# Improving quality and relevance of education through mobile learning in Rwanda: A promise to deliver

Case study by the UNESCO-Fazheng project on best practices in mobile learning
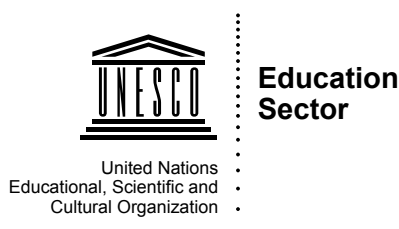
RWANDA

⚙ Approach: Top-down

🌐 Implementing organization: Ministry of Education, Rwanda

📅 Year launched: 2015

**Authors:**
Peter Wallet and Eric Kimenyi

**Editors:**
Fengchun Miao and Anett Domiter

Education 2030

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# Acknowledgments

# Abstract

Rwanda's education sector is evolving through the adoption of information and communication technology (ICT). Whereas the focus was previously on the extensive deployment of laptop devices, it is shifting towards advancing adaptive child-centred learning and the use of ICT augmented environments to enrich teaching and learning. In developing countries, however, an orientation frequently remains to select strategies which have previously shown to be successful in developed contexts without taking into account the full range of elements required for effective implementation including a comprehensive assessment of the financial implications required to ensure longer term sustainability.

This case study aims to showcase Rwanda's customised approach to the integration of ICT in classrooms adapted to meet the particular needs of the Rwandan education system. The *SMART* *Rwanda* Master Plan lays out a vision to transform Rwanda's economy by leveraging the use of ICT. Aligned to SMART Rwanda, the Ministry of Education (MINEDUC) is implementing the *SMART Classroom* initiative under its ICT in Education Master Plan to reach all schools by 2020. Although there have been several challenges encountered during the various phases of implementation, more than half of all schools across the country are now equipped with ICT devices and many teachers have undergone various capacity-building initiatives to make better use of ICT in teaching and learning. More work is required in order to develop a fully functioning ICT in education ecosystem in Rwanda; nevertheless, this case study demonstrates progress made thus far and describes the various system stakeholders, their roles, responsibilities and contributions to date to improve access, quality and relevance of education through ICT adoption.

*The SMART Classroom initiative in Rwanda, based on the lessons learned from the OLPC programme, is a comprehensive approach that includes a wide use of existing and new ICT infrastructure and devices, the development of new digital content aligned with the national curriculum and teacher capacity building for primary and secondary education. This case study shows how this initiative has been implemented and piloted and how it led to the incorporation of ICT in the national competence-based curriculum, providing more access to educational resources for children of different age groups, improving teachers' ICT skills and capacity for the pedagogical use of ICT and developing student's basic ICT skills.*

**Yongyeon Won, UNESCO**

**Keywords: Customized approach, SMART Rwanda Master Plan, SMART Classroom**

# 1. Introduction

According to *Rwanda's Vision 2020*, the Government aims to transform itself from an agrarian to a knowledge-based economy through the widespread integration of information and communication technology (ICT) in all sectors (Rwanda, 2012). Viewed as a key component for the achievement of middle income country status by 2020 (Rwanda, 2015c), the stimulus for transformation using ICT was the design and implementation of the *National Information Communication Infrastructure* (*NICI*) plans (Rwanda, 2001; 2006; 2015b). For the education sector, the NICI plans I, II and III outlined scaling up of technology integration programmes in primary schools as well as the establishment of prerequisite school-level infrastructure to support ICT adoption.

In 2009, the Ministry of Education (MINEDUC) launched and piloted the *One Laptop Per Child* (*OLPC*) programme in primary schools. However, with the introduction of the *SMART Rwanda Master Plan 2015–2020* (Rwanda, 2015c), MINEDUC issued its *ICT in Education* Master Plan in 2016, which incorporates the *SMART Classroom* initiative (Rwanda, 2016b) to accelerate the integration of ICT beyond the *OLPC* initiative to the entire education sector at all levels: primary and secondary, technical and vocational education and training (TVET) and higher learning institutions (HLIs). Designed with input from different education stakeholders, both in and outside Rwanda, the *SMART Classroom* model also included the objective to expand ICT integration beyond a focus on device deployment towards a more robust ICT ecosystem that targets curriculum and content development, models of teacher continuous professional development, resourcing and implementation and streamlined management and coordination systems.

Approved by Cabinet in 2016, Rwanda released its *ICT in Education* Policy (Rwanda, 2016a) to more widely disseminate its goals related to ICT in education. The policy is aligned to international standards and norms including references made to the Sustainable Development Goals (SDGs)—in particular SDG 4 which aims to "*Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*". Given worldwide recognition of ICT (in education) as an enabler to bridge the digital divide between and within communities and to increase access to information and knowledge, the policy is therefore also aligned to international instruments including the *Incheon Declaration and Framework for Action of the Education 2030* agenda (United Nations, 2016) as well as the *Qingdao Declaration* which further emphasises ICT's important role to transform education (UNESCO, 2015).

## 1.1 Vision

The *SMART Classroom* initiative was designed to align Rwanda's basic education sector to the *SMART Rwanda Master Plan*. In line with the national ICT in Education policy, the vision of the *SMART Classroom* initiative is:

> 'To harness the innovative and cost-effective potential of world-class educational technology tools and resources, for knowledge creation and deepening, to push out the boundaries of education: improve quality, increase access, enhance diversity of learning methods and materials, include new categories of learners, foster both communication and collaboration skills, and build capacity of all those involved in providing education' (Rwanda, 2016a).

In order to achieve this vision, the SMART Classroom initiative includes the following core objectives:

- Achieve knowledge-based economic development through education and human resources development and utilization;

- Enhance human resources at a national level, and improve educational opportunities and access through expansion of information digitization and e-learning programmes; and

- Enhance domestic human resources and social security through development of education and skills training.

In turn the major directions of change and benefits of utilization of ICT in education include:

- National education materials and contents available via online platforms;

- All learning institutions connected to the national education network, with full access to digital contents; and

- Increased educational opportunities and information for ordinary citizens (Rwanda, 2015c).

**Picture 1: Rwandan primary school children prepare for school.**

# 2. The model

The *SMART Classroom* initiative builds upon the foundation of the *OLPC* programme launched in 2009 with high level support from the President of Rwanda. *OLPC* was piloted in five schools across the country to achieve wide geographic distribution including some located in remote and disadvantaged regions. The five core principles of the OLPC initiative were adopted including that:

**i)**   each child has access to their own durable XO laptop;

**ii)**   students are able to take computers home;

**iii)**   the scheme applies to children aged between six and twelve years of age;

**iv)**   devices have Internet connectivity; and

**v)**   laptops run free and open source software.

While most principles were adhered to, not all pilot schools had connectivity given that Internet was and remains absent in many Rwandan schools, especially in remote areas.

Based on lessons learnt from the *OLPC* pilot, MINEDUC decided to design a nation-wide initiative adapting the model more closely to the national context. For example, the original goal to achieve 1:1 computing (i.e. one pupil per device) in primary schools was reassessed to better manage deployment progress in a cost effective manner due to prevailing resource limitations. As such, Rwanda improved programme coverage by redeploying laptops from schools where devices were unused, to those with better infrastructure including access to the electrical grid as opposed to off-grid solutions, for example solar paneling. This decision made it possible to provide access to ICT, albeit in a less than 1:1 computing environment, to greater numbers of primary students and teachers. There was also a need to extend ICT-

based instruction to higher levels of education starting in secondary schools where students who had previously used laptops at the primary level needed to build on their experience. Finally, the Ministry recognised that Grade 1-3 classrooms were not putting the laptops into full use, and as such the model was further refined so that ICT usage would henceforth begin in Grade 4.

Given the decision to adapt the original *OLPC* model, MINEDUC designed the comprehensive *SMART Classroom* initiative in 2015 to:

**i)**   widen the use of existing ICT to additional primary and secondary schools;

**ii**)   add more types of devices including teacher laptops, projectors and sound systems;

**iii)**   develop new digital content aligned with the national curriculum; and

**iv)**   accelerate teacher capacity-building efforts to meet increasing need.

## 2.1 School-wide planning

Through the active participation of all MINEDUC stakeholders, roles and responsibilities have been defined to ensure smooth and efficient implementation of Rwanda's ICT in Education policy and coordination of its Master Plan. The Rwandan Education Board (REB), which is the implementing agency for basic education, therefore plays a significant role to ensure full and efficient compliance of the *SMART Classrooms* initiative in primary and secondary schools.

To effectively coordinate programme implementation, the ICT in Education Master Plan is organised around four pillars:

- ICT infrastructure, which covers the smart classrooms, connectivity, cloud services, and access to power;

- Curriculum and content, which cover a student-centred curriculum promoting twenty-first- century skills, interactive e-books and cloud-based content distribution platforms;

- Teacher training that includes building capacity of master trainers and trainers of trainers (ToTs) using face-to-face, online delivery, and imparting blended learning and project-based learning skills; and

- Resourcing and implementation, in particular innovative and sustainable resourcing methods, maintenance and support structures, as well as effective project management and coordination.

**Figure 1:** The ICT in Education Master Plan Framework
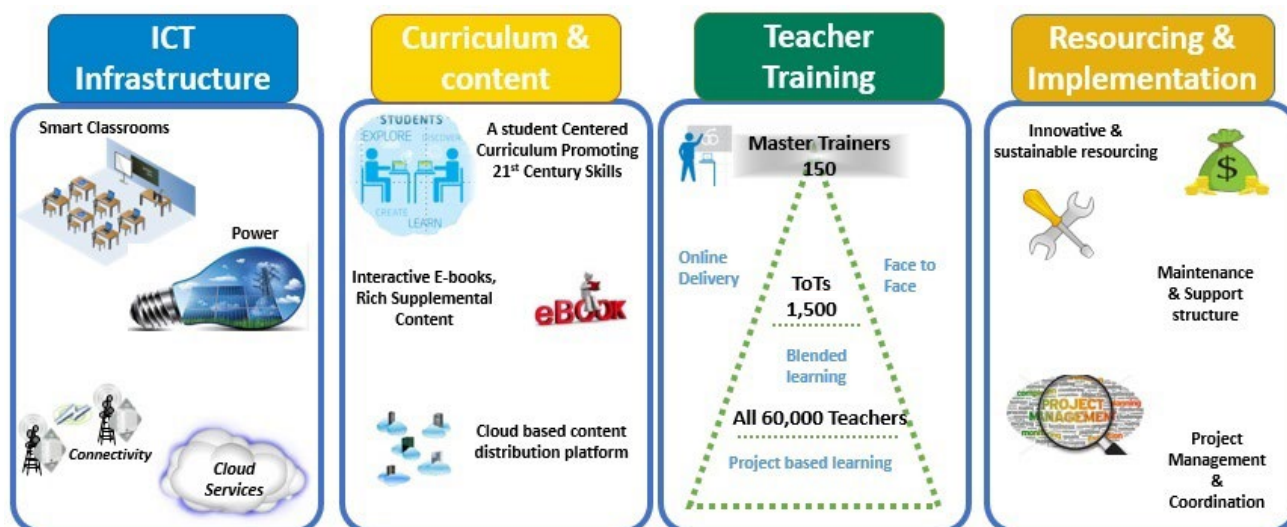


*Source*: Rwanda, 2015d.

In smart classrooms, the physical setup is considered to significantly influence learning. Instructional communication theories suggest that seating arrangements can impact how the teachers communicate with students and how the students interact with one another, impacting engagement, motivation, and focus. Since not all pupils will have access to their own computer, this setup is key to ensuring children at different grades have access to an effective environment to learn 21st century skills. To date, more than 692 smart classrooms across the country have been set up in schools to improve the quality of ICT-enhanced teaching and learning

based on a more collaborative seating arrangement encouraging a student-centred approach. Moreover, the REB is also considering new class configurations to be implemented across Rwanda's schools during further expansion (Rwanda, 2018c).

In order to expedite device procurement, Rwanda's evolving policies to ease conducting commercial business were instrumental. In 2015, the Government of Rwanda signed an agreement with a computer manufacturing company to locally assemble laptops, computers, tablets and other electronic devices. Since the education sector was the first target market,

this was a strong boost for school-wide planning and ensured better access to affordable and reliable devices in both public and private institutions (Rwanda, 2016c).

While the local digital content development community is still in its infancy, a number of small-scale initiatives to develop educational games and other types of digital content is increasing. Before deployment across schools, new content must be approved by the Curriculum, Teaching and Learning Resources Department (CTLRD) under the REB. The goal is for digital content to be digitally rich, interactive, and have inclusivity and accessibility features to ensure that students with disabilities have access. Rwanda's digital content, which is available as pre-loaded software, as well as online, is aligned to the new competency-based curriculum. In the case of *OLPC* XO computers, primary students can access and download open source content and games through the *OLPC* 'Sugar' operating system. Reflecting official language of instruction, there are materials available in Kinyarwanda for Grades 1-3, and in English for higher grades.

As ICT has been scaled up in primary schools, many teachers understandably lacked basic digital and ICT skills. In response, various training initiatives are provided in parallel beginning with training covering basic usage and troubleshooting so teachers could provide first-level support. Heads of schools are also trained focusing on management, storage and handling of ICT devices to ensure administrators understand the programme and develop a strong sense of ownership. During training sessions, teachers and heads of schools are also introduced to the *SMART Classroom* model (Rwanda, 2018c) and the ICT in Education policy and Master Plan to ensure a solid understanding of the Ministry's goals. Annually, supplementary workshops and conferences are organized to bring together teachers, head of schools with local government officials to collectively gain deeper knowledge about the initiative and to engage in dialogue.

While past efforts saw weak continuous monitoring and evaluation conducted by MINEDUC, the Inspectorate of Education and local government officials have oversight of schools and education. Inspection reports have shown that a sense of ownership by heads of schools and teachers is a significant enabling factor in the adoption of technology at school level. Online communication channels and smartphone platforms have also been set up for teachers and heads of schools to share resources, experience and best practices. Anecdotal evidence suggests that information shared through these channels during various exercises has helped different education stakeholders to ensure that best practices are implemented and to further refine and reflect on decisions where additional resources and interventions are needed.

In order to sensitise communities at large, a cross-sectoral approach has been taken where the Ministry of Information, Technology and Communication (MITEC), in collaboration with MINEDUC, conducts district roadshows so that students from nearby schools may showcase their skills to parents and other residents of the different ongoing ICT initiatives in their classrooms.

## 2.2 Mobile learning environment

The infrastructure provided by the government to public schools to create *SMART Classrooms* has included:

- Laptops:150–200 devices in primary schools and 100 laptops deployed in smart classrooms in secondary schools;

- School servers: 410 and 200 primary and secondary schools, respectively, have servers loaded with digital content aligned to the curriculum;

- Projectors and sound systems; and

- Fibre and 4G Internet connections for access to Online Moodle platform in some schools.

Laptops in primary schools are equipped with pre-loaded applications that are open source and can easily be modified. A MINEDUC team reviewed existing applications and selected fifty on different areas including computer programming, typing skills, music, spelling and different wikis. Meanwhile, laptops in secondary schools are Windows-based with Microsoft Office installed allowing for cloud-based tools to facilitate collaboration. The devices allow mobility among students, while teachers are advised to encourage project-based learning that emphasises working in groups, both in and outside the classroom.

Rather than teaching ICT as a stand-alone subject in primary education, the integration of ICT as a pedagogical tool to enhance teaching and learning is coming into focus. In contrast, not only is ICT increasingly integrated as a pedagogical tool in secondary education, but it is also taught as a standalone subject. According to the curriculum, there is a course on ICT skills in lower secondary education while a course on Computer Science is offered at the upper secondary level. For this reason, practical hands-on sessions in primary grades are considered important for students who transition to secondary education and study more advanced ICT subjects.

As reflected in the ICT in Education policy and implementation plan, digital content development is a key goal. In addition to REB's regular pre-loaded and online content, it is also conducting an in-house e-book production exercise by digitizing various textbooks. The REB has also packaged available open educational resources (OERs) such as the RACHEL digital content and provided it to schools as supplementary content for teachers and students. As a cybersecurity mechanism, a content-filtering system has been put in place to ensure online activity adheres to age-appropriate websites.

Local government and the Inspectorate of Education work together to monitor schools with ICT to conduct physical inspection of equipment and monitor teaching processes. When equipment is found not functioning per specifications, maintenance is carried out. Likewise, teachers who are not using equipment effectively nor employing effective teaching methodologies are recommended for additional support. Rwanda's new Continuing Professional Development framework based on teacher competencies will play an important role to monitor use of ICT in education and provide a set of guidelines to offer corrective action including further training.

## 2.3 Capacity-building and incentive strategy for teaching staff

The average Rwandan primary school has about ten to twelve teaching staff, while overall, 54 per cent are female and typically between 23 and 45 years of age. They should have the minimum qualification requirement of a teacher training college diploma while school heads should hold a tertiary level degree. In contrast, secondary schools are larger (i.e. between twelve and eighteen teachers), secondary teachers are more often male (i.e., 70 per cent), older (typically between 30 and 45 years), and require a minimum qualification of a tertiary level degree. However, according to education statistics in 2016, 94 and 69 per cent of primary and secondary level teachers, respectively, were qualified (Rwanda, 2017c).

To reinforce teachers' capacity to use ICT, MINEDUC is creating new directives that will require all freshly recruited teaching staff in primary and secondary schools to have basic ICT competencies. Meanwhile, in order to meet these evolving needs, teacher training content and methodologies are being adapted to emphasize the use of ICT in teaching and learning (Ndayambaje & Ngendahayo, 2014; Rwanda, 2015a; Rwanda, 2017a). The REB organises and delivers continuous in-service teacher training throughout the academic year and during holiday periods to support teachers to incorporate technology in the teaching and learning process. Beginning with the 'Introduction to ICTs' course, the usual format is a hands-on participatory workshop where teachers conduct practice sessions with other teachers before finally

practicing in the classroom with students. For primary schools, first-level training is conducted at each school with ICT involving all teachers. A second-level training is also given to selected teachers responsible for ICT who are tasked with cascading the training to others in their respective schools. For secondary schools, all training used a master trainers approach due to the secondary sector's smaller scale as well as the finding that secondary teachers already had good knowledge of ICT and thus did not need the introductory training provided to their primary level counterparts. While data are unclear on the proportions of teachers currently meeting required ICT competencies, 2016 data show that 17,791 teachers have been trained on basic ICT skills, while 5,584 have training on ICT-enhanced pedagogy (Rwanda, 2017b) representing approximately 26% and 8% of all primary and secondary teachers, respectively. Currently, no certification is awarded for

successfully completing training. However, a plan to certify teachers is underway based on the certification standards under development by MINEDUC (Rwanda, 2017a).

Moving towards building a unified centrally planned capacity-building system implemented by relevant public institutions and mechanisms, the current mix of government and donor-dependent initiatives has resulted in an oftentimes fragmented coordination. Some programmes have focused too explicitly on ICT skills and not on the pedagogical aspects of ICT in the classroom to transform education (UNESCO, 2017). To remedy this, the REB recently refined its certified '*ICT Essentials for Teachers*' training modules (Rwanda, 2015a), based on UNESCO's ICT Competency Framework for Teachers (ICT-CFT) (UNESCO, 2011), to set national standards for the ICT teacher



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**Picture 2: President Paul Kagame interacting with children benefiting from the OLPC initiative.**

competencies required to foster effective teaching and learning. Based on assessment of teachers' current skills, the '*ICT Essentials for Teachers*' course focuses primarily on basic level ICT skills and some content related to ICT-based pedagogy and will be rolled out to 43,000 teachers over the next three years in Centres of Excellence with donor support (Moore et al., 2018). Successful completion of certified courses is mutually regarded as an important achievement by teachers and administrators and is commended for performance appraisals, which are used as a basis for advancement and promotion, as well as corrective measures including additional training.

According to the ICT in Education Masterplan, all teachers are provided with laptops resulting in a teacher-to-computer ratio of almost 1:1 in both primary and secondary education (Rwanda, 2017b). They use them primarily during school hours for in-school and in-class activities; however they may also be used for additional purposes outside of school and at home including online training as a part of continuing professional development. Some development partners working with REB on in-service training have provided Internet access for teachers via mobile modems. Currently, the Ministry is examining the potential to include this feature to more teachers in various in-service training programmes.

The formation of teacher *communities of practice* has been encouraged during recent in-service continuing professional development. Teachers following course requirements both in and out of school are required to participate in online discussion forums on moderator proposed topics. Equally so, teacher participants may exchange with the leader and other teachers to seek and give advice on the challenges they face and share resources, experience and best practices. Communications groups have also been set up on various smartphone platforms, for example using Whatsapp, for additional exchange (Moore et al., 2018).

## 2.4 School-wide mobile learning practice

Rwanda's ICT in Education Master Plan firmly recognizes the role of a widening variety of ICT tools, quality digital content and an enabling environment for both pupils and teachers to develop digital skills as well as take advantage of an ICT-enriched ecosystem that transforms teaching and learning to improve educational outcomes. The development of coherent and innovative school-wide mobile practices becomes an important factor to achieve national objectives.

ICT has no doubt brought several changes to the way students learn and carry out classroom activities in Rwanda. *SMART Classrooms* use pre-loaded ICT devices with e-learning platforms that provide rich supplementary materials to deepen the educational experience, while connectivity allows students to search and choose from unlimited sources of online information including text-based, images, audio, video and animation formats to enrich learning. This has been shown to be especially motivating during different research-, project- and problem-based assignments rendering the teaching and learning process ever more dynamic and rewarding. Internet is also used to increase communication and collaboration with other learners by sharing ideas and information, as well as with their teachers, especially when out of class. Finally, ICT has potential to transform classroom practice from rote learning towards a child-centred methodology emphasizing the creation of knowledge through ICT thus affording students greater independence in the overall educational process. While earlier research in Rwanda has shown progress can be gradual with many teachers and students initially viewing the use of computers as another tool to reinforce rote learning, others also reported students being empowered in their learning through ICT (Fajebe et al., 2013).

## Grandmother Rwanda - Enriching social science using innovative mobile models

Consistent with REB guidelines, schools have launched different mobile learning projects that take place in combined inclass/ non-formal settings to accelerate changing teaching and learning practices. The *Grandmother Rwanda* project, which takes place both in the classroom and in public settings, also has a secondary goal to demonstrate to the local community how ICT tools can be used to enhance learning and research practices. Connected with the social sciences curriculum, at the primary level, Grade 6 level students use mobile computers to create personal stories based on the cultural identity of Rwandan citizens. Working in groups, pupils use the classroom Internet to conduct research and identify appropriate images that are summarised into a story format to share with other students in class, with families, and later on in a public community setting. The ICT-based research project promoted listening and teamwork skills, as well as sharing information and ideas using mobile technology both in class and in public. Teachers on the other hand gained experience in designing and implementing innovative forms of creative storytelling that fully exploits the features afforded by mobile technology (OLPC, 2011).

## IWitness in Rwanda: Enhancing citizenship education through critical thinking

Developing critical thinking skills and promoting constructive dialogue remain foundational in preparing youth to participate responsibly in society. The *iWitness in Rwanda* project uses personal testimonies from genocide survivors via Internet based resources to promote positive values through increased understanding of the atrocities of genocide. It aims to enhance empathy with victims and survivors among the youth as a means to ultimately strengthen community and public life (iWitness Rwanda, 2019). Students were given access to over 1,300 video testimonies of survivors and other witnesses of the Nazi Holocaust and other genocides, including the genocide against the Tutsi. Based on a strong orientation to change classroom teaching methodologies, the project embedded content within sets of sequenced learning activities, which included elements of peer discussion, both face-to-face as well as online. In order to prepare teachers for the project, activities include in-depth training at the Kigali Genocide Memorial Centre (KGMC) about the project, its associated activities, and teaching methodologies (iWitness Rwanda, 2019).

## Using mobile devices to reinforce higher order thinking skills

Engaging children in the creation of animations, interactive stories, games, and music, mobile technology using free object-oriented software development kits (SDK) such as SCRATCH, play a key role in the development of children's higher order thinking skills including critical thinking, logic and problem solving skills. Targeting primary students between 8 and 16 years, teachers coach children in the process of conceiving an idea, transforming it into "computer language" or code units, carrying out testing and trial runs, identifying problems, debugging the script, and finally producing and sharing a working programme. During computer programming classes, primary level teachers also encourage students to work in groups since it is understood this will simultaneously strengthen pupil's teamwork, communication and collaboration skills. Taking advantage of the technology's mobility feature, exemplary students share their creations in person at the International Scratch Day event in Kigali, and virtually with others around the world to celebrate Scratch, and the children who code and create with it.

## School-based mentors using mobile technology to upgrade mobile learning practices

Rwanda's School-Based Mentors (SBMs) are appointed to provide peer-to-peer support to other basic education teachers throughout the country (each SBM covers two schools). Previous to the integration of ICT, SBMs had little contact with other teachers and little access to resources and information beyond initial training. With support from FHI 360[1], the *Mentorship Community of Practice* (MCOP) project uses ICT to enable SBMs to interact, offer peer support, and exchange resources via an online *Community of Practice* (COP). The COP provides information about Rwanda's education system, and makes resources available to mentors for use with other teachers to improve English-language skills and pedagogical practice. The project affords a stronger school-based mentoring mechanism to improve education quality in the targeted 1,000 basic education schools and their approximately 25,000 teachers. SBM teachers are now able to draw on resources from the MCOP online library and share with each other. They can use them in their designated schools for sharing with other teachers to build capacity across the country. As a consequence, for example, more teachers are found to be increasingly creating new ICT-based lessons, which include many features to enrich the teaching and learning process (FHI360, 2019). School-wide uptake is however not without its challenges including teacher apprehension to adapt to new methodologies and a lack of appropriate training. Recent development of self-learning videos, targeting teachers, which may be accessed through a combination of laptop or mobile devices, can help to decrease potential feelings of professional isolation and a lack of easy-to-access teacher training materials.

1   https://www.fhi360.org/projects/mentorship-community-practice

## E-assessment and prospective online evaluation methodologies

As outlined in the ICT in Education Master Plan, the introduction of a new competency-based curriculum is interwoven with the Ministry's decision to push ahead plans to implement electronic assessment (e-assessment) so that teachers can make use of ICT to score and interpret student performance and link it back to teaching practices. With support from UNESCO, a strategy to transition Rwanda from paper-based to e-assessment in primary and secondary education was piloted to meet the needs of a teaching and learning model based on ICT and using digital materials.

The pilot was designed to build the capacity of teachers to create e-assessments on the national e-learning system and of MINEDUC officials to administer, modify, expand, and operate the system. It led to an initial e-assessment system within the national ICT infrastructure, guidance manual for administrators and teachers, and a repository of 300 e-assessment questions for national curricula in various subjects including English language, mathematics and sciences (Cheung et al, 2019; Moore & Gomes, 2018).

## 2.5 Overall and crosscutting achievements

Education is one of seven pillars underpinning the SMART Rwanda Master Plan; *the Smart Classroom initiative* was therefore a response designed to align basic education towards this orientation.

### *Increased ICT penetration and usage in primary and secondary education:*

While ICT was once the domain of upper secondary education and institutions of higher learning, ICT covered approximately 66 and 50 per cent of primary and secondary schools, respectively, in 2016 (Rwanda, 2017b). The range of devices deployed also expanded beyond XO computers to include other laptop models, projectors, local wireless networks and school servers.

In spite of increasing numbers of children enrolled, computer access is increasing based on continuous deployment strategies. Rwanda has in fact achieved one of the lower pupil-to-computer ratios (PCRs) in Sub-Saharan Africa as reflected by national statistics. PCRs may be considered as a proxy measure for computer/ Internet usage level since lower figures suggest fewer students sharing a single device and therefore increased potential time on task. Between 2012 and 2016, PCRs decreased from 40:1 and 40:1 in primary and secondary education, respectively, to 13:1 and 26:1 (Rwanda, 2017b; UNESCO-UIS, 2015; Wallet, 2015). In spite of progress made, the consistent rollout of ICT to schools with electricity—for example in the capital of Kigali—has resulted in new forms of disparity that exacerbate the existing digital divide between urban schools with high numbers of devices and the many remote schools with no electricity and thus no ICT devices. Off-grid power solutions may continue to be considered to ensure the disparity does not increase but rather diminishes.

### *Increased access to information for educational institutions*

Previously, instruction focused on theoretical aspects of ICT given the limited resources available. However, the expanded deployment of ICT infrastructure under the SMART Classrooms initiative has led to the incorporation of ICT into the national competence based curriculum at all levels. In support of the SMART Classroom's role in building ICT competencies, the Government of Rwanda is improving the availability of information through digitization, open educational resources, and e-learning programmes as pre-loaded materials or online through national e-portals. There are resources available in both Kinyarwanda and in English and include:

- Sciences e-book site containing teacher and student digitized textbooks in mathematics, geography, biology, chemistry and physics;
- REB e-Learning Platform, which holds the ICT Essentials for Teachers course, other teacher training programmes, digital content model questions, and e-assessment items for schools;
- OER packaged materials including the RACHEL digital content to provide to schools as supplementary content for teachers and students; and
- E-learning applications including programming platforms such as Scratch and mathematical analytical tools like Geogebra.

Lastly, the Kigali public library has become digital providing access to many more resources as well as STEM materials for children of different age groups.

## Develop teachers' capacity and capability in and through ICT

Rwanda is accelerating teacher capacity building efforts to meet the current deployment strategy and growing needs. Supporting deployment efforts, continuous professional development programmes for teachers have been strengthened. Training is shifting from ICT skills improvement towards enhanced pedagogy emphasizing blended approaches and project-based learning to foster the view of technology as an enabler of self-directed learning and educational quality both in and outside of the classroom. For example, the blended *ICT Essentials for Teachers* training course, which includes numerous modules targeting ICT's role to enhance pedagogy is being rolled out through national *Centers of Excellence* to train 43,000 primary and secondary teachers—roughly two thirds of the entire teacher workforce—over the next 3 years. Aligned to UNESCO's ICT competency framework for teachers (ICT-CFT), training now targets developing competencies such as incorporating appropriate ICT activities in lesson plans, how to use digital resources to support instruction and problem solving, and other topics to enhance traditional education. Final assessment is weighted towards teachers' portfolios to ensure successful completion reflects capacity to demonstrate the related ICT competencies (Rwanda, 2015a).
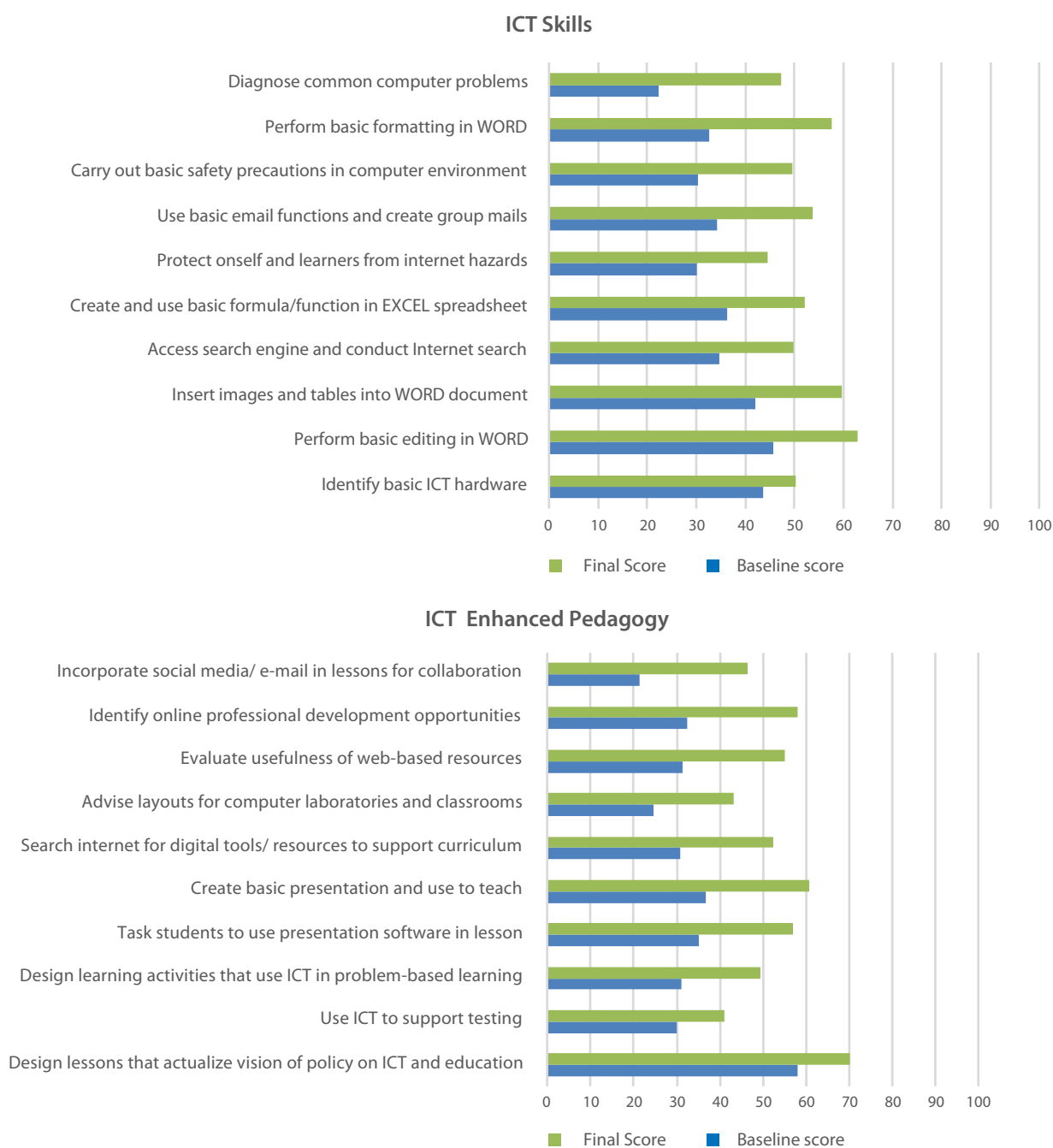
Additionally, the *Mentorship Community of Practice* online library allows school-based mentors (SBM) to interact more frequently with teachers and share teaching and learning resources fostering not only a culture of self-directed learning, but instilling in teachers the sense that online environments are a rich source of new and innovative educational content and tools. School leaders and administrators comprising principals, head teachers, inspectors and local government have also been trained as part of an initiative to improve key stakeholder capacity to better monitor the programme's implementation and success.

Certification standards have been developed and implemented to ensure forthcoming capacity building efforts contribute to ICT competencies outlined in the national ICT Essentials for Teachers in-service training programme (Rwanda, 2015a). More specifically, these standards help to clarify minimum expectations for prospective in-service and preservice programmes to effectively deliver ICT-based instruction and foster transformative learning using innovative and collaborative ICT tools and platforms (Rwanda, 2017a).

A recent evaluation conducted by REB provides some preliminary evidence that the rollout of ICT Essentials for Teachers across Rwanda has strong potential to help meet the teacher workforce's considerable training needs. Analyzing 114 teachers' self-reported

ICT competencies before and after the blended face-to-face/ online course suggests the training reinforced teachers' ICT skills and built their capacity to integrate ICT more effectively in teaching and other areas of their professional practice (Nyirigira, 2018). Comparing average pre- and post-test scores, teachers' self confidence invariably increased for both ICT skills as well as for practicing ICT-enhanced pedagogy. In terms of ICT skills, the largest self perceived improvements included diagnosing computer problems and performing basic functions in word processing applications. Equally, if not more important for quality education, the largest reported improvements related to ICT-enhanced pedagogy were incorporating social media and email into lessons to improve student collaboration; identifying online professional development opportunities; and evaluating the usefulness of web-based resources. The fact the course uses a blended approach may partially explain the self-reported improvements for online efficacy. While most teachers do not frequently engage in these types of activities due to a lack of resources such as time, devices and connectivity, sharing materials through email and social media, exploring new online training materials and evaluating them were common course activities and would therefore be expected to impact teachers' overall confidence and skill level.

**Figure 2:** Teachers' self perceived mastery level of ICT competencies in relation to piloting the ICT Essentials for Teachers course, 2018

### ICT Skills

| Competency | |
|---|---|
| Diagnose common computer problems | |
| Perform basic formatting in WORD | |
| Carry out basic safety precautions in computer environment | |
| Use basic email functions and create group mails | |
| Protect onself and learners from internet hazards | |
| Create and use basic formula/function in EXCEL spreadsheet | |
| Access search engine and conduct Internet search | |
| Insert images and tables into WORD document | |
| Perform basic editing in WORD | |
| Identify basic ICT hardware | |

■ Final Score    ■ Baseline score

### ICT Enhanced Pedagogy

| Competency | |
|---|---|
| Incorporate social media/ e-mail in lessons for collaboration | |
| Identify online professional development opportunities | |
| Evaluate usefulness of web-based resources | |
| Advise layouts for computer laboratories and classrooms | |
| Search internet for digital tools/ resources to support curriculum | |
| Create basic presentation and use to teach | |
| Task students to use presentation software in lesson | |
| Design learning activities that use ICT in problem-based learning | |
| Use ICT to support testing | |
| Design lessons that actualize vision of policy on ICT and education | |

■ Final Score    ■ Baseline score

*Source*: Nyirigira, 2018.[2]

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2    Note: Subjects were asked to rate themselves using a five point scale where 1 = no ability and 5 = master practitioner for 20 test items. Final scores comprise a composite of these 20 test items. Data for both *ICT Skills* and *ICT Enhanced Pedagogy* are listed based on decreasing percentage change between average baseline scores and final scores.

Inasmuch as the data suggest the course had a positive impact on teachers' perception of their competencies, given the low final scores on many items, including teachers' ability to use ICT in testing and assessment, ongoing continuing professional development remains critical and would be aided by technical and pedagogical support mechanisms and backstopping. Potentially problematic, remains the issue of ongoing needed support from partners and longer-term sustainability as teachers turnover, technology changes, and teaching and learning methodologies evolve.

### Cross-cutting monitoring and evaluation

Outlined in the Master Plan, monitoring and evaluation will be carried out in all schools with ICT and at all levels using different instruments for data collection and evaluation purposes. While no comprehensive evaluation of the SMART Classroom initiative has been completed to date, assessments including both formative and summative are in the planning phase to provide more concrete information on how the initiative has impacted student outcomes including learning achievement. More recently REB has begun collecting both quantitative and qualitative data to evaluate impact on students' ICT skills, their perceptions, attitudes, and beliefs in terms of how they interact with ICT systems. Analyses using both descriptive and inferential statistical methodologies will be employed yielding results as soon as 2020 to inform future decisions, policies for ICT in education, and programme development in Rwanda's primary and secondary schools.

Meanwhile there is growing evidence that, in schools with ICT, increasing numbers of students have some ICT skills. Based on teacher's reports, many students are able to use word processors, spreadsheets and presentation packages, and can effectively navigate file storage systems. Teachers also corroborate that students can browse through digital content and pick relevant information to use in their classwork or homework exercises. In schools with access to the Internet, students are also able to conduct online

research, drawing on vast amounts of information, and incorporating their findings into their in-class or out-of-class exercises including enriched learning around social sciences and citizenship education (OLPC, 2011; iWitness Rwanda, 2019. Reflecting on the incremental transition towards more ICT-based instruction, heads of schools reported that ICT and rich digital content in science and other subjects is a motivating factor and may help improve student attendance, retention; and reduce dropout. As a result of this widespread belief, many heads of schools embraced the introduction of ICT and encouraged its expanded use in spite of the challenges and support needed to ensure that deployed equipment is used. For smaller numbers of students, they are developing higher order ICT skills including coding in SCRATCH and other online applications.

The SMART Classroom initiative aims to target themes that affect students' real lives, such as education for girls, protection of forests, ensuring clean water, and citizen education to meet today's educational challenges and serious issues confronting Rwandan society as well as the international community. Meetings with parent-teacher associations, which are composed of the school head and parent representatives, suggest that parents are supportive of the introduction of ICT in schools and encourage its continued use.

Concerning the evaluation of the SMART Rwanda Master Plan, there is a lack of a rigorous evaluation methodology and to date there was no extensive data collection conducted on the achievements of the SMART Rwanda initiative. However, despite of the scarcity of evidence available on education and ICT statistics, we can conclude that progress has been made towards achieving the objectives of the Master Plan. A comprehensive evaluation of the initiative will be conducted producing quantitative and qualitative results in 2020.

# 3. Sustainability and broader impact

The MINEDUC is responsible for fully implementing all ICT in Education initiatives across the country. Integral to the SMART Classroom implementation plan is a continuous monitoring and evaluation process conducted by staff from MINEDUC, the Inspectorate of Education, and local governments with responsibility for education. The Ministry is working towards hiring technical staff dedicated strictly to ICT at the school, district and provincial levels, to help sustain, support and ensure the continued usage of technology in and out of classrooms. At the school level, as part of teacher training activities, ICT clubs have been established where students get a chance to take part in first-level troubleshooting to sort out problems with the ICT devices. Most students have been very pleased to learn while solving the technical issues on their own devices. MINEDUC also runs awareness campaigns in which local government leaders and parent–teacher associations hold town-hall meetings. All attendees are given a chance to raise any issue that they believe is faced by their schools, ideas are exchanged and solutions are agreed upon. ICT in education is one topic raised and discussed, together with other issues affecting schools such as hygiene, teaching and learning resources, and overall teachers' well being.

While specific data measuring ICT usage in schools will become available in 2020, the *Learning Achievement in Rwandan Schools* (*LARS III*) provides literacy rates among school children, which suggest some challenges for online learning and acquiring certain ICT skills. For example according to Kanniainen et al. (2019) low literacy levels are a strong predictor of difficulty in online research and comprehension skills. Analyzing Rwanda's primary and secondary literacy data, the LARS III study showed that just 55, 56 and 71 per cent of students in primary III, VI, and secondary III, respectively, tested at or above the expected level (Rwanda, 2018a; 2018b). This finding suggests that almost half of all primary students and 30 percent of secondary students in Rwanda would struggle in digital and online environments to research, comprehend information and develop ICT skills adequately. These data highlight a valid concern for the programme's sustainability. Conversely, the data also present opportunity for the creation of well designed ICT-based interventions to help build emerging ICT skills to promote both literacy and numeracy in primary and secondary education.

E-assessment piloting will be important to ensure the programme's sustainability as the REB continues to ensure it moves away from paper-based assessment as stated in the SMART Rwanda Master Plan. Based on the piloting exercise, results show that both teachers and students enjoyed the e-assessment system and reported the skills learned were beneficial. However, necessary conditions for success include the training of management staff and teachers to work effectively on the platform and the existence of robust infrastructure, including expanding Internet connectivity (Cheung et al, 2019). Incidentally, based on positive evaluation findings, an expansion of the e-assessment system is to be carried out in 2019 including development of a management information system (MIS) hosted by the REB server containing a bank of questions for teachers to upload and download. The MIS also supports formative and continuous assessment with a dashboard and analytics on learning achievement for Head teachers and district officials to monitor school performance (Rwanda, 2019). A concept for a pilot run in 200 schools has also been recently completed for implementation (Education Development in Trust, 2019).

# 4. Challenges and lessons learned

### Lack of electricity and Internet connectivity

The shortage of electricity in schools, particularly those in remote regions, continues to be a challenge delaying the introduction of ICT in all of Rwanda's schools. In 2016, 66 and 50 per cent of primary and secondary schools, respectively, had access to devices using electricity provided through the national grid or using off-grid solutions, such as solar paneling. While the challenge posed to schools unconnected to the national grid is somewhat overcome through off-grid solutions, full connection to the grid remains the best solution to ensure devices are charged and properly maintained, ensuring the sustainability of any ICT-enhanced teaching and learning initiative. In the meantime collaborative action by all responsible stakeholders including ministries of Education, Infrastructure and local governments as well as parents can work together to try to achieve different temporary off-grid solutions.

Internet continues to pose a particularly significant challenge for Rwandan schools given the prohibitive commercial costs associated with subscription. In 2016, primary and secondary schools were connected to the Internet at rates of just 10 and 18 per cent, respectively, necessitating the practice of pre-loading content to the majority of ICT devices deployed in Rwandan schools. MINEDUC is however working towards installation of a national Internet infrastructure by cooperating with different development partners to help more schools meet costs. While this objective will likely take time to achieve, MINEDUC is also currently working on establishing a single education network linking all learning institutions to enable better sharing of educational software resources.

### ICT resources not fully utilized

ICT equipment is not being fully utilized in schools. The reasons range from the lack of adequate training, resistance to change, and classroom challenges such as large class sizes and a lack of time to engage in training. The planning and roll-out of new national training programmes is currently underway; however one of the challenges is related to the inherent limitations of the use of cascade training whereby teachers often cannot find time to train their colleagues. This is somewhat explained by the existing school timetable where many Rwandan teachers double shift, which reduces opportunity for the transfer of skills. REB is however working on increasing the time allocated for trained teachers to build their colleagues' capacity.

To further improve the frequency of ICT usage, there are now additional Ministry level efforts underway to i) provide additional supplementary training materials and simplified manuals for teachers' reference, ii) ensure proper maintenance of devices through more frequent inspection, and iii) recognise teachers' exceptional use of ICT through national awards. Lastly, there are Ministry plans for certified ICT proficiency tests to be provided to teachers, which will incentivize ICT use since ICT competence will become part of performance-based contracts and determine career advancement.

The integration of ICT in teaching and learning could potentially play a big role to enhance teaching and learning in Rwandan schools. However with one of the highest pupil-teacher ratios in primary education in the region at about 58:1, classroom sizes can be very large and possibly impede effective use of ICT in education. In contrast, if planned and implemented

effectively paired with adequate training and ongoing support, collaborative project-based learning guided through ICT could also ameliorate the challenges imposed by large class sizes.

### Theft of ICT equipment

The theft of ICT equipment is a challenge which directly affects its use in schools, not only because the stolen equipment is then unavailable for use, but because theft affects the trust of the school administrators, who become reluctant to allow teachers to use the devices at home or even in class. This also affects the teachers, because they do not want to be held responsible for devices that go missing under their watch. As a response REB has included sensitization, awareness building, device management, storage and follow-up issues in training sessions for teachers and school heads.

**Picture 4: Secondary school students using laptops on class.**

## 5. Transferability

Since ICT requires sustainable electricity to function effectively, computer redeployment activities have and continue to follow schools that connect to the grid. Likewise, teacher training continues to be adapted to fit Rwandan teachers' needs. Other issues being reviewed include adoption of simplified teaching and learning aids, training manuals, and the timing of capacity-building activities.

REB staff have also set up discussion groups, both for teachers and heads of schools. School heads mostly raise issues regarding the management and control of the ICT devices and it is found that those with substantial experience play an important role providing advice to colleagues. Teachers on the other hand mostly raise issues regarding technical and pedagogical practices. Here too, some of the better-trained teachers are able to provide solid advice related to technical problems and make suggestions on how to implement ICT-enhanced teaching.

Rwanda was an early adopter both in the region and across Africa to rapidly uptake ICT in schools. However, based on the Rwandan experience, it is clear that decision makers and education administrators should not be pressured into believing that what has worked in developed countries will necessarily work for them. Instead, they should be open to learning from others, but adapt their approach and programmes to fit their specific context and needs. This is not only true of initial stages, but flexibility and adaptations may be needed even after many years into operationalisation of national initiatives. Experience also demonstrates the importance of employing a strategic intersectoral approach while planning ICT deployment through consultations with stakeholders from both the education and the ICT sectors. Furthermore, while there may be multiple stakeholders functioning at the international, regional and/or local levels, the experiences shared from such consultations is helpful to analyse the current situation, permit sharing of best practices, propose strategies on the way forward, and accelerate cooperation.



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**Picture 3: Primary school children using laptops as part of the OLPC initiative.**

# 6. Conclusions and recommendations

The Government of Rwanda, through MINEDUC, is making progress in the mainstreaming of ICT across the education sector to maximise access to devices, enhance quality and maintain its relevance to current educational and labour market needs. In a stepwise manner the *SMART Classroom* initiative that began in primary schools under the *OLPC* framework has now spread more widely to include secondary education with plans now under development to cover TVET institutions and HLIs, as previously outlined in the ICT in Education Master Plan. In contrast several significant challenges remain including the expansion of Internet and establishing sustainable teacher capacity-building mechanisms.

When implementing ICT initiatives, it is recommended to consistently work closely and regularly with last-mile implementers. This includes local government officials as well as school authorities, parent representatives, school heads, teachers and students. Feedback from school-level stakeholders is also essential to ensure devices are used and managed in the most effective way, so the initiative will have the greatest possible impact.

Finally, planning should go hand in hand based on feedback from all stakeholders to ensure resources are being fully optimized. Teacher training initiatives and methodologies need to reflect the specific requirements and diverse context of the various heads of schools and teachers involved. Regular follow-up, including site visits and infrastructure status checks by the responsible authorities is also very important to ensure the implementation plan is progressing according to schedule, that bottlenecks are mitigated, and that adequate support is given to the intended target schools, teachers and students.



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**Picture 5: Primary school aged children in the remote Gicumbi District.**

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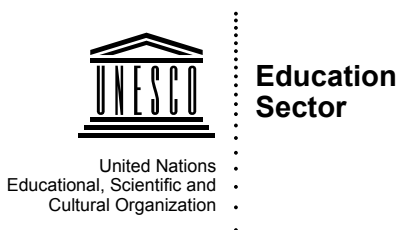
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**Education 2030**

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