International Labour Organization

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Teaching and the teaching profession in a digital world – Rwanda

Background paper

Teaching and the teaching profession in a digital world – Rwanda

Background paper

With financial support from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of Federal Ministry for Economic Cooperation and Development (BMZ).

As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Irénée Ndayambaje

First published 2023

Teaching and the teaching profession in a digital world – Rwanda. Geneva: International Labour Office, 2023

ISBN: 9789220388754 (web PDF)

Design by the International Training Centre of the ILO, Turin – Italy

Table of contents

List of tables

Abbreviations

CADIE	Capacity Development for ICT in Education
CAP	Content Access Point
CBC	competence-based curriculum
CFT	Competency Framework for Teachers
DAP	Digital Ambassadors Programme
EDPRS	Economic Development and Poverty Reduction Strategy
ESSP	Education Sector Strategic Plan
ICT	information and communication technology
IPRC	Integrated Polyctechnic Regional Centre
IT	information technology
KOICA	Korea International Cooperation Agency
LAN	Local Area Network
NICI	National Information and Communication Infrastructure
NST	National Strategy of Transformation
OLPC	One Laptop per Child
REB	Rwanda Basic Education Board (formerly Rwanda Education Board)
RISA	Rwanda Information Society Authority
SDMS	School Data Management System
TMIS	Teacher Management and Information System
TVET	technical and vocational education and training

1. Introduction

One of the main objectives of Rwanda Vision 2020 was to transform the country from an agriculture-based to a knowledge-based economy. The provision of high-quality science and technology education and the development of information and communication technology (ICT) skills were recognized as key strategies (Government of Rwanda, 2012). Accordingly, as set out in the ICT in Education Policy, adopted by the Government in 2016, the use of ICT in education is seen as a strategic lever to achieve the required social and economic transformation. In December 2020, the Government released Rwanda Vision 2050, which emphasizes that access to affordable high-quality education is at the centre of human capital development. As part of the commitment to universal access to high-quality education, Rwanda Vision 2050 indicates that "[t]eachers will be empowered and equipped to deliver an education that provides all Rwandans with the capabilities to continually improve their skills and productivity" (Government of Rwanda, 2020b, p. 13). Furthermore, greater emphasis will be placed on science, technology, engineering and mathematics (STEM) courses to strengthen the use of technology, support innovation and enhance digital literacy with a view to ensuring inclusive participation in the knowledge society and changing labour market.

In order to realize these commitments, a number of initiatives have been launched by the Government to promote digitalization in basic education. This paper focuses on three initiatives: One Laptop per Child (OLPC), launched in 2008; the smart classrooms initiative, introduced in 2016; and several activities relating to digital content development and the integration of digital technology, which have been strengthened since 2018. These initiatives have been selected not only because they mark Rwanda out among the leading countries in Africa in ICT, but also because they have transformed the delivery of teaching and learning over the past two decades. The paper analyses challenges and achievements related to these initiatives and discusses the participation of the various education stakeholders in digitalization initiatives, before providing recommendations for ways forward to achieve the commitments of the various strategic frameworks, such as Rwanda Vision 2050.

2. Methodology

The paper is informed by a review of existing literature (secondary data) and key informant interviews (primary data). The secondary data includes: reports and articles from academia, development agencies and international organizations; news media; and statistical data, policies, strategies and reports from relevant ministries. Particular emphasis has been given to the three digitalization in education initiatives enumerated above.

The primary data consists of qualitative data from 13 key informant interviews with various stakeholders in the education sector, including affiliated institutions/implementing agencies of the Ministry of Education, development partners, teacher unions, employers' organizations and the private sector. The interview questions focused on: policies, plans and strategies for the integration of ICT in teaching and learning; the status of digitalization in education, including challenges and best practices; stakeholder involvement in digitalization initiatives; and the impact of digital technology and digitalization initiatives on the teaching profession and the working conditions of teachers. The responses from the key informants have been organized around key themes to support the analytical framework of the study.

3. Brief overview of the education sector

3.1. Rwanda education system

In Rwanda, the education system is organized into: (i) pre-primary education; (ii) primary education; (iii) secondary education; (iv) technical and vocational education and training (TVET); and (v) tertiary education (Ministry of Education, 2015). Public primary and secondary education are provided free-of-charge, and the first nine years are compulsory (that is, primary and lower secondary education). In terms of enrolment, the 2019 education statistics of the Ministry of Education (2020a) show that 282,428 students were registered in pre-primary education, of whom 138,911 (49.2 per cent) were boys and 143,517 (50.8 per cent) were girls. There were 6,931 teaching staff in pre-primary education, 5,872 (or 84.7 per cent) of whom were women and 1,059 (15.3 per cent) were men. Of these, 47.3 per cent are qualified to teach at this level.

In terms of enrolment in primary education, Rwanda is one of the top performing countries in sub-Saharan Africa, with a net primary enrolment rate of 98 per cent (UNICEF, 2019). In 2019, of the 2,512,465 registered students in primary education, 1,268,996 (50.5 per cent) were boys and 1,243,469 (49.5 per cent) were girls. In 2020, the teaching staff in primary schools totaled 43,878, of whom 19,534 (44.5 per cent) were men and 24,344 (55.5 per cent) were women. Of these, 94.3 per cent were qualified to teach in primary schools (Ministry of Education, 2020a). The student-textbook ratio in primary school ranges between 3:1 and 4:1, depending on the subject (Ministry of Education, 2020a). Despite the high enrolment rate, the primary completion rate is approximately 65 per cent and classrooms are often too crowded, with a pupil-teacher ratio of 58:1 (UNICEF, 2019).

In terms of ICT in primary schools, the 2019 statistics show that the Government had distributed 254,602 computers to 2,468 primary schools, which would suggest that 83.4 per cent of primary schools countrywide were equipped with computers. On average, each primary school received 150 Xo laptops as part of the OLPC programme. Of the 2,468 primary schools that received Xo laptops, 1,029 (34.8 per cent) had internet connectivity (Ministry of Education, 2020a).

According to the competence-based curriculum (CBC) adopted in 2015 (REB, 2015), the use of Xo laptops is for the upper primary level (from primary four (P4) to primary six (P6)), for use in science and elementary technologies, with the aim of equipping learners with competences in ICT that can be used across other subjects. The CBC was adopted with the intention of promoting critical thinking, innovation, research and problem solving. Under the CBC, the key ICT and digital competences revolve around applying elementary scientific and ICT concepts to real life experiences and problem solving (REB, 2015). Students develop

these competences by: (i) locating, extracting, recording and interpreting information from various sources; (ii) assessing, retrieving and exchanging information through the internet or mobile phones; (iii) using mobile phones and the internet for leisure and financial transactions; (iv) using the computer keyboard and mouse to write and store information; and (v) using ICT to enhance learning. The use of ICT in primary education has also been a driving force in reconceptualizing teaching and learning approaches and in supporting ICT-driven school management practices, including through the School Data Management System (SDMS), which collects data on schools, students and the curriculum, and the Teacher Management Information System (TMIS), which includes key data on teachers. The Government is seeking to upgrade both systems to support digital transformation in the sector in order to improve access to and the quality and equity of education (Government of Rwanda, 2020a).

As of 2019, there were 732,104 students in secondary education, of whom 341,691 (46.7 per cent) were male and 390,413 (53.3 per cent) were female. The transition rate from primary to lower secondary education increased from 71.6 per cent in 2017-18 to 72.2 per cent in 2018-19. The average class size in 2019 was 42 students. Teaching staff numbered 23,585 in 2019, consisting of 16,903 (71.7 per cent) men and 6,682 (28.3 per cent) women. Of these, 79.2 per cent were qualified to teach in secondary education in 2019 (Ministry of Education, 2020a).

In 2019, 1,523 secondary schools (85.4 per cent) had computers and 1,089 (61.1 per cent) had 4G broadband connectivity. In fulfillment of the 2016 ICT in Education Policy, the Government redoubled its efforts to distribute computers to schools. As a result, there has been an exponential increase in the number of computers in secondary schools, rising from 25,218 in 2016 to 100,336 in 2019. The increased provision of computers has significantly reduced the ratio of secondary school students per computer, from 27:1 in 2016 to 8:1 in 2019 (Ministry of Education, 2020a). This is largely attributable to the policy of distributing computers manufactured locally by Positivo BGH, a Brazilian firm that entered into partnership with the Government to assemble computers locally (Mazimpaka, 2015). ICT-related hardcopy textbooks have also been provided to secondary schools, of which 32,032 are for the Senior-1, 27,717 for the Senior-2 and 23,905 for the Senior-3 levels (Ministry of Education, 2019).

In Rwanda, TVET is organized in levels. Levels one and two are certificate levels open to youth (15 years and above) and adults (with or without prior formal education) seeking to acquire specific skills. Levels three to five are equivalent to upper secondary general education and therefore accept candidates who have successfully completed ordinary/lower secondary level general education. The upper levels (six and seven) involve attendance at the Rwanda Polytechnic, which is equivalent to general higher education.

For levels one to five, the number of trainees in 2019 was 107,167, of whom 63,138 (58.9 per cent) were male and 44,029 (41.1 per cent) were female. There were 5,281 teaching staff at these levels, of whom 3,745 (70.9 per cent) were men and 1,536 (29.1 per cent) were women (Ministry of Education, 2019). To support TVET from lower levels of education, the Government created an apex agency in the Ministry of Education in 2020 called the Rwanda TVET Board. The mission of the Board is to promote quality education in TVET from levels one to five, with the overall aim of fast tracking the socio-economic development of the country. At levels six and seven, TVET efforts are overseen by the Rwanda Polytechnic, which was established in 2017 to oversee the implementation of TVET skills development across the country, including through the preparation of TVET curricula, the design of courses at the various levels and the organization of programmes and activities to build the capacities of teaching and research staff. The Rwanda Polytechnic is organized into Integrated Polyctechnic Regional Centres (IPRCs). Statistics for 2019 show that a total of 14,078 students, of whom 10,135 (72 per cent) were male and 3,943 (28 per cent) were female, were attending levels six and seven in the various IPRCs (Ministry of Education, 2020a). In terms of staffing, there were 1,430 staff at levels six and seven, of whom 1,158 (81 per cent) were men and 272 (19 per cent) were women (Ministry of Education, 2020a). Rwanda Vision 2050 recognizes TVET as key to training and upskilling workers to respond to labour market demands, and is committed to its continued development (Government of Rwanda, 2020b).

3.2. ICT policy environment and initiatives in education

Although chalk and talk have been the primary tools for imparting knowledge for many decades, the integration of ICT into education in Rwanda has gradually revolutionized teaching and learning. Rwanda Vision 2050 identifies ICT as a key driver of social and economic transformation, human resource empowerment and improved public service delivery (Government of Rwanda, 2020b). Similarly, the ICT in Education Policy (2016) recognizes that the education sector has a pivotal role to play in the desired social and economic transformation. The Policy therefore emphasizes that the use of ICT in education will not only rebrand teaching and learning, but will also constitute an arm for professional teacher development (Ministry of Education, 2016).

Rwanda's progress in ICT in education today is anchored in a number of policy initiatives, including:

- Rwanda Vision 2050: implemented since 2020, which operationalizes the priority of transforming the education sector through the use of ICT (Government of Rwanda, 2020b);
- Rwanda Vision 2020: implemented since 2000 and revised in 2012, which places emphasis on human capital development and the improvement of ICT infrastructure (Government of Rwanda, 2012);

- the SMART Rwanda 2020 Master Plan: implemented in 2015 with the aim of transforming Rwanda into a knowledge-based economy, the five-year tool sought to fast-track the attainment of the goals set by Rwanda Vision 2020. It was specifically mandated to provide more education opportunities and improve access by developing ICT skills;
- the Economic Development and Poverty Reduction Strategy (EDPRS): implemented in two phases (EDPRS1, 2008-12; and EDPRS 2, 2013-18), the EDPRS leveraged ICT in education by initiating ICT professional certification courses. Each phase adopted strategies to accelerate the progress achieved in national development;
- the National Strategy of Transformation (NST1): implemented between 2017 and 2024, NST1 recognizes ICT as a cross-cutting enabler of development. Greater digitalization and ICT-driven innovation are therefore seen as being instrumental in supporting productivity gains across both the primary and non-primary sectors;
- the National Information and Communication Infrastructure (NICI) Plans: implemented in phases, beginning with the NICI Plan 2001-05 and ending recently in 2015, they envisioned ICT as the engine of socio-economic development in Rwanda;
- the Policy on Science, Technology and Innovation: adopted in 2006, the Policy fosters research and promotes the development of the ICT sector;
- the National Digital Talent Policy: approved since 2018, the Policy aims to increase digital literacy, support the acquisition of ICT skills and address the gender digital divide (Ministry of Youth and ICT, 2016);
- the Education Sector Strategic Plan (ESSP): implemented from 2018-19 to 2023-24, the ESSP promotes the use of ICT in education to improve quality in teaching, learning and research (Ministry of Education, 2018);
- the ICT in Education Policy: implemented since 2016, the Policy is mandated to develop a relevant ICT professional foundation, increase ICT penetration and usage, develop education leadership and teachers' capacities through ICT and use ICT to enhance teaching, learning and research in higher learning institutions (Twagilimana and Mannikko-Barbutiu, 2018).

These policies have strengthened pre-existing practices, as well as opened up new initiatives in ICT in education, including: the provision of computers to schools; the development of the CBC and digital content; and opportunities for teacher training. For example, the 2016 ICT in Education Policy is being implemented through the provision of teaching and learning devices (such as computers), internet connectivity and digital content through smart classrooms established in secondary schools. Box 1 provides an example of a new initiative that emerged in response to the ICT in Education Policy.

Box 1. One Laptop per Teacher initiative

The COVID-19 pandemic and its mitigation measures resulted in the closure of schools in Rwanda. In response, the Ministry of Education introduced remote learning (through radio, television and mobile technology) and increased the use of existing e-learning platforms. As part of the response, the One Laptop per Teacher initiative was launched by the Rwanda Basic Education Board (REB) with the aim of providing all teachers in public schools with a laptop by the end of 2024 to enhance teaching and learning. The initiative commenced in April 2021 with the deployment of laptops to secondary schools. By August 2021, one in eight teachers had received laptops. So far, the initiative has reached 135 secondary schools to support teachers with lesson planning and delivery and continuous professional development.

Source: Nkurunziza, 2021; Ufitiwabo, 2021; key informant interview, 2021.

Other innovative strategies include the Rwanda Digital Ambassadors Programme (DAP), led by the Ministry of ICT and Innovation in partnership with the World Economic Forum (WEF) and the Digital Opportunity Trust (DOT). The DAP is a youth-led digital inclusion initiative, which aims to realize the 2016 Digital Talent Policy. As part of the programme, 5,000 young Rwandans will be trained as digital skills trainers, or Digital Ambassadors, to deliver basic digital skills training to the general population, particularly in rural areas, where internet use has been limited or absent. The programme will also provide training in the use of e-government and e-business services (Wong, 2017). An early evaluation shows that it has been effective in enhancing digital skills and instilling confidence in beneficiaries in the use digital technologies. It has also had a positive impact on the skills development of the Digital Ambassadors, including developing leadership, digital and problem-solving skills that can support greater employability and social impact initiatives. However, the cost of internet connectivity remains prohibitive (DOT, 2019). There were 4.12 million internet users in Rwanda in January 2021, with an internet penetration rate of 31.4 per cent. The number of internet users in Rwanda increased by 24 per cent between 2020 and 2021.[1] So far, most internet access is through mobile phones.

In 2018, the Government entered into partnership with Andela, a company focused on training software developers, to establish a Pan-African tech hub in Rwanda. The presence of the hub in Kigali will contribute to promoting skills development and employment opportunities for young Rwandans. Over a five-year period, Andela will provide paid training for 500 Rwandans with expertise in software development, following which they will be offered positions as remote workers for global software development firms (Ministry of ICT and Innovation, 2018). In support of skills development, the first coding academy in Rwanda was launched in 2019, which takes the form of a specialized secondary school that supports high achieving students to develop coding skills. The coding academy is intended to address the shortage of software developers in the country and region, thereby responding to the

[1] For more information, see Digital 2021: Rwanda, accessed 11 November 2021.

recommendations of the National Digital Talent Policy. It opened with 60 students (30 boys and 30 girls), and the Ministry of ICT and Innovation indicated that the aim is to open at least five academies. The programme, supported by the Korea International Cooperation Agency (KOICA), includes a six-month internship in the Republic of Korea following graduation (Buningwire, 2021; Ministry of ICT and Innovation, n.d.).

3.3. Stakeholder perceptions of ICT integration in education

Key education stakeholders were asked about their perceptions of the priority of digitalization in teaching and learning processes. One key informant noted that digitalization in education is important as it enables access to educational data/resources (including teaching resources, student data and school data) and facilitates teaching and learning, information sharing and evidence-based decision-making. Key informants also pointed out that technology provides access to a broader range of learning resources and knowledge, as well as opportunities to improve communication and digital skills, which can help in developing a positive attitude to using technology to resolve issues, developing course materials and using new ways to share material and knowledge, such as cloud platforms. As indicated by another key informant, "digitalization will improve quality and access to teaching and learning resources, which would not be possible in traditional settings." Some key informants also noted that it may be more efficient, cost-effective and flexible in terms of when and where education is delivered (key informant interviews, 2021).

In light of changes in society and the economy, as well as the COVID-19 pandemic, some of the key informants noted the importance of technology in education for continued learning when in-person teaching and learning is interrupted. The integration of technology is also increasingly necessary to meet international standards of academic delivery. Others added that the role of teachers is changing to that of facilitators, with technology playing a role in this shift. One key informant observed that a change of mind-set is needed in this regard, and that digitalization in education and teaching is a priority because it helps to change the mind-sets of teachers and the notion that education can only be imparted face-to-face. It was also noted that technology has provided opportunities for improved interaction among teachers, as well as between teachers and parents and the community (key informant interviews, 2021).

Digitalization in education is also expected to enhance teacher management. As an example of a good practice in relation to technology, one key informant described the recent launch of the TMIS, a tool for collecting and managing information on teachers. The combination of technology and trained teachers has the potential to improve learning outcomes and the quality of education (key informant interviews, 2021).

3.4. Challenges to digitalization in education

Although Kigali, the capital of Rwanda, leads in terms of access to ICT infrastructure and the internet, efforts are under way to roll out electricity and promote ICT use and ownership in other areas, and to develop secondary cities and modernize villages and towns, including through the use of mobile technologies for financial transactions and government services (Chuks, 2017). There remain differences in access to ICT devices between male- and female-headed households. The proportion of female-headed households owning ICT devices (radios, computers, video/DVD players, mobile phones and television sets) is lower than that of male-headed households. Differences in income, literacy and exposure are some of the main reasons for this gap. Participation by women in ICT-related courses is much lower than that of men in both public and private schools (Gender Monitoring Office, 2017). According to the Food and Agriculture Organization of the United Nations (FAO), 60 per cent of men and 38 per cent of women own a mobile phone in Rwanda. Although the Government has made efforts to integrate gender as a cross-cutting issue in policies and strategies, more remains to be done. Other challenges to ICT integration include the high cost of internet connectivity, lack of infrastructure and digital illiteracy, particularly in rural areas. Only 18 per cent of people in rural areas have access to electricity (Kropff et al., 2020).

In the education sector, even though the effective use of digital content requires schools to have computers and internet connectivity, many still lack access to ICT equipment and infrastructure (Raman and Yamat, 2014). It also requires qualified teachers and educators who are trained to use digital technology for pedagogical purposes. However, many teachers lack digital and ICT skills, while others are still reluctant to embrace ICT in teaching and learning (REB, 2019).

These challenges, as captured in the literature, were also highlighted in interviews with education sector stakeholders. Many of the key informants confirmed that teachers lack digital and ICT skills and preparedness to integrate ICT in teaching and learning. Some indicated that the lack of ICT skills is linked to the lack of basic ICT infrastructure, such as ICT rooms, devices and equipment, internet connectivity and electricity, as well as the lack of training for teachers in the effective use of ICT equipment. As noted by one key informant, “a number of teachers are yet to recognize the available opportunities to use digital technologies for their professional development.” It was also noted that no assessment has yet been carried out to determine accurately the proportion of teachers who have the required ICT competences, which makes it harder to formulate an operational plan to develop the required skills and overcome skills gaps. Moreover, it is difficult to keep up with the rapid pace of technological change.

The opportunities and benefits of digitalization in education were well recognized by some key informants, who noted that technology may reduce the time it takes for teachers to prepare and deliver lessons. However, they also emphasized the importance of providing relevant training. As noted by one key informant, “although there are many benefits

to digitalizing school data, the lack of school community readiness may bring about frustrations as users would find these systems too demanding and far beyond their competences and thus accrue resistance to their adoption." One key informant added that the use of digital technology can also increase teachers' working hours, particularly to ensure access to the courses that are created, support students in the use of technology and online resources, upload learning materials and activities, conduct assessments and provide feedback. In this regard, a number of informants highlighted the importance of providing exposure to and continuous professional development (CPD) in the use of digital technology in teaching and learning so that teachers become comfortable working with technology and acquire digital skills.

According to one key informant, pre-service teacher training institutions do not provide opportunities for ICT skills development due to the lack of adequate ICT equipment. Another observed that teaching faculty at pre-service teacher education institutions require capacity-building themselves in the new modes of learning, including in course design, learner support and assessment. Pre-service teacher education programmes and teacher training colleges should ensure that graduates leave with advanced ICT literacy skills, which would reduce the burden on in-service teacher training. This recommendation addresses the concern that it would be very costly to train the large number of in-service teachers in the required ICT competences.

Other challenges noted by the key informants include: financial constraints and the limited budget for ICT software and hardware and ICT-related training; resistance to change, including by older teachers; insufficient ICT personnel in schools; and poorly packaged ICT training.

4. Initiatives to promote digitalization in education

4.1. One Laptop per Child (OLPC)

4.1.1. Introduction

In 2005, Professor Nicholas Negroponte of the Massachusetts Institute of Technology (MIT) unveiled his idea of developing and distributing rugged low-cost laptops to children in primary schools in developing countries with a view to improving access to knowledge and supporting exploration and experimentation with the latest technology (Shah, n.d.). This led to the launch of the One Laptop per Child (OLPC) programme in Rwanda in October 2008, with the aim of providing Xo laptops, which are small and inexpensive, to primary school students.

The OLPC programme, through digital, interactive and animated graphic rich content, is able to help learners visualize, simulate and share various complex concepts, which improves their understanding, retention and innovation capacity (REB, 2018a). The main objectives of the programme are to:

- enhance education by enabling learners to learn by doing through graphically rich, animated and interactive digital courses and gaming;
- transform the role of the teacher from *a knowledge holder* to *a facilitator* who guides learners to access the vast knowledge on laptops, servers and the internet**;**
- enable primary school learners to have early access to computers in order to develop computer skills through computer science courses, including programming skills;
- expand the knowledge of learners on specific subjects, such as science, mathematics, languages and social sciences, through online research and digital content hosted on individual school servers, which are provided and maintained by the Government (REB, 2018b).

The various components of the OLPC programme include: distributing Xo laptops; developing and distributing digital content; providing capacity building for head teachers and teachers; repairing and maintaining Xo laptops; and engaging in project sustainability and contributing to ICT growth (REB, 2018b). The OLPC programme is part of the ICT in Education Department of the Rwanda Basic Education Board (REB), the apex implementation agency of the Ministry of Education.

4.1.2. Distribution of Xo laptops

In 2008, during the first phase of programme implementation, the Government ensured that a minimum of five schools were running the OLPC programme in all 30 districts. During the second phase, launched in 2011, the Ministry of Education, through the REB, ensured that all administrative sectors in the country had a minimum of one school running the programme. The current distribution strategy involves the provision of Xo laptops to schools according to the number of learners per study shift (morning and afternoon) or class size, which implies that the bigger the class size, the more Xo laptops a school will receive.

Table 4.1. Distribution of Xo laptops by fiscal year

Fiscal year	2013-14	2014-15	2015-16	2016-17	2017-18
Number of Xo laptops distributed	4,194	23,297	40,559	-	-

Source: Rwanda Education Board, 2018a.

As shown in table 4.1, no new Xo laptops have been imported and distributed to schools as of the financial year 2016-17. In response to the absence of new Xo laptops, as the number of schools with grid electricity or solar panels was increasing, and in view of the imperative to broaden the impact of ICT in education through the fair distribution of the available educational resources, the REB embarked upon the redistribution of Xo laptops. Redistribution is an equity-focused exercise involving the reallocation of laptops to schools recently provided with access to electricity (that is, some computers are taken from schools equipped earlier to benefit newly established schools or pre-existing schools that now have electricity). This activity is still on-going. As shown in table 4.2, a total of 87,020 Xo laptops were redistributed to 581 new schools between the financial year 2016-17 and 2017-18.

Table 4.2. Redistribution of Xo laptops by fiscal year

Fiscal year	2013-14	2014-15	2015-16	2016-17	2017-18
Number of Xo laptops redistributed	-	-	-	75,117 to 537 new schools	11,903 to 44 new schools

Source: Rwanda Education Board, 2018a.

4.1.3. Development of digital content and related technology for access

In addition to imparting basic ICT literacy to students, the OLPC programme also includes the establishment of an integrated school ecosystem consisting of a wireless Local Area Network (LAN) and a server. The server is designed to host interactive digital lessons, provide access to digital books and software and manage lesson plans. The LAN enables

communication between Xo laptops and the server. As of the financial year 2017-18, the number of servers distributed had reached 410.

In view of the challenges relating to server maintenance, and in response to technological advances, older servers are being used as office computers, while Content Access Points (CAPs) are taking over the role of servers. A CAP is a wireless access point with an integrated digital content distribution system, which provides an easy-to-use interface and storage that can be loaded with educational materials for students to access without the internet. As of the financial year 2018-19, the REB had purchased 1,613 CAPs for deployment to primary schools (REB, 2019). CAPs are used as modern servers to store digital content and provide access to the internet using Xo laptops.

4.1.4. Building the capacity of teachers and education workers

To ensure that the Xo laptops are serving their intended purpose, when they are distributed to schools, the OLPC team organizes training for level 4-6 primary teachers, in which ICT basic skills are taught as part of science and elementary technology (SET) (REB, 2018a).

Training focuses on learning generic ICT terms and creating a dialogue in Scratch. In the same training package, trainees are taught the use of AbiWord, including text formatting, the use of spreadsheets in class and the design of student activities. More advanced skills include the use of the Management Information System (MIS) to monitor the usage of laptops and manage the roll call. As shown in table 4.3, a total of 17,641 teachers received training between financial years 2013-14 and 2017-18 (REB, 2018a).

Table 4.3. Capacity building of teachers by fiscal year

Fiscal year	2013-14	2014-15	2015-16	2016-17	2017-18
Number of teachers trained	1,234	2,735	3,484	9,297	891

Source: Rwanda Education Board, 2018a.

In order to ensure that teacher supervisors are familiar with the use of Xo laptops, and can therefore provide appropriate pedagogical support, training was also provided to head teachers, sector education inspectors and district education officers. In the financial year 2018-19, some 411 sector education inspectors and 27 district education officers in charge of primary schools were trained, with the training focusing on three main aspects:

- OLPC basic activities: introduction to Xo laptops and physical parts, journal, interfaces and typing turtle;
- OLPC basic technical skills; and,
- ICT integration in teaching and learning: paint activity, AbiWord, Gnumeric spreadsheet and Scratch activity basic programming skills using Xo laptops.

4.1.5. Repair and maintenance of Xo laptops

It is common for any device to become defective or unserviceable. Accordingly, to maximize the lifetime of Xo laptops, and to ensure that technical and functional issues are resolved, the maintenance and repair of damaged Xo laptops is organized regularly. Initially, Xo laptops with technical issues, which required repairs beyond those that could be carried out by local stakeholders (such as teachers), were brought to the REB headquarters. It was later realized that this was time consuming and logistically challenging. The REB therefore adopted the approach of organizing bi-annual/annual maintenance and repair sessions at the district level, where head teachers would bring defective equipment and take it back immediately following the repair, or be provided with cannibalized devices if those they brought in were completely unserviceable. Maintenance and repair are therefore ongoing activities. Table 4.4 provides statistics on the Xo laptops repaired and maintained over a five-year period.

Table 4.4. Repair and maintenance of Xo laptops by fiscal year

Fiscal year	2013-14	2014-15	2015-16	2016-17	2017-18
Xo laptops repaired and maintained	2,763	1,949	804	130	1,785

Source: Rwanda Education Board, 2018a.

4.1.6. Impact, lessons learnt and challenges related to the OLPC programme

The OLPC programme has had a positive impact on the provision of and quality of education in Rwanda. It has triggered the earlier exposure of young children (aged 7-8) to technology and has informed the revision of the curriculum to make it competence-based by providing learners with opportunities for exploration, creation and presentation. As a result, it has introduced new and revised teaching and learning practices in Rwandan schools. The implementation of the OLPC programme has also made the electrification of schools one of the top priorities in the country and has enhanced teachers' ICT skills.

A 2017 study on teachers' perceptions of the integration of ICT in education through the implementation of the OLPC programme showed that primary school teachers found the programme beneficial for students, particularly in gaining experience with computers, and were positive about integrating technology into teaching and learning. Some of the barriers to ICT integration identified by teachers included the lack of adequate devices and infrastructure, limited training to enhance ICT skills and high student-teacher ratios. The study also noted that little research and few studies have been undertaken to assess the impact of the OLPC programme (Munyengabe et al., 2017).

Although designed to integrate technology in education, the OLPC programme has been criticized for failing to fully take into account local contexts of implementation, especially in terms of the availability and affordability of electricity, and access to an adequate number of power plugs to charge the devices (Bizimungu, 2018). According to the REB (2018a), the leading challenges to the OLPC programme include: (i) the lack of electricity infrastructure across schools, which is hindering the deployment of Xo laptops to all primary schools; (ii) the limited budget to acquire new laptops and spare parts for repairs; (iii) concerns about some school administrators keeping laptops, rather than making them available to students, and the resulting damage to some laptops due to extended poor storage; and (iv) the delayed re-activation of the lease key, the reporting of defective laptops, theft and the insufficiency/absence of technical staff to support head teachers in the management of ICT equipment.

During the COVID-19 school closures, laptops remained largely unused, as they were stored in schools. The pandemic highlighted the importance of ensuring that ICT is also available in households so that students can continue learning beyond/after school, including during crisis situations.

4.2. The smart classroom initiative

4.2.1. Introduction

While the OLPC programme targeted primary schools, the smart classroom initiative has been introduced in secondary schools. It is expected to gradually replace the OLPC programme in primary schools in order to adopt changing technology, reduce costs and increase access and equity (Ministry of Education, 2016). The smart classroom initiative is informed by the imperatives of the CBC, which calls for comprehensive change and new thinking about instructional approaches and assessment patterns. It indicates that the curriculum must enable educators and students to use ICT as a tool to improve teaching and learning practices in all subjects at all levels. ICT integration is expected to boost the use of student-centred approaches by encouraging research, communication and collaboration among students (REB, 2018b).

In support of these policy directions, in 2016, the Government began equipping secondary schools with smart classrooms, which consist of 50 laptops, each connected to the internet. The computers provided are assembled locally by Positivo BGH, a Latin American multinational information technology (IT) company that manufactures technology products and services, including devices and software, which has been established in Rwanda since 2015.

The laptops are loaded with specialized software, multimedia digital content, audio responsive technology and audio-visual capabilities, such as interactive whiteboards or projection screens and projectors. They are used to teach both ICT-related and other subjects. Due to infrastructure and computer deficits, schools have one or two smart classrooms of this kind. The target is still for all secondary schools to have been equipped with at least one smart classroom by 2024 (REB, 2018b).

While smart classrooms are used in rotation by the students in each school, teachers require additional devices to prepare and deliver lessons. An additional five laptops are therefore distributed in each school to assist teachers in their work (REB, 2018a). This is also supported by the One Laptop per Teacher initiative, which aims to provide all teachers in public schools with a laptop by the end of 2024 (see box 1).

The TMIS was established to improve teacher management by collecting and validating data and information on teachers. However, many teachers are not able to access the TMIS due to limited internet connectivity and lack of access to devices (Mugiraneza, 2021a). Ensuring smart classrooms have internet connectivity will also enable teachers and other education staff to have access to information systems such as the TMIS and the SDMS. Both systems require continued access to upload the various types of data on school life (key informant interview, 2021).

4.2.2. Progress made in the establishment of smart classrooms

According to the REB (2018a), as of the financial year 2017-18, the smart classroom initiative has achieved the following:

- 13,220 laptops have been distributed to 150 schools across the country for smart classroom implementation and 3,435 laptops have been distributed for use by teachers in lesson preparation and delivery;
- 200 schools have been connected to the internet through 4G long-term evolution;
- 82 licences for Adobe Photoshop and 82 licences for Adobe Premier Pro software have been purchased and installed in 10 schools;
- computer refurbishment and training of trainers on PC refurbishment and maintenance has been carried out.

Smart classrooms have also been introduced to improve traditional TVET teaching and learning and support the development of 21st century skills, including through furthering student-centred learning, interdisciplinary work, competence-based education and training and problem-solving. According to the Rwanda Technical and Vocational Education Board, 66 smart classrooms have been established and 349 TVET schools have internet connectivity.[2]

[2] For further information, see the Digital Technologies Division of the Rwanda TVET Board, accessed 15 February 2022.

The aim is for 100 per cent of TVET schools to be equipped with smart classrooms by 2023-24 (Rwanda Technical and Vocational Education Board, 2021; Iriza and Uhiriwe, 2021).

4.2.3. Laptop repair and disposal

With the increasing number of Positivo laptops in schools, it became a challenge for schools to maintain them themselves or to have them sent to the ICT department of the REB for repair. An agreement was therefore concluded between the REB, Positivo BGH (the manufacturing firm), the Rwanda Information Society Authority (RISA) and the Rwanda Polytechnic to establish a Management Information System (MIS) to monitor laptops for technical issues and enable administrative decisions on their repair to be made either remotely or at a decentralized IPRC, which is managed by the Rwanda Polytechnic (Ministry of Education, 2020b).

Positivo laptops are repaired in accordance with the National ICT Strategy and Policy 2011-15 (NICI-III), which provides guidance on the refurbishment and recycling of old and defective computers/laptops and other ICT equipment. In line with this policy, outdated and broken computers/laptops do not necessarily have to be disposed of, as they can be repaired or, if beyond repair, can be stripped for components, such as capacitors and memories (Government of Rwanda, 2011). The refurbished computers are provided to schools for teaching and learning.

4.2.4. Teacher training

The optimum use of smart classrooms is dependent on the ICT skills of teachers, and in-service teacher training has therefore been planned and carried out on the integration of ICT in teaching and learning. The training is developed from the module "ICT Essentials for Teachers", based on the UNESCO ICT Competency Framework for Teachers (ICT-CFT), which outlines the competences that teachers need for the integration of ICT into their professional practice (Ministry of Education, 2017).

In view of the number of teachers who require training, a cascade approach has been adopted, through which trained master trainers (that is, teachers acting as master trainers for other teachers) are mandated to train other teachers in their respective communities (sectors and schools). Some of the challenges arising in the cascade approach include a time delay in reaching targeted beneficiaries and the limited budget, which has pushed the cascade approach into phases. During the financial year 2017-18, the REB used its ordinary budget to train 10,800 secondary school teachers (45.8 per cent of the total) in the integration of ICT in teaching and learning (REB, 2018a).

Evidence from the first and second phases of teacher training in ICT Essentials for Teachers showed that teachers in Rwanda have the skills, expertise and strategies to integrate ICT into

teaching and learning. Training manuals were produced relatively quickly and economically, based on adapted Open Educational Resources (OERs) and the UNESCO ICT Competency Framework for Teachers (REB, 2018a).

4.2.5. Impact, lessons learnt and challenges related to the smart classroom initiative

The smart classroom initiative is flourishing in Rwandan schools. It has not only enabled teachers to teach ICT subjects in secondary schools, but has also supported the integration of ICT into teaching and learning in other subjects. The initiative requires teachers to develop new skills, including ICT skills, and permits students to gradually acquire research and innovation skills.

The majority of the criticisms of the initiative are that existing infrastructure and human resources are not sufficient to realize its potential in practice. For example, due to a lack of skilled technicians across the country, Positivo laptops had to be sent to Kigali for repair and maintenance, until a Memorandum of Understanding for the decentralization of repair work was signed in 2018 between the REB, RISA, Rwanda Polytechnic and Positivo BGH (Ministry of Education, 2020b). There is also concern about the lack of parts on the local market required to repair and maintain equipment. Moreover, funding remains a challenge, as the Government is struggling to raise adequate funds for the acquisition of more computers (Bishumba, 2020). Other challenges include large class sizes and insufficient rooms to set up smart classrooms/install laptops. Moreover, there are still schools without electricity (REB, 2019).

4.3. Initiatives in digital content development and the integration of digital technology

4.3.1. Digital content development

In 2015, the Government adopted a CBC, which was rolled-out in three phases, beginning in 2016 and ending in 2018 (REB, 2015). It was imperative in the country to improve the quality of education and access to digital resources. The exclusive use of printed textbooks limited access to updated and diverse educational resources, and many existing online resources either imposed limitations (such as the requirement for licences) or were not adapted to the national context. Accordingly, the development of locally relevant digital content aligned with the curriculum and with free access emerged as a solution. This was undertaken in the spirit of the strategic objectives of the 2016 ICT in Education Policy (Ministry of Education, 2016), and was piloted with the development of digital content for three secondary school subjects, namely mathematics, science and English for senior one (S1) to senior six (S6) levels (REB, 2018a).

With a view to ensuring that all core textbooks used in primary and secondary education are the full property of the Government and can therefore be reproduced and converted into digital format, the Ministry of Education has changed its textbook acquisition strategy from outside sources to in-house production, using local scholarly expertise. It started in 2018 with the development of 46 titles, 12 for primary and 34 for secondary education, which were not acquired through tenders (REB, 2019). The final validated textbooks are printed for distribution to schools. The soft copies have been fully uploaded onto the REB website and are accessible free of charge. The textbooks have also been gradually converted into interactive digital content uploaded onto the REB e-learning platform. Both the website and the platform were accessible to students and teachers during the COVID-19 pandemic, which served to emphasize the need to invest in ICT and the development of digital content to ensure the resilience of the education system.

4.3.2. Teachers' preparedness and capacity development

Teachers are central to curriculum implementation, and the learning experiences of students depend heavily on teachers' skills. Teachers' capacities in the use of ICT for pedagogical purposes require further and continuous support, including through training. According to the REB (2019), 8,000 of 29,046 secondary school teachers were trained in the Advanced UNESCO-ICT CFT, and 4,600 of 59,866 primary school teachers were trained in the UNESCO-CFT basic course/ICT skills literacy.

In support of the capacity development of teachers, the Government has engaged in partnerships with advanced nations and funding agencies. In December 2017, the Government of Rwanda, through the Ministry of Finance and Economic Planning, and the Government of the Republic of Korea, through the KOICA, launched the Capacity Development for ICT in Education (CADIE) project, which is being implemented by the REB. In addition to building the capacity of 43,000 teachers, the project will also support 446 district and sector education officers in the use of ICT in education (Murori, 2017).

The main objective of the CADIE project is to integrate and utilize ICT in teaching and learning in primary and secondary schools. As part of the project, a training programme will be established for in-service teachers, pre-service teacher inspectors, sector education officers, district education officers and master trainers. The project, which has a budget of USD 7,000,000, will be implemented from 2019 to 2023. To support teachers to become conversant with e-learning technologies and to widen its reach, an online teacher training course and monitoring strategies have also been developed.[3]

The need for in-service teacher training in ICT is discussed by Twagilimana and Mannikko-Barbutiu (2018), who emphasize that teachers not only need to be trained in new pedagogy

[3] For more information on CADIE, see REB Capacity Development for ICT Use in Education, accessed 23 November 2021.

and subject teaching methods, but also to make good use of ICT in the various subject areas. The Ministry of Education has ranked ICT training for teachers as the second priority (after school construction) for human capital development in Rwandan education. It was with this in mind that the Ministry of Education set the objective of training 13,136 teachers (56.3 per cent men and 43.7 per cent women) in ICT in 2019 (Ministry of Education, 2019).

This ambitious target was also driven by the fact that primary school teachers have continuously noted their concern at the lack of skills for the operation of the OLPC programme and teaching with laptops. Moreover, the Japan International Cooperation Agency (JICA) (2020) reports that primary school teachers teach only theory, instead of allowing students to use computers. In secondary education, a three-year project entitled Rwandan Quality Basic Education for Human Capital Development (QBEHCD), which started in 2019, involves training teachers to strengthen the content of mathematics and science subjects, with the aim of integrating ICT in these subjects and improving teachers' digital literacy (World Bank, 2019). As part of the project, ICT equipment will be provided to schools and teacher training colleges in the near future, for which purpose a tender was issued in May 2021 (REB, 2021).

4.3.3. Technology to support digitalization of education

While the full integration of ICT in teaching and learning has been slow due to the traditional face-to-face in-person learning environment (Ndayambaje, Bimenyima, and Ndahayo, 2015; Bahati, 2010), earlier experience in the country (Ndayambaje, 2015) has been the building block for rebooting e-learning, especially in response to the COVID-19 pandemic.

Following the announcement by the World Health Organization (WHO) in March 2020 that COVID-19 was a global pandemic (Kaup et al., 2020), health and safety measures were put in place in Rwanda, which included lockdowns and school closures. These measures brought an end to in-person instruction and face-to-face teaching (Di Pietro et al., 2020). In Rwanda, the Government ordered school closures on 16 March 2020, and all students were evacuated from boarding schools. To ensure the continuation of learning, priority was given to e-learning and lessons over radio and television (Houser, 2020; Mugiraneza, 2021b). However, few students were able to continue learning through virtual means due to a lack of access to equipment, such as computers, tablets and smart phones and internet connectivity. Radio and television therefore ended up as the leading channels for learning, as they are available in a considerable proportion of households in Rwanda (Mugiraneza, 2021b).

With the gradual reopening of schools, e-learning is continuing to play a pivotal role in facilitating teaching and learning and is increasingly being considered as a focus of investment with a view to transforming education provision. However, the real physical,

cultural and contextual worlds of students need to be taken into consideration in this regard (Mukama, 2014).

Embarking on the use of e-learning in teaching and learning from primary education is possible, especially as considerable progress was made in the development and provision of digital learning materials and resources in 2021. One significant step was that all digital textbooks have been made available on the REB e-learning portal and can be accessed free of charge by students, teachers, parents and the general public. Indeed, 852 secondary schools out of a total of 1,559 (54.6 per cent) and 1,819 primary schools out of 3,093 (58.81 per cent) now have access to digital educational resources. Further efforts need to be made to ensure that these resources are interactive and inclusive and that individual teachers have access to digital devices to prepare and deliver content (REB, 2019). It is also important to further invest in ICT infrastructure and internet connectivity and ensure that they are financially affordable with a view to guaranteeing equal learning opportunities within and outside schools.

5. Participation of education stakeholders in digitalization initiatives

The teachers' unions in Rwanda include the Rwanda National Union of Teachers (Syndicat National des Enseignants au Rwanda, SNER), which represents teachers from pre-primary to secondary education in public and government-aided schools, and the Union of Teachers and Other Education Personnel (Syndicat des Enseignants et Autres Personnels de l'Education, SYNEDUC), which organizes teachers in the private sector. In key informant interviews, unions indicated that they are invited to participate in meetings with the Government on policies and plans that have an impact on teachers and their work. They added that the unions provide financial support for teacher training in ICT, as well as computers and internet connectivity. They have also supported the acquisition of solar systems for some schools that are not connected to the electricity grid. One of the unions organizing teachers in private schools has also created a digital data ecosystem to monitor and track teacher training, development and capacity-building.

In addition to teachers' unions, the Ministry of Education, the REB and other relevant ministries (including the Ministry of ICT and Innovation), development agencies and not-for-profit organizations, which support a number of education projects (some of which are referred to above), are also key stakeholders in the national education system. For example, the Building Learning Foundations (BLF) of the Education Development Trust promotes online training for mathematics teachers through digital and interactive teaching aids and supports access by teachers and head teachers to digitized resources through mobile phones (key informant interview, 2021). The private sector has also been playing an increasing role in education, as seen during the COVID-19 pandemic, when the Government agreed with the Airtel and MTN internet service providers on free access to education content on three e-learning portals (Mugiraneza, 2021b).

6. Conclusions and recommendations for ways forward

The introduction of ICT in primary and secondary education and the adoption of ICT-related policies and strategies in education and other sectors have transformed teaching and learning in Rwanda. To ensure that learners gain the intended benefits from the three initiatives and activities discussed above, namely the OLPC programme, the smart classroom initiative and digital content development and integration of digital technology, the Government must support the provision of, access to and the use of ICT in schools and at home. It is also important to: continue investing in teacher training so that teachers are conversant with the use of technologies for teaching and learning; speed up the roll out of electricity in schools and communities; ensure that schools have sufficient rooms that can be used to learn ICT and learn with ICT; provide access to the internet and safe storage for ICT devices; and procure enough computers for learners and teachers to guarantee equal learning opportunities for Rwandan children. It is also essential to consider the provision of IT staff at the school level to help infuse ICT competences, repair/fix equipment and assist with technical issues. Working with different education sector stakeholders can have a positive impact on digitalization efforts.

Interviews with key informants identified a number of conclusions and recommendations with a view to enhancing existing strategies and efforts to support digitalization in education in Rwanda:

- If ICT is to become an engine for socio-economic transformation, it should be enhanced beyond educational institutions. In this regard, the development of ICT hubs, including in open spaces and buses, as well as strong public-private partnerships, can help realize the 2018-19 to 2023-24 ESSP, which provides a blueprint for the education system to equip citizens with sufficient and appropriate skills, competences, knowledge and attitudes to drive social and economic transformation.
- In order to attain better learning outcomes, it is vital to increase investment in teachers' competences and welfare to boost their motivation. With a view to guaranteeing the effective integration of digital technology in teaching and learning and the effective use of teaching and learning management systems in schools, it is important to improve the technological knowledge of teachers and head teachers. Putting in place well-structured refresher training on ICT competences for teachers is an imperative and can alleviate the challenges of mind-set and resistance to change.
- As noted by one key informant, teaching online places new demands on teachers: "to teach online is different and more demanding than face-to-face … also the assessment patterns online are far more demanding than those of face-to-face". The informant therefore recommends adapting the workload of teachers to the evolving ICT landscape.

- ICT infrastructure (devices, electricity and internet connectivity) has to be enhanced and special attention must be given to schools in rural and remote areas to address the digital and learning divide. There is an urgent need for affordable and quality ICT devices in schools. Building on the lessons learned from school closures during the COVID-19 pandemic, individual teachers should be provided with their own ICT devices to support learners remotely.
- It is essential to adopt well-coordinated plans, implementation polices and activities in relation to digitalization in education in order to prepare for crises or situations similar to the COVID-19 pandemic. Digitalization is a collective concern that requires collaborative efforts between education stakeholders.

References

Bahati, Bernard. 2010. *Is ICT Being Integrated Pedagogically into Teaching and Learning Events at Kigali Institute of Education (KIE)?*. Johannesburg: University of the Witwatersrand.

Bishumba, Nasra. 2020. "Minister Irere Sheds Light on Positivo Challenges". *The New Times*, 3 December 2020.

Bizimungu, Julius. 2018. "Meet the Rwandan Innovation for One-Laptop-Per-Child". *The New Times,* 5 June 2018.

Buningwire, Williams. 2021. "Rwanda Coding Academy Provides the First Solution". *KT Press*, 2 February 2021.

Chuks, Otioma. 2017. "Exploring the Urban Digital Divide in Kigali: Spatial Analysis and Institutional Adaptation". Master's thesis, Enschede, Netherlands.

Di Pietro, Giorgio, Federico Biagi, Patricia Dinis Mota da Costa, Zbigniew Karpiński, and Jacopo Mazza. 2020. *The Likely Impact of COVID-19 on Education: Reflections Based on the Existing Literature and Recent International Datasets.* Luxembourg: European Union.

Digital Opportunity Trust (DOT). 2019. *Digital Ambassador Program Proof of Concept: Final Evaluation.* Ottawa.

Gender Monitoring Office. 2017. *Gender and Information and Communication and Technology (ICT).* Kigali: Government of Rwanda.

Government of Rwanda. 2020a. *An Architecture for the Integrated Education Management Information System*. Kigali: Ministry of Education.

———. 2020b. *Vision 2050*. Kigali: Ministry of Finance and Economic Planning.

———. 2012. *Rwanda Vision 2020 (Revised 2012)*. Kigali: Ministry of Finance and Economic Planning.

———. 2011. *Rwanda ICT Strategic and Action Plan: NICI-2015*.

Houser, Veronica. 2020. "Radio Learning in the Time of Coronavirus: UNICEF and Partners Support Rwanda Education Board to Develop Radio Lessons for Students Affected by COVID-19 School Closures". UNICEF, 13 April 2020.

Iriza, Jade Natacha, and Better Benigne Uhiriwe. 2021. "TVET Schools to Get Smart Classrooms". *The New Times*, 11 June 2021.

Japan International Cooperation Agency (JICA). 2020. *The Project for Supporting Institutionalizing and Improving Quality of SBI Activity (SIIQS): Project Completion Report*.

Kaup, Soujanya, Rashmi Jain, Siddharudha Shivalli, Suresh Pandey, and Soumya Kaup. 2020. "Sustaining Academics during COVID-19 Pandemic: The Role of Online Teaching-Learning". *Indian Journal of Ophthalmology* 68 (6): 1220-1221.

Kropff, Wietske, Edward Mabaya, Olukemi Afun-Ogidan, Evan Girvetz, and Andy Jarvis. 2020. *Digital Agriculture Profile: Rwanda*. Food and Agriculture Organization of the United Nations.

Mazimpaka, Magnus. 2015. "First 'Made in Rwanda' Computers in Kigali Stores". *KT Press*, 6 November 2015.

Ministry of Education. 2020a. *2019 Education Statistics*. Kigali: Government of Rwanda.

———. 2020b. *2019/20 Backward-Looking Joint Review of the Education Sector: Report*. Kigali: Government of Rwanda.

———. 2019. *Education Statistical Yearbook.* Kigali: Government of Rwanda.

———. 2018. *Education Sector Strategic Plan 2018-2024*. Kigali: Government of Rwanda.

———. 2017. *ICT Essentials for Teachers: Based on the UNESCO ICT Competency Framework for Teachers*, Version 2. Kigali: Government of Rwanda.

———. 2016. *ICT in Education Policy*. Kigali: Government of Rwanda.

———. 2015. *2014 Education Statistics Yearbook*. Kigali: Government of Rwanda.

Ministry of ICT and Innovation. n.d. "Rwanda Launches the First Coding Academy". Press Release.

———. 2018. "Andela to Open pan-African Technology Hub in Kigali". Kigali: Government of Rwanda.

Ministry of Youth and ICT. 2016. *National Digital Talent Policy*. Kigali: Government of Rwanda.

Mugiraneza, Jean Pierre. 2021a. *Digitalization in Teaching and Education in Rwanda*. *Digitalization, the Future of Work and the Teaching Profession project*. Geneva: ILO.

———. 2021b. *Digitalization in Teaching and Education in the Context of COVID-19: Rwanda. Digitalization, the Future of Work and the Teaching Profession project*. Geneva: ILO.

Mukama, Evode. 2014. "Bringing Technology to Students' Proximity: A Sociocultural Account of Technology-Based Learning Projects". *International Journal for Research in Vocational Education and Training (IJRVET)* 1 (2): 125-142.

Munyengabe, Sylvestre, Zhao Yiyi, He Haiyan, and Sabin Hitimana. 2017. "Primary Teachers' Perceptions on ICT Integration for Enhancing Teaching and Learning through the Implementation of One Laptop per Child Program in Primary Schools of Rwanda". *EURASIA Journal of Mathematics, Science and Technology Education* 13 (11): 7193-7204.

Murori, Kajuju. 2017. "43000 Teachers in Rwanda to Acquire ICT Skills". *The African Exponent*, 19 December 2017.

Ndayambaje, Irénée. 2015. "Facing ICTs and e-Learning Environment: An Investigation from the Graduates Registered in the First Batch of e-Learners under PanAfrican Tele-Education Programs in Rwanda". *Rwandan Journal of Education* 2 (1): 61-69.

Ndayambaje, Irénée, Théoneste Bimenyimana, and Viateur Ndahayo. 2015. "A Study on the Practices and Challenges of the Distance Training Programme (DTP) under the Kigali Institute of Education (KIE)". *Rwandan Journal of Education* 1 (2): 69-76.

Nkurunziza, Michel. 2021. "All Public School Teachers in Rwanda to Get Laptops". *The New Times*, 17 April 2021.

Raman, Kumutha, and Hamidah Yamat. 2014. "Barriers Teachers Face in Integrating ICT during English Lessons: A Case Study". *The Malaysian Online Journal of Educational Technology* 2 (3): 11-19.

Rwanda Basic Education Board (REB). 2021. "Specific Procurement Notice", Quality Basic Education for Human Capital Development Project/Supply of ICT-Equipment. 7 May 2021.

Rwanda Education Board (REB). 2019. *Annual Report for the Fiscal Year 2018-19*. Kigali: Government of Rwanda.

———. 2018a. *Annual Report Financial Year 2017-18*. Kigali: Government of Rwanda.

———. 2018b. "Smart Classroom Design: Concept Note". Kigali: Government of Rwanda.

———. 2015. *Competence-Based Curriculum: Curriculum Framework Pre-Primary to Upper Secondary 2015*. Kigali: Government of Rwanda.

Rwanda Technical and Vocational Education Board. 2021. "Brochure 2021: Employable Skills for Sustainable Job Creation". Kigali: Government of Rwanda.

Shah, Namank. n.d. "A Blurry Vision: Reconsidering the Failure of the One Laptop Per Child Initative". Course paper, Arts and Sciences, Boston University.

Twagilimana, Innocent, and Sirkku Mannikko-Barbutiu. 2018. "ICT in Education Policy in Rwanda: Current Situation, Challenges and Prospects". In "ACRID 2017: Proceedings of EAI International Conference for Research, Innovation and Development for Africa", European Alliance for Innovation.

United Nations Children's Fund (UNICEF). 2019. *UNICEF Rwanda Country Profile*.

Ufitiwabo, Aurore Teta. 2021. "Over 1,800 Science Teachers to be Given Laptops in August". *The New Times*, 3 August 2021.

Wong, Alex. 2017. "Rwanda's Digital Ambassadors are Boosting Computer Literacy". World Economic Forum, 24 February 2017.

World Bank. 2019. "Rwanda: Quality Basic Education for Human Capital Development Project".

ISBN: 9789220388754