the President, Ministry of Education and Basic Skills (MEBS), Gaborone
13. Thabitha Gombalume, Department of ICT and Media Services, Ministry of Education and Basic Skills (MEBS), Gaborone
14. Voltah Modiredi Gabonthone, Senior Teacher, Computer Studies, St. Joseph's College, Gaborone
15. Zobo Motsemme, Computer Teacher, Matatla Junior Secondary School, Gaborone

Cape Verde

1. Albertino Delgado, Professor das TIC & Dirigente Sindical do SIPROFIS / Sindicato de Professores da Ilha de Santiago Praia, Santiago
2. Amilcar Lopes Alves, Monitor Weblab, Escola Secundária António Silva Pinto, Ribeiradas Patas, Santo Antão
3. Aristides Silva, Pre-reitor para o Pos-Graduação e Investigação, Universidade de Cabo Verde, Praia, Santiago

4. Cátia Marísia de Brito Boaventura, Subdiretora para Assuntos Sociais e Comunitário, Escola Industrial e Comercial do Mindelo, Mindelo, São Vicente
5. Cleonice Moreira, Universidade de Cabo Verde, Praia, Santiago
6. Cristina Ferreira, Universidade de Cabo Verde, Praia, Santiago
7. Daniel Augusto Correia de Pina, Secretaria Direção, Escola Secundária António Silva Pinto, Ribeiradas Patas, Santo Antão
8. Domingos Andrade, Coordinador do Grupo Disciplinar Informatica e Tecnologias Multimídia, Universidade de Cabo Verde, Praia, Santiago
9. Donaciano dos Reis Oliveira, Subdiretor Técnico e Profissional, Escola Industrial e Comercial do Mindelo, Mindelo, São Vicente
10. Edna Suzete Mendes Pereira, Técnica na Unidade de Recursos e Tecnologias Educativas Serviço de Multimídia e Educação, Ministerio da Educação e Desportos, Praia, Santiago
11. Emilia Monteiro Tavares, Universidade Jean Piaget, Praia, Santiago
12. Eufemia Mascarenhas, Jornalista, Radio Educativa do Cabo Verde, Ministerio da Educação e Desportos, Praia, Santiago
13. Evandro Fonseca, Universidade Jean Piaget, Praia, Santiago
14. Fernando Lima, Delegação da Educação do Santo Antão, Porto Novo, Santo Antão
15. Helen Andrade, Chefe da Delegação do São Vicente, Mindelo, São Vicente
16. Lídia de Brito Gomes, Directora do Liçeu Ludgero Lima, Mindelo, São Vicente
17. Joanita Rodrigues, Universidade Jean Piaget, Praia, Santiago
18. João Pires Pinheiro, Subdirector Administrativo e Financiero do Liçeu Ludgero Lima, Mindelo, São Vicente
19. Jorge Anildo Oliveira da Luz, Diretor, Escola Industrial e Comercial do Mindelo, Mindelo, São Vicente
20. José Marques DGPOG, Secretaria, A Direção Geral de Planeamento, Orçamento e Gestão Ministerio da Educação, Praia, Santiago
21. Josina Melício de Oliveira Ferreira, Subdiretora Pedagógica, Escola Industrial e Comercial do Mindelo, Mindelo, São Vicente
22. Luisa Soares Inocêncio, Universidade de Cabo Verde, Praia, Santiago
23. Mírcia Sofia Almeida Évora, Monitora da WebLab da EICM-GDC, Escola Industrial e Comercial do Mindelo, Mindelo, São Vicente
24. Oceano Artur da Luz, Diretor, Escola Técnica de Porto Novo, Santo Antão, Cabo Verde
25. Osvaldina Oliveira Lima Brito, Subdiretora Administrativa e Financeira, Escola Industrial e Comercial do Mindelo, Mindelo, São Vicente
26. Teodolinda Pereira Sousa Duarte, Secretária, Escola Industrial e Comercial do Mindelo, Mindelo, São Vicente

Mauritius

1. Hawabhay, Chief Technology Officer, Ministry of ICT
2. Ricaud Auckbur, Director e-Education, Ministry of Education and Human Resources
3. Om Varma, Director, Mauritius Institute of Education
4. Iqbal Maudarbacus, Project Supervisor National Computer Board
5. Yamal Matabadul, CEO, Polytechnics Mauritius
6. Jogesser Ravi, Rector, Secondary School, MGI-RTI Moka
7. Dharyan Minien, Secondary Educator, New Devton College, Rose Hill
8. Romeenah Boojhawon, Secondary Educator, Rajkomar Gujadhur SSS, Flacq
9. Ranjeeta Mungur, Secondary Educator, College Ideal, Rivière du Rempart
10. Gita Bachwa, Secondary Educator, Friendship College, Goodlands
11. Steeven Mootoocurpen, Secondary Educator, State Secondary School
12. Shikha Barosa, Secondary Educator, Friendship College, Goodlands
13. Rajen Appalsawmy, Secondary Educator, Ramsoondar Prayag SSS, Rivière du Rempart
14. Brinda Surnam, Secondary Educator, St Barthelemews College, Port Louis
15. Maheswaree Pem, Secondary Educator, Vacoas SSS (Boys)

Portugal

1. Fábio Sousa, Técnico Superior, Divisão de Parcerias Estratégicas Instituto Camões, Lisbon
2. Joaquim Barradas, Digital Education & E-learning, Director, Leya, Lisbon
3. Jorge Castilho, Director of Products and Solutions, JP Group, Porto
4. Jorge Sa Couto, Chairman, JP Group, Porto
5. Julio Santos, Invited Professor, Faculty of Psychology and Education Sciences, University of Porto, Porto
6. Maria Ántonia Barreto, Profesor Coordinador Instituto Politecnico de Leiria
7. Mario Franco, Founder & Chairperson, Millennium@EDU / Sustainable Education, Lisbon
8. Sandra Jesus, Communications Director, JP Group, Porto

South Africa

1. Alexa Alexander, Student (Grade 4), SPARK School Bramley, Johannesburg
2. Andile Dube, Executive Head for Education, Vodacom Foundation, Centurion
3. Bailey Thomson Blake, Head of Schools, SPARK Schools, Johannesburg
4. Brian Schreuder, Head of Education, Western Cape Government, Cape Town
5. Caroline Mabena, Deputy Principal, Mbuya Seondary School, Daveyton Township
6. Clinton Walker, Director of eLearning Directorate, Western Cape Government, Cape Town
7. Corrin Varaday, CEO, Idea Digital Education, Johannesburg
8. Debbie Schäfer, Minister of Education, Western Cape Province, Cape Town
9. Emmanuel Mohlala, Deputy Education Specialist, Ekurhulani North District, Gauteng Province Department of Education (GPEDU)
10. Eric Matsomane, Senior Manager Educational Programmes, MTN Foundation, Johannesburg
11. Fatima Rahiman, Programme Specialist, SAIDE, Johannesburg

12. Freddie Mokhashane, Chief Education Officer, Ekurhulani North District, Gauteng Province Department of Education (GPEDU)
13. Gerald Roos, Learning and Teaching Support Materials, Policy Development and Innovation, Department of Basic Education (DBE), Cape Town
14. Happy Jelelti, Principal, Hulwazi Secondary School, Daveyton Township
15. Helen Zille, former Premier of the Western Cape, Cape Town
16. Henry Kavuma, Acting Director, Curriculum Innovation, Department of Basic Education, (DBE), Pretoria
17. Irma Eloff, former Dean of Faculty of Education University of Pretoria (now leading Special Projects for the Executive of the University)
18. Jamie Martin, CEO and Founder, Injini, Cape Town
19. Janet Thomson, Director, SchoolNet South Africa, Johannesburg
20. Jeanine Briggs, Program Creator, The Training Room Online, Cape Town
21. Jenny Glennie, Director, SAIDE, Johannesburg
22. Jessica DuToit, Analyst, E-learning and After School Game Changer, Cape Town
23. Jolandi Gibson, Life Sciences Teacher, Parklands College, Cape Town
24. Lebo Kikine, IT Director, Mbuya Seondary School, Daveyton Township
25. Leroy Ngwenya, Blended Learning Facilitator FLEX model, SPARK School Bramley, Johannesburg
26. Madwa Mzangwa, Principal, Wordsworth High School, Beroni, Johannesburg
27. Maryla Bialobrzeska, Programme Specialist, SAIDE, Johannesburg
28. Megan Rademeyer, Programmes Manager, SchoolNet South Africa, Johannesburg
29. Neo Mothobi, Chief Education Specialist, Department of Basic Education, Pretoria
30. Oliver Dick, Lead Blended Learning, SPARK Schools, Johannesburg
31. Omashani Naidoo, Operations Manager, SchoolNet South Africa, Johannesburg
32. Paul Mayers, Associate Principal of Innovation in Learning and Teaching, Parklands College, Cape Town
33. Penelope Tainton, Delivery Support Union, Western Cape Government, Cape Town
34. Phumzile Nkomo, Blended Learning Facilitator Lab model, SPARK School Bramley, Johannesburg
35. Randall Faulmann, Director of E-learning, Department of Basic Education (DBE), Pretoria
36. Richard Knaggs, Director of Technology & Innovation, Parklands College, Cape Town
37. Seliki A. Tihabane, Curriculum and Quality Enhancement Programmes, Department of Basic Education, (DBE), Pretoria
38. Simon Lee, Information and Technology Manager, Independent Schools Association of Southern Africa, ISASA, Johannesburg
39. Temwani Phiri, Student (Grade 6), SPARK School Bramley, Johannesburg
40. Tony Mays, Manager, Unit for Distance Education, University of Pretoria, Pretoria
41. Tshepang Kgokong, Student (Grade 5), SPARK School Bramley, Johannesburg
42. Vincent Montjane, Senior Education Specialist, Ekurhulani North District, Gauteng Province Department of Education (GPEDU)

Non-Country-Specific (Literature Review)

1. Aashti Zaidi Hai, Director, Global Schools Forum
2. Anthony Bloome, Senior Education Specialist, USAID
3. Elizabeth Vu, Implementations Lead, Learning Equality
4. Freda Wolfenden, Professor of Education and International Development, The Open University of the United Kingdom
5. Glenn MacCance, Teaching Practice and Content Specialist, Can’t Wait to Learn, War Child Holland
6. Jacob Korenblum, CEO, Souktel Digital Solutions
7. Kate Radford, Programme Director, Can’t Wait to Learn, War Child Holland
8. Laura Miller, Deputy Programme Director, Can’t Wait to Learn, War Child Holland
9. Lisa Felton, Head of Services Regulation, Vodafone Group
10. Michel Otto, Coordonnateur de l’Agence pour la Promotion de l'Enseignement (APE), République Démocratique du Congo
11. Mike Trucano, Senior Education & Technology Policy Specialist and Global Lead for Innovation in Education, World Bank
12. Patrick Kapena, Chef de division chargé de la Technologie au sein du Ministère d’Education, République Démocratique du Congo
13. Patti Swarts, former Director of Programmes, GESCI
14. Rebecca Telford, formerly DFID, now Chief of Education, UNHCR
15. Sean Geraghty, Chief Academic Officer, Bridge International Academies
16. Tim Kelly, Lead ICT Policy Specialist, Digital Development Practice, World Bank

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