Convergence of Open Data, Digital Libraries, and Smart Technologies for Accelerating Progress Toward Sustainable Development Goals

Ibrahim Sidi Zakari

1 Introduction

The convergence of information and communication technologies is gaining momentum as highlighted by several authors including Huang et al. [11].

During the last two to three decades, the boundaries between information technology (IT), which refers to hardware and software used to store, retrieve, and process data and communications technology (CT), which includes electronic systems used for communication between individuals or groups, have become increasingly indistinguishable.

For example, at the end of the 1990s, people used to gather in large computing rooms for data processing purposes. Computing tasks are currently performed thoughout networks of geographically separated but interconnected devices. The use of massive datasets and advanced simulations and computation methods is impacting positively scientific research and knowledge co-creation.

Moreover, in many places around the world, mobile Internet users (e.g., 3G and 4G, or third-generation and fourth-generation, mobile phone subscribers) outnumber fixed Internet users (e.g., personal computer users).

The convergence of information and communication technologies (ICT) and smart devices is contributing to the production and dissemination of various types of data including administrative data, commercially licensed data, geospatial data, metadata (e.g., call detail records), official statistics, open data, photo or video data, private sector data, qualitative data, satellite imagery, sensor data, survey data, unstructured data, web or social media data and paradata (e.g., geographic location of the respondents, used devices, browsers, and platforms; level of vocabulary in a

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text). Facts that are fostering synergies between communities of non-official data (e.g. Academia, Industry and Open Street Map communities) and official statistics producers (e.g. National Statistical Offices).

Furthermore, smartphones and tablets combine computer, maps, TV, GPS, telephone, camera, projector, alarm clock, personal research assistant, music player, newspaper, translator, flashlight, web browsing, data sharing, and data storage by providing vast storage capacity and acting as a modem for Internet access to other devices.

Moreover, we are currently living in the era of the Internet of Things (IoT) where physical devices have the ability to collect data, exchange information, make decisions, and control themselves or other devices. Combinations of statistical analysis, semantic technology, personal assistants, and advanced irtificial intelligence are increasing human–machine interactions. The book[1] entitled *Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems* (2013) provided an overview of various topics of the IoT including the R&D priorities. Nowadays, many governments around the world are harnessing the potential of ICT to build a more transparent, efficient, and inclusive relationship with citizens. This new paradigm of open government (introduced in 2007), which is interrelated with e-government, differs among countries due to many reasons including technological and socioeconomic ones.

E-government systems allow citizens to receive government information, provide feedback, and carry out needed transactions in real time. Fixed and portable/wearable sensors and mesh networks are making cities and villages smarter, able to diagnose and fix local problems.

The concept of open data was introduced in the middle of year 2000, and which is closely related to open government, represents a more proactive data-based communication and interaction with citizens and end users as well as an opportunity of value-added services for private sector. The state of open data has been recently investigated by Davies et al. [8].

Countries are updating their national strategies for ICT by adapting the corresponding institutional, legal, and regulatory frameworks related to electronic communication for taking into account technological evolution, the convergences of networks and systems, and information society requirements.

ICT are fundamental for accelerating the achievement of the 17 United Nations Sustainable Development Goals (SDGs) to transform our world. Wu et al. [19] recently investigated the landscape of ICT for SDGs with a focus on state-of-the-art needs and perspectives, while Kostoska and Kocarev [12] proposed a novel ICT framework for SDGs.

This chapter is a contribution for advancing knowledge related to the convergence of open data portals, digital libraries, interactive whiteboards, and smart devices widespread that conduct to emerging applications and data innovations related to the United Nations Sustainable Development Goals (SDGs).

[1] https://www.riverpublishers.com/book_details.php?book_id=176

The rest of the chapter is organized as follows: the first section dedicated to general concepts and terminologies is followed by the research methodology, the analysis of some illustrative case studies, and the concluding remarks.

2 General Concepts and Terminologies

The concept of convergence has many definitions as highlighted in the lines below.

2.1 What Is Convergence?

Convergence is the coming together of two different entities, and in the contexts of computing and technology, is the integration of two or more different technologies in a single device or system. A good example is the convergence of communication and imaging technologies on a mobile device designed to make calls and take pictures - two unrelated technologies that converge on a single device.[2]

Convergence is a deep integration of knowledge, tools, and all relevant activities of human activity for a common goal, to allow society to answer new questions to change the respective physical or social ecosystem. Such changes in the respective ecosystem open new trends, pathways, and opportunities in the following divergent phase of the process [3, 16].

2.2 What Is Technology Convergence and How Is It Possible?[3]

A convergence is when two or more distinct things come together. Technology convergence is when different forms of technologies cohabitate in a single device, sharing resources and interacting, creating new technology and convenience.

Borés et al. [6] define technological convergence as "a process by which the telecommunications, broadcasting, information technologies and entertainment sectors (collectively known as ICT – Information and Communications Technologies) may be converging towards a unified market." Technological convergence has both technical and functional sides. The technical side refers to the ability of any infrastructure to transport any type of data, whereas the functional side means the ability of consumers to seamlessly integrate various functions (computation, entertainment and voice) in unique devices.

[2] https://www.techopedia.com/definition/769/convergence

[3] https://shape.att.com/blog/technology-convergence

2.3 Examples of Convergence

Digital convergence occurs when the same multimedia content can be displayed on different types of devices (due to digitilization), and this binary information can be stored, published, and sent in an efficient manner. This is not possible for analog data and other data types, which are modified during the copy or transmission processes. This digital convergence is making technological convergence possible.

Technological Convergence in Education (EdTech)
Technology has brought about a revolution in the way knowledge is passed from a teacher to a student. Various devices such as smartphones and tablets are being introduced to work in conjunction with cloud-based models at the back end for the easy sharing of content among knowledge seekers. Numerous platforms are developed by universities for open discussions among researchers to better decompose problems and identify more optimal solutions.

ICT can contribute to quality of education and universal access to lifelong learning opportunities.

Despite the ability of technological advances to improve quality of education, some barriers reduce the effectiveness of the use of ICT in the learning environment (Blackwell et al. [5]).

Graham and Michael [9] and Annika and Åke [2] also highlighted the importance of ICT integration when teaching literacy and mathematics.

Although M-Learning is contributing to track students' progress in many areas (thanks to mobile phone widespread use), smartphone penetration rate (by 2017) was only expected to reach 20% (Agence Française de Développement [1]).

2.4 Technology Convergence Regulatory Issues

Access to intellectual property (IP) represents one of the biggest challenges in the multimedia industry and regulation of digital data. However, solutions for preventing copyright crimes include trademarking and copyrighting of creative contents through mechanisms like the Digital Millennium Copyright Act (DMCA).[4]

2.5 Open Data

The relationships between different types of data were highlighted in Guyon et al. [10] through Fig. 1.

[4] https://www.copyright.gov/legislation/dmca.pdf

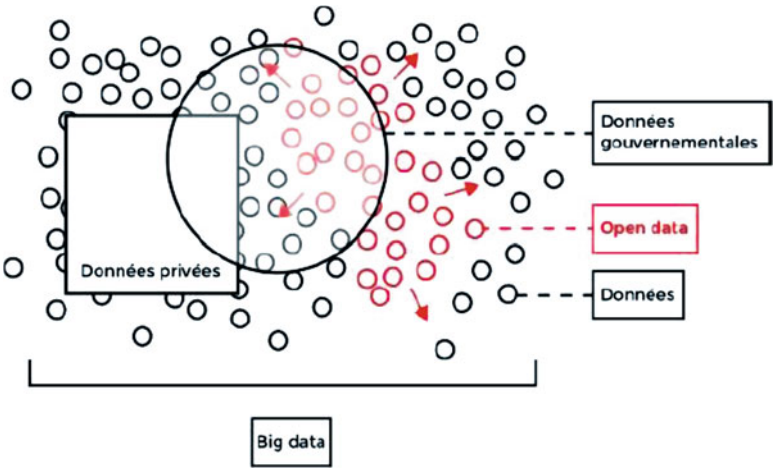

Fig. 1 The relationships between different types (Données = data; Données gouvernementales = Government data; Données privées = private data) of data © Sophie Czich (CC) BY-NC-SA

Open data are public or third-party (private sector, NGO, research institutions, etc.) data offered to users according to certain conditions.

Private data (in the sense of personal data) are data protected by the laws on the protection of personal data and do not enter by principle in the world of open data. Government data is potentially public data diffusable under the name of open data.

Other data are those held by companies or individuals which can potentially also be offered as open data. Big data is all big data managed publicly or privately (in the sense of third party), with open data included, but also a multitude of micro-data collected by all applications primarily on the Internet.

These conditions were initially defined during a meeting in Sebastopol (California), then completed in the article published by the Sunlight Foundation "Ten Principles for Open Government Information," that is, "ten principles for the opening of government information."[5] Open data is the idea that certain data should be freely available to everyone to use and republish as they wish, without restrictions from copyright or any other restrictions (Ubaldi [18]).

2.6 Open Government Data[6]

According to the Open Government Data (OGD) website, "open" means data is open, i.e., "free for anyone to use, re-use, and re-distribute," and "Open Government

[5] https://sunlightfoundation.com/policy/documents/ten-open-data-principles/

[6] Open Government Data. (2015). Retrieved July 10, 2019 from http://opengovernmentdata.org/about/

Data" means "data and information produced or commissioned by government or government controlled entities." The government data shall be considered open if it is publicly available in a way that complies with the following eight principles[7]:

(i) *Complete*
(ii) *Primary*
(iii) *Timely*
(iv) *Accessible*
(v) *Machine processable*
(vi) *Nondiscriminatory*
(vii) *Nonproprietary*
(viii) *License-free*.

According to Ubaldi [18], "a number of challenges may be associated with the implementation of OGD initiatives which, if not properly tackled, might obstruct or restrict the capture of benefits of national efforts aimed at spurring OGD." The challenges are:

(a) Harmonization of government data (multiple sources of data, different formats, and standards).
(b) Interoperability.

The lack in guidelines for regulating and helping in the process of opening data (for transparency and accountability of governments) has been raised by Nugroho [15]. According to Braunschweig et al. [7], availability of the data online is not sufficient; and some legal, administrative, and technical requirements need to be fulfilled by publication platforms.

3 Research Methodology

We investigate the convergence of ICT and smart devices through the following methodology which is based on our research on UN SDGs or the implementation of open data projects and illustrative case studies from the integration of ICT in education:

1. Understanding the linkages between ICT and the SDGs.
2. Analysis of digital convergence through an experimental open data portal for promoting data innovations and visualizations related to SDGs.
3. Analysis of digital and technological convergences in the context of integration of digital libraries for education in areas without the Internet.
4. Analysis of digital and technological convergences in the context of the integration of interactive whiteboard and smart microprojector for teaching statistics.

[7]Open Government Data Principles. (2015). Retrieved July 10, 2019 from https://public.resource.org/8_principles.html

The following sections will comment in more detail on these four different strands to the research.

3.1 ICT and the UN Sustainable Development Goals (SDGs)

Huawei's 2019 ICT Sustainable Development Goals Benchmark report[8] highlighted (Fig. 2) the fact that ICT can make the most difference in achieving SDG #4 (Quality Education), SDG #3 (Good Health and Well-being), SDG #9 (Industry, Innovation, and Infrastructure), SDG #5 (Gender Equality), SDG #11 (Sustainable Cities and Communities), and SDG #7 (Affordable and Clean Energy).

For example in the case of SDG #4 (*72% correlation with ICT*), the report stated that "In the future, all development is inseparable from talents and culture. However, there are currently more than 265 million children out of school worldwide, which greatly hinders social and economic development. The high correlation between SDG 4 and ICT skills indicates that a country's overall education level is closely related to its ICT education and training level. Only when the need for the required skills is satisfied can we promote the fair development of the whole society."

In the case of SDG #9 (*63% correlation with ICT*) it is mentioned that "16% of the global population does not have access to mobile broadband networks. Research has found that people and organizations' ability to access and use ICT

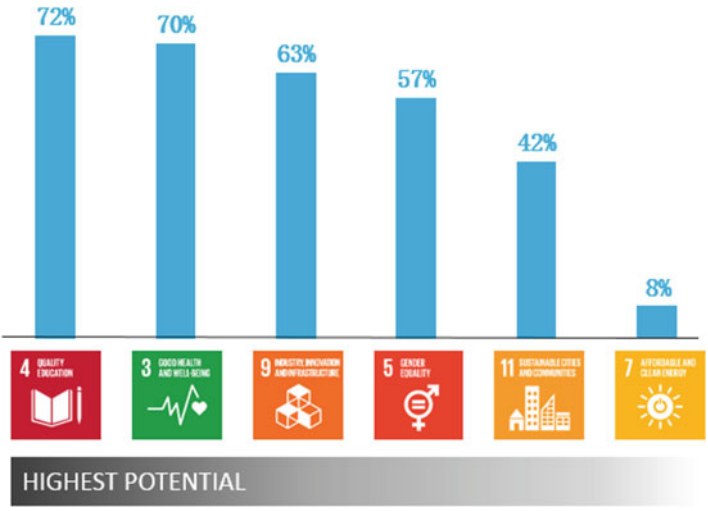

Fig. 2 Highest correlations between SDGs and ICT. (Source: 2019 ICT Sustainable Development Goals Benchmark report)

[8] https://www.huawei.com/en/about-huawei/sustainability/sdg, accessed on 22 July 2019.

services is more likely to drive economic development than ICT education and skills. Therefore, countries should focus on improving the access and use of ICTs, increase investment in industry, innovation and infrastructure, promote industrial development, and enable people to enjoy the social and economic dividends brought about by ICT development and promote social equity development."

The previous report also identified three critical pathways for ICT to drive sustainable development: (a) increase access to information and services, (b) increase connectivity between people and organizations, and (c) increase productivity and resource efficiency.

Furthermore, as part of the data for climate action challenge,[9] organized in 2017, leading companies around the world provided data to researchers and cloud computing support from Microsoft and/or data visualization support from Tableau. These datasets anonymized to protect privacy allowed participants to generate new solutions to help meet Sustainable Development Goal #13: Climate Action. However, because the 2030 Agenda is integrated and indivisible and climate action affects the attainment of its other goals, the challenge was also designed to support achievement of the 2030 Agenda as a whole, including a specific thematic focus on how climate action relates to the other goals.

3.2 Digital Convergence and Open Data Portals

This section highlights digital convergence through an award-winning open data portal initiative (Fig. 3), implemented since September 2018 in Niger as part of strategic projects identified by the Conference Afrique Francophone sur les Données Ouvertes (CAFDO)[10] in 2017.

In Niger, the right to information is a right guaranteed by the Constitution of the Seventh Republic on 25 November 2010, which stipulates in Article 31 (in respect of the rights and duties of the human person) that "Any person has the right to be informed and to have access to information held by the public services under the conditions determined by the law."

This portal[11] will not only federate existing open data sources on Niger but also identify data needs to improve the ranking of Niger vis-à-vis of international standards including the Global Open Data Index[12] and the Open Data Barometer.[13]

It should also be noted that most of the existing data sources are the result of isolated initiatives that have not necessarily been the subject of wide-ranging consultation between the different actors in the data ecosystem (public administrations,

[9] http://dataforclimateaction.org/

[10] https://www.donneesouvertes.africa

[11] https://odn.datafordev.org/

[12] https://index.okfn.org

[13] https://opendatabarometer.org

Fig. 3 Overview of the experimental open data portal (https://odn.datafordev.org/) highlighting data per categories as well as data analytics tools for descriptive statistics

sector private sector, civil society, technical and financial partners, universities and research institutes, etc.).

On the other hand, achieving the Sustainable Development Goals (SDGs) necessarily means producing (in a participatory manner) access (fair and at a lower cost) and using (by all) quality and reliable data so that no one will be left behind by 2030.

Indeed, in the age of the knowledge economy and SDGs, it is also important to educate citizens about the importance of open data for:

- Enjoyment of fundamental human rights
- Better decision-making with a view to improving their living conditions
- Promotion of quality services
- The follow-up of the action of the executive, legislative, and judicial power
- The promotion of good governance and the consolidation of democracy

Finally, Niger's accession to the Open Government Partnership (OGP) initiative is still under discussion, and we hope to make the necessary advocacy to speed up the process.

This experimental open data portal was developed under the CKAN platform, and its key functional features include the publication of data, exploring datasets, visualization of datasets, and access to data through an API. The interface was customized based on the portal's graphic charter and optimized for being responsive on various devices (Fig. 4).

In terms of data format, the datasets from this portal can be represented in a variety of formats such as PDF, XLS, CSV, JSON, RDF, LOD, and more. However, the standard formats for open data are nonproprietary formats such as CSV, JSON, and RDF. These formats enable the users to further reuse the datasets without having to purchase software to process them. Formats such as the LOD promote the concept of open linked data, which is the apex of the five-star rating.[14]

Finally, for datasets published on the data portal to be reusable by users, it has to be published under an open data license. The most recognized and commonly used data licenses are Creative Commons (CC) licenses, CC zero (CC0), Open Data Commons, and Open Government License.

Digital Content Diffusion Solutions in Area without the Internet and Library Network Collective Catalog[15]: The Case of the Culture Box

The CultureBox (Fig. 5) is an innovative project conceived and launched by the media library of Franco-Nigerien Cultural Center (CCFN) of Niamey (Niger), with the support of the Institut Français de Paris. The French company Mind & Go ensures its development. In a context of digital divide, it is a mobile, autonomous

[14] https://5stardata.info/en/

[15] https://mediatheques-niger.org/index.php?lvl=index

Fig. 4 Digital convergence of the experimental open data portal on different devices

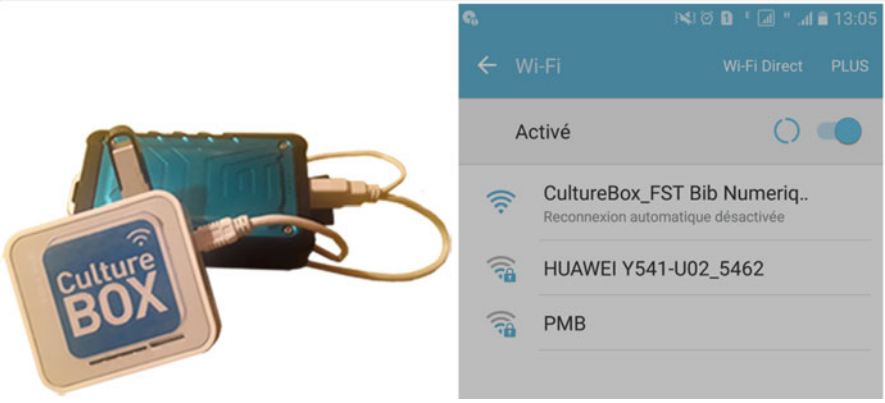

Fig. 5 The CultureBox digital content library accessible via Wi-Fi for areas without the Internet

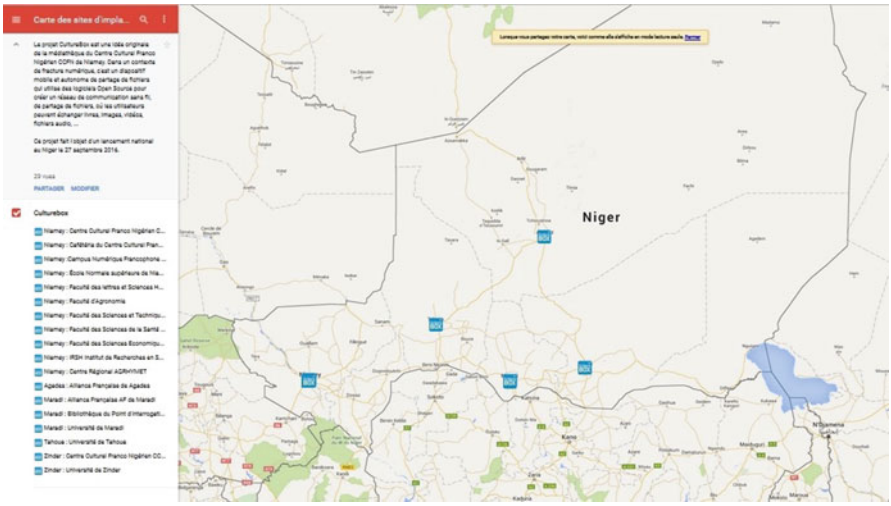

Fig. 6 Mapping of the CultureBox network in Niger © Éric Durel

file-sharing device that uses open-source software to create a wireless file-sharing communication network, where users can exchange books, images, videos, audio files, and more. CultureBox is a new way to make documents available in libraries, with a philosophy of free sharing of common goods that symbolizes the public domain.

The CultureBox was launched in Niger on September 27, 2016, and it is no less than 22 Culture Boxes that were deployed on 19 sites in Niger (see Figs. 6 and 7 and Table 1).

Those Boxes constitute an Offline Digital Library with 22 stand-alone routers deploying an offline digital file-sharing network in as many libraries across the country.

CultureBox is very easy to access. It does not require an Internet connection: just be within 50 meters of the device, connect to cultureBox by Wi-Fi, then type in the browser www.culturebox.lan. The CultureBox page will open automatically, and you will have immediate access to thousands of resources (books, movies, speeches, games, etc.) free and downloadable in less than a minute.

Access to Digital Content for Areas Without the Internet: The Case of the DataCup[16]

Accessible from smartphones, tablets, computers, or even televisions, DataCup (Figs. 8 and 9) offers access to thousands of educational and cultural resources.

[16] https://datacup.io/-La-DataCup-

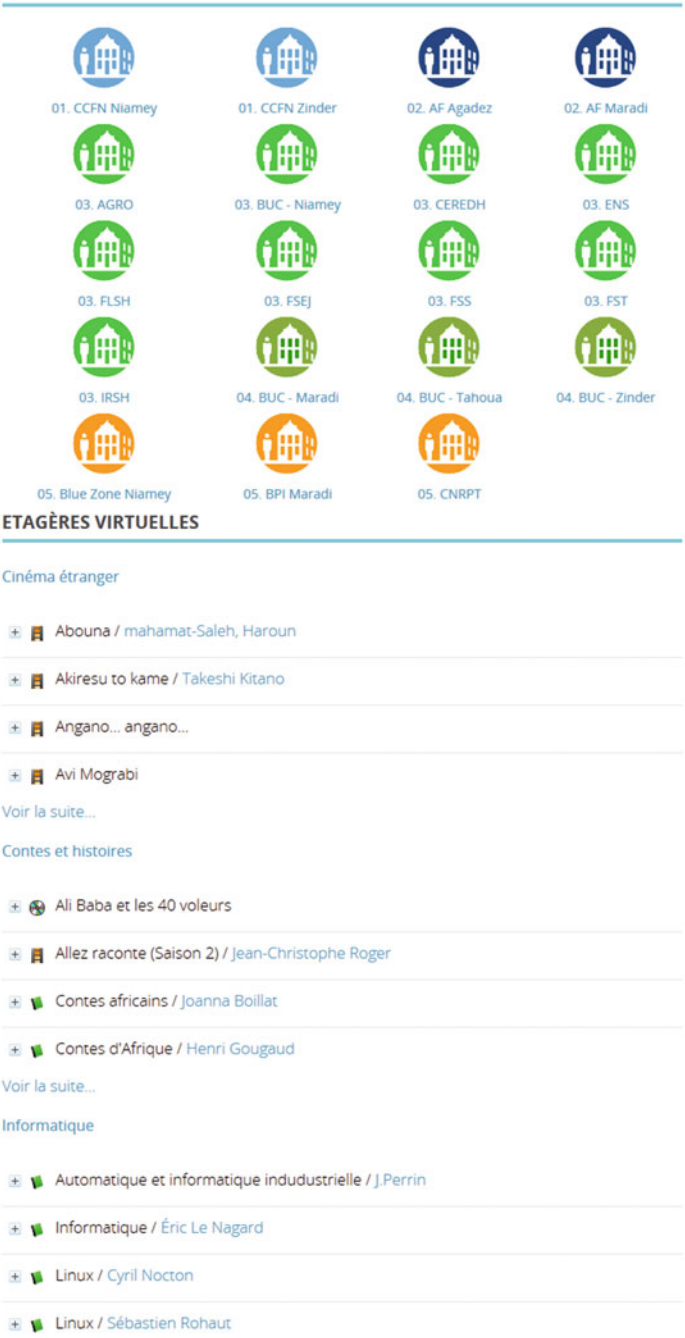

Fig. 7 Overview of the CultureBox network and integrated multimedia content

Table 1 Places with CultureBox in Niger

Sites	ID	Region
Centre Culturel Franco Nigérien CCFN de Niamey	CCFN Niamey	Niamey
Cafétéria du Centre Culturel Franco Nigérien CCFN de Niamey	Cafeteria CCFN Niamey	Niamey
UAM-Bibliothèque Universitaire Centrale	BUC Niamey	Niamey
UAM-Campus Numérique Francophone CNF de Niamey	CNF	Niamey
UAM- École Normale supérieure de Niamey	ENS	Niamey
UAM-Faculté des lettres et Sciences Humaines (FLSH)	FLSH	Niamey
UAM-Faculté d'Agronomie	Agro	Niamey
UAM-Faculté des Sciences et Techniques (FST)	FST	Niamey
UAM-Faculté des Sciences de la Santé (FSS)	FSS	Niamey
UAM-Faculté des Sciences Economiques et juridiques (FSEJ)	FSEJ	Niamey
UAM-IRSH Institut de Recherches en Sciences Humaines	IRSH	Niamey
Centre Régional AGRHYMET	AGRHYMET	Niamey
Alliance Française d'Agadez	AF Agadez	Agadez
Alliance Française AF de Maradi	AF Maradi	Maradi
Bibliothèque du Point d'interrogation BPI	BPI Maradi	Maradi
Université de Maradi	BUC Maradi	Maradi
Université de Tahoua	BUC Tahoua	Tahoua
Centre Culturel Franco Nigérien CCFN de Zinder	CCFN Zinder	Zinder
Université de Zinder	BUC Zinder	Zinder

Fig. 8 Digital convergence through the DataCup deployed at Abdou Moumouni University of Niamey

Fig. 9 Design and hardware aspects of the DataCup

Deployable in any public place, it offers access to royalty-free, interoperable, public domain, or Creative Commons resources that can be consulted and downloaded: encyclopedias, books, tales and audiobooks, podcasts, photo library, video library, scores, tutorials, theses, games, etc.

No need for specific software, a simple browser is enough; additional features include a powerful connectivity and high number of simultaneous consultations through all existing media.

Powered by Mind And Go, a specialist in OpenSource management solutions including library management solutions, the DataCup comes from a UNHCR's request for cultural animation in refugee camps in Niger.

On the bases of concrete needs users faced with problematic of stability of electricity and Internet networks in addition to the issues like so-called tropical climate, Mind And Go has designed a simple solution, reliable and robust, distributed in Open Hardware. Based on standard market components and accessible materials, DataCup resists to intense use; it can be transported easily and repaired anywhere.

DataCup is thought to distribute documents offline (more than 250GB royalty-free data) on all types of media available for users (a Wi-Fi access point is accessible on tablets, smartphones, and computers for about 150 users).

Scheduled to be updated in terms of content, DataCup automatically connects itself to a centralized platform available in France and offeris a common varied catalog with many accessible documents.

Since 2017 and after 2 years of research and development, DataCup is present in the camps of the UNHCR of Niger, within the antenna Humanity and Inclusion (formerly Handicap International) in Niamey, and 14 prototypes are currently being deployed at Abdou Moumouni University (UAM) in Niamey.

Refugees from UNHCR can thus discover documentaries, referring to their place of origin just as the Abdou Moumouni University students will soon be able to consult all the digitized theses of all their faculties, and this for free.

Coming soon, e-learning or mapping solutions will be easily deployable.

3.3 Digital and Technological Convergences in the Context of the Integration of Interactive Whiteboard and Smart Microprojector for Statistical Education

In the award-winning video[17] on innovation in pedagogy entitled *Ressources Numériques Pédagogiques et Apprentissage de la Statistique*, Sidi Zakari illustrated some of his innovations in the field of statistics education (bachelor level at Abdou Moumouni University in Niamey, Niger) through:

1. The use of the culture box digital library (previously discussed)
2. The Use of an interactive whiteboard
3. The use of brainstorming
4. The use of a smart microprojector with electric autonomy (also integrating multimedia, USB and HDMI ports, search engines, QR code, Wi-FI, and Bluetooth technologies)

Marzano and Haystead [13] indicated that the usage of interactive whiteboard has risen student achievement by 16%.

Becta defined interactive whiteboard as "a large, touch-sensitive board, which is connected to a digital projector and a computer. The projector displays the image from the computer screen on the board. The computer can then be controlled by touching the board, either directly or with a special pen" [4].

According to Moss et al. [14], "Combining touch sensitive screens with digital projection opens up new possibilities. In terms of audience presentation, the combination of digital projection and a touch sensitive screen allows the presenter to operate from the screen itself without having to go to the computer. Using a hand or pen on the screen like a mouse, the user can then move about within that environment with exactly the same kind of functionality associated with mouse use at a computer terminal: clicking, dropping and dragging, or scrolling. This makes it possible to exploit different kinds of computer software and the choices they offer whilst any presentation is in process, including making use of the internet by moving around and between websites; as well as using the full potential of the tool bar and its menus to zoom in and out on images, cut and paste within documents and open up new windows. In this way, new texts can be created from the board as the display proceeds."

Smart Technologies Incorporation [17] listed several functions of Interactive WhiteBoard in its White Paper as follows (Fig. 10).

Currently interactive whiteboards integrate simultaneous touch differentiation function for multiuser collaboration which means many students can work simultaneously.

[17]First prize of the Agence Universitaire de la Francophonie's competition 2018 on innovation in pedagogy entitled « Mon innovation en 120 secondes » available on Youtube via https://youtu.be/v8uSGVz1-80

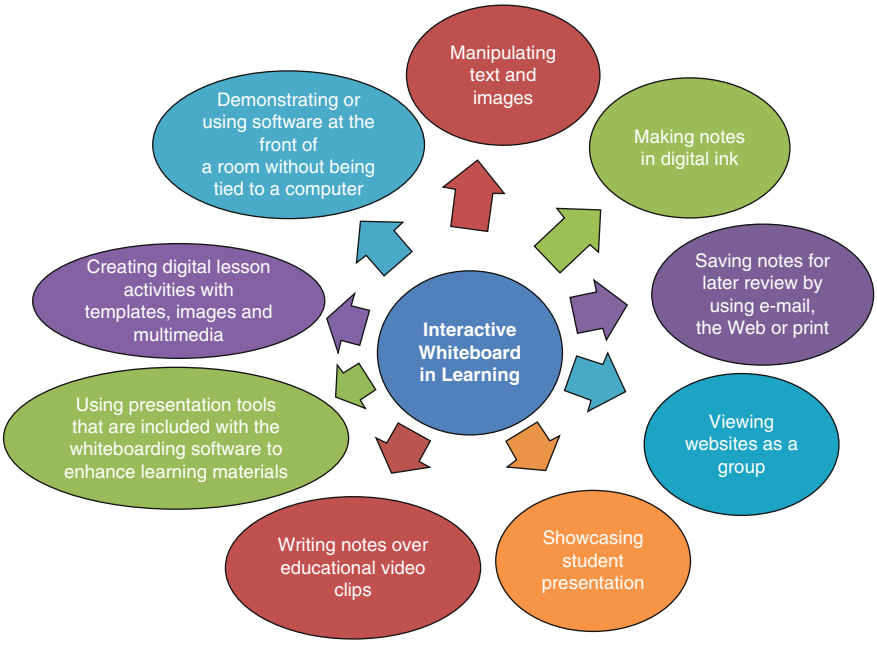

Fig. 10 Several functions of Interactive WhiteBoard. (Source: https://sites.google.com/a/myport.ac.uk/ict-and-the-secondary-classroom-esliarozhi/project-definition/interactive-white-board)

4 Concluding Remarks

In this chapter, we investigated recent advanced topics related to the convergence of open data portals, digital libraries, interactive whiteboards, and smart devices widespread that conduct to emerging applications and data innovations related to the United Nations Sustainable Development Goals (SDGs).

Technological convergence plays a crucial role in society from sustainable development perspectives and for bridging the digital divide and data gap.

Digital technologies provide solutions for more efficient ways to collect and analyze large sets of data with the help of big data analytical tools, which have wide-ranging implications for SDG's progress.

Technological convergence, together with technological standardization, can enable transparent and modular communication between diverse devices over the network and provides advantages for service providers for coordinated and more efficient service delivery. However, technological convergence has some limitations related to interoperability, interconnection, consumer protection, and universal access. Others include new regulatory frameworks related to intellectual property, licensing and regulation of providers, bandwidth shortage, infrastructure upgrades, strategic alignment by service providers, privacy, security, and reliability.

Drawbacks also include lower quality of multiple task-converged devices and possible waste of investments in separate technologies that were already made.

In this regard, continuous effort and collaboration are needed to better facilitate technological development through convergence.

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