BUILD BACK BETTER WITH BROADBAND

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ABSTRACT

The United Nations Secretary-General's Roadmap for Digital Cooperation states that "meaningful participation in today's digital age requires a high-speed broadband connection to the Internet", and that every person should have "safe and affordable access to the Internet by 2030, including meaningful use of digitally enabled services". As part of efforts to achieve these goals, ITU launched the Connect2Recover initiative in September 2020, to help countries transition from responding to the coronavirus disease (COVID-19) pandemic and natural hazards to building back better with broadband. The initiative has the strong support of Australia, Japan, Lithuania and Saudi Arabia. As part of the Connect2Recover initiative, a research competition was launched in July 2021 to identify promising research proposals from across the world to accelerate digital inclusion during recovery from the COVID-19 pandemic. This resulted in the selection of 15 winning research proposals in December 2021. The 15 research teams, which represent 43 universities and institutions from 22 countries, focused on the themes of digital inclusion (in the areas of education, health care, enterprises and job creation, and vulnerable groups), and digital connectivity and resilience. The wealth of knowledge and insights compiled within are based on diverse methodologies, including desktop research, surveys, interviews and focus groups, which covered 17 countries in Africa, the Americas, Arab States and Asia-Pacific. The research showed that, while the use of broadband and digital technologies has been critical for coping with the pandemic, many people faced challenges and barriers in their adoption and use. In schools and universities, teachers and students struggled to get access to online education. During lockdowns, many in rural communities were isolated from health- care providers in cities. In the business sector, the financial needs of micro, small and medium- sized enterprises (MSMEs) were not adequately addressed by financial institutions. The digital needs of vulnerable groups – such as women and girls, ageing populations and persons with disabilities – were also not adequately addressed. Ubiquitous and reliable network infrastructure, as well as affordable and accessible services, are essential to deliver digital solutions such as telemedicine, e-education and e-business services. Policy and regulatory enablers are also critical. Outdated policies or regulations that are not inclusive or do not meet post-pandemic recovery requirements need to be revamped. Digital skills gaps need to be addressed through sustained efforts for institutional and human capacity building. For instance, teachers, healthcare providers and enterprises require digital skills and competencies to thrive and be successful; digital literacy is important for everyone, including vulnerable groups, so that they can fully participate in digital societies and economies. An estimated 2.7 billion people – or one-third of the world's population – remain unconnected to the Internet in 2022. The goal of universal and meaningful connectivity cannot be addressed through improving coverage alone. By leveraging the lessons learned from these 15 published research reports – and working to ensure access, adoption, affordability and resiliency of broadband services – together we can build back better with broadband.

KEYWORDS: *Connect2Recover initiative, broadband and digital technologies, digital skills, COVID-19.*

INTRODUCTION

As part of the Connect2Recover initiative, a research competition was launched in July 2021 to identify promising research proposals from across the world to accelerate digital inclusion during recovery from the COVID-19 pandemic. This resulted in the selection of 15 winning research proposals in December 2021.

The 15 research teams, which represent 43 universities and institutions from 22 countries, focused on the themes of digital inclusion (in the areas of education, health care, enterprises and job creation, and vulnerable groups), and digital connectivity and resilience. The wealth of knowledge and insights compiled within are based on diverse methodologies, including desktop research, surveys, interviews and focus groups, which covered 17 countries in Africa, the Americas, Arab States and Asia-Pacific.

The research showed that, while the use of broadband and digital technologies has been critical for coping with the pandemic, many people faced challenges and barriers in their adoption and use. In schools and universities, teachers and students struggled to get access to online education. During lockdowns, many in rural communities were isolated from health- care providers in cities. In the business sector, the financial needs of micro, small and medium- sized enterprises (MSMEs) were not adequately addressed by financial institutions. The digital needs of vulnerable groups – such as women and girls, ageing populations and persons with disabilities – were also not adequately addressed. Ubiquitous and reliable network infrastructure, as well as affordable and accessible services, are essential to deliver digital solutions such as telemedicine, e-education and e-business services.

Policy and regulatory enablers are also critical. Outdated policies or regulations that are not inclusive or do not meet post-pandemic recovery requirements need to be revamped. Digital skills gaps need to be addressed through sustained efforts for institutional and human capacity building. For instance, teachers, health-care providers and enterprises require digital skills and competencies to thrive and be successful; digital literacy is important for everyone, including vulnerable groups, so that they can fully participate in digital societies and economies.

An estimated 2.7 billion people – or one-third of the world's population – remain unconnected to the Internet in 2022. The goal of universal and meaningful connectivity cannot be addressed through improving coverage alone. By leveraging the lessons learned from these 15 published research reports – and working to ensure access, adoption, affordability and resiliency of broadband services – together we can build back better with broadband.

Research competition: The journey, research stories, lessons learned and the opportunity

The story of the Research Competition began in early 2021 with discussions between ITU and Huawei to design the concept, modalities and desired outcomes within the scope of the Connect2Recover initiative. Connect2Recover aims to build back better with broadband by reinforcing digital infrastructure and digital ecosystems of beneficiary countries, so that they can better leverage information and communication technologies (ICTs) to support COVID-19 pandemic recovery efforts and preparedness for a post-COVID-19 normal, and to remain resilient in hazardous times. In that light, the Connect2Recover Research Competition was designed with the objective to identify promising research proposals that could provide empirically sound and targeted insights, as well as recommendations for fostering digital inclusion during the global COVID-19 recovery. There were 307 research proposals received from 80 countries, demonstrating overwhelming support and interest in this area.

RESEARCH STORIES

The 15 research reports are a compilation of stories and lessons learned from the front line during the COVID-19 pandemic. These include case studies, focus groups and interviews collected from 17 countries in Africa, Asia-Pacific, the Americas and Arab States. The research reports are organized into sections, shown in Figure 2, as follows:

- Digital inclusion in health;
- Digital inclusion in education;
- Digital inclusion for enterprises and jobs;
- Digital inclusion for vulnerable persons; and
- Digital connectivity and resilience.

Section 1 focuses on digital inclusion in health. The first two research reports explore the technologies and solutions required to overcome the challenges in providing health services in rural and remote areas.

The first research report shares a "network-in-a-box" technical solution – that is portable, low-priced and easily deployed. The solution supports broadband and Internet of Things (IoT) health data, and has the potential to revolutionize health services in rural and remote areas.

The second research report describes the successful deployment of communication satellites to deliver telemedicine services in Nigeria.

The third and fourth research reports analyse the deployment of telemedicine. While the third report focuses on the needs of Dominica, the fourth report considers the state of telemedicine and the needs of vulnerable persons in Ghana. They collectively assess the challenges, and propose solutions to address health needs, particularly to those in rural and remote areas.

Section 2 focuses on digital inclusion in education. The first two research reports spotlight digital inclusion in higher education. The first compares three higher education systems in Australia, the Philippines and South Africa, while the second focuses on higher education in Ethiopia and the needs of vulnerable students. The third research report addresses the digital divide in education by considering the cities of Benguerir, Morocco, and Nairobi, Kenya. They collectively highlight the challenges in online learning, and propose measures and policies to address them and enhance digital inclusion in education.

Section 3 focuses on digital inclusion for enterprises and jobs. The first research report focuses on the opportunities for micro-enterprises to leverage digital technology in Ghana; the second report investigates e-business usage and digital financial inclusion of micro, small and medium-sized enterprises (MSMEs) in the Common Market for Eastern and Southern Africa (COMESA) region; and the third proposes a roadmap, with the goal of transforming the smallholder agriculture sector into a digital agriculture ecosystem in Botswana. They collectively demonstrate that digital technologies are necessary to transform smaller enterprises and advance the agricultural sector, and effectively improve jobs and livelihoods.

Section 4 focuses on digital inclusion for vulnerable persons. Both research reports focus on challenges faced in accessing digital services. The first report focuses on the vulnerable persons in Uganda and South Africa, and the second focuses specifically on the challenges faced by older persons in Malaysia. They collectively establish the opportunity available to society by empowering vulnerable persons with digital services.

Section 5 focuses on digital connectivity and resilience. The first two research reports focus on Kenya. The first provides a macro view on infrastructure and policies and their impact on the economy; and the second explores the challenges faced by rural counties in the area of education and health, and the opportunity provided by community networks to address these needs. The third report explores the opportunities at the grass-roots level to leverage community networks in South Africa and India. They collectively demonstrate the need to ensure ubiquitous, reliable and affordable services to support the digital inclusion highlighted in the four earlier sections.

These research stories will be detailed in greater detail in the following sections (Fig. 1).

The challenges of digital inclusion and digital connectivity and resilience are not new; nevertheless, the extent of the challenges have been exacerbated during the COVID-19 pandemic.

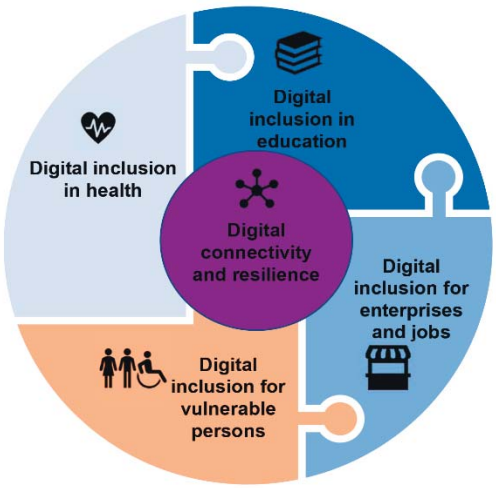

Fig. 1. Five thematic areas of focus

Lessons learned

In the current stage of the pandemic, universal and meaningful connectivity and digital inclusion have taken centre stage. As such, the lessons learned from the 15 research reports are not only applicable to "building back better" in the recovery from COVID-19, but can be applicable to the broader effort to close the digital divide. The insights and recommendations of the 15 research reports are distilled into four enablers (Fig. 2).

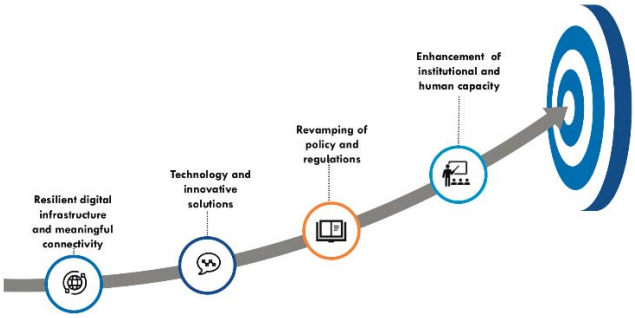

Fig. 2. Four enablers for digital inclusion and digital connectivity and resilience

- The first enabler is resilient digital infrastructure and meaningful connectivity. Digital solutions require that the network and infrastructure are ubiquitous and reliable, and that the services are affordable and accessible by all.
- The second enabler is technology and innovative solutions. Digital solutions to enable e-learning, telemedicine, e-business and digital financing are available and should be embraced. The solutions should also be inclusive and accessible by vulnerable persons.
- The third enabler is revamping of policy and regulations. It is recommended that outdated and restrictive policies and regulations be reviewed to ensure that they facilitate technological developments, and are fit-for-purpose and inclusive in nature.

• The fourth enabler is enhancement of institutional and human capacity. Institutions need to prioritize capacity building, particularly in digital skills. This applies to all sectors and institutions – such as health, education and enterprises – and covers health-care providers, teachers, students and employees. Schools should also emphasize equipping their students with digital skills. In addition, vulnerable persons should be empowered with digital skills.

The opportunity

This Research Competition journey that started in July 2021 does not end with the launch of the 15 research reports. In fact, the focus shifts to implementation. We encourage policy-makers to consider reviewing the recommendations and implementing them with impact, as appropriate. Researchers are encouraged to consider the research conducted and to further the work. Finally, we also encourage pilot projects to be conducted or multi-stakeholder partnerships to be formed, and resources to be mobilized, to address these challenges and ensure a more inclusive and connected world.

SECTION 1: DIGITAL INCLUSION IN HEALTH

Network-in-a-box to provide health services in remote areas

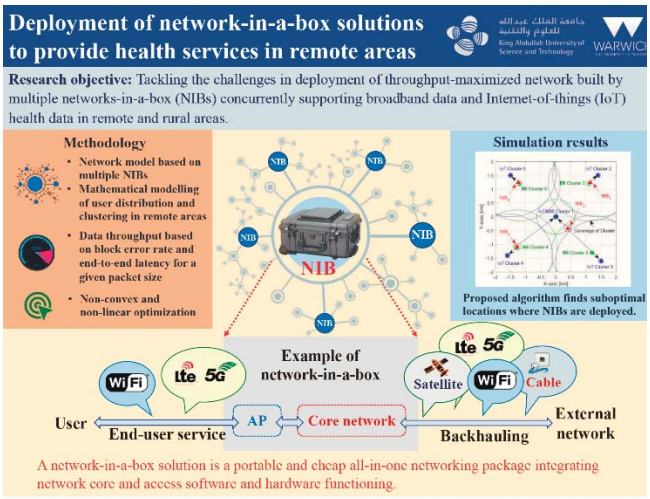

Fig. 3. Deployment of network-in-a-box solutions to provide health services in remote areas

Background

This winning research project involves two research teams: Mr Mohamed-Slim Alouini and Mr Ki-Hong Park of the King Abdullah University of Science and Technology, Saudi Arabia; and Mr Yunfei Chen of the University of Warwick, United Kingdom. Mr Alouini is an active research participant in this project, and is responsible for overseeing all its aspects. Mr Yunfei and Mr Park have capitalized on their expertise to formulate and model the challenge, build a new methodology and discover new findings.

In this project, the team tackled the challenges of network deployment, while concurrently supporting broadband data and IoT health data in remote and rural areas. It introduced a network-in-a-box (NIB) solution, a portable and cheap all-in-one networking package integrating network core and access functioning. It proposed and verified the deployment algorithm to maximize the total throughput in a network supported by multiple NIBs.

Report findings and outcomes

In order to find the optimal deployment of multiple NIBs, the team will face several new challenges:

• First, the end users in rural areas are sparsely located over a wide area, and it is not appropriate to apply a traditional network model. The network topology in this area is likely to be disjointed and irregular, and therefore the user distribution should be modelled by geometrically reflecting and clustering the real user density with reference to local census. The Gaussian density function is used to characterize the distribution of users in a cluster. Its mean and variance reflect the location of the cluster centre and the population concentration in a cluster.

• Second, the team carefully estimated the performance metric that each NIB could provide at one position. The IoT information in health services might have different characteristics, distinguishing it from conventional network data. It requires periodic sensing over multiple wearables, implants and IoT devices on the human body or using wireless sensing through off-body monitoring units. It usually consists of short data packets that are delay-limited, highly reliable and energy-efficient. Therefore, the throughput of health IoT information in rural areas should be characterized by block error rate and latency for a given packet size. The end-to-end latency is characterized by decoding processing delay and transmission delay. Average aerial throughput of IoT health information can be computed under the statistical models of user clustering and distribution. When the IoT health data is limited to a certain latency requirement, the optimal aerial throughput exists with the unique coding rate. On the other hand, the throughput of broadband data can be featured by a fundamental Shannon capacity formula, and averaged over the modelled user distribution and clustering.

• Third, the conditions in multi-NIB-based IoT health networks have to be carefully considered. NIB is capable of supporting multiple networks, but users in different networks will not overlap. This means that the NIB can support low-rate massive IoT health networks, while servicing broadband. Thus, the resource allocation and position of multiple NIBs need to be jointly considered for all networks. Minimum data rate requirements for users and maximum delay constraints for NIBs are constraining the problem of maximizing the total throughput in a network where multiple NIBs are

receiving data from multiple IoT health devices and from mobile broadband users in cellular systems.

The optimal deployment of NIBs can be obtained by solving non-convex and non-linear optimization problems with block coordinate descent methods and the relaxation techniques used in its inner loop algorithm, such as successive convex approximation, fi approximation and linear relaxation. The optimal coding rate for IoT health data and user association are jointly determined in the proposed algorithm. The simulation results have validated that multiple NIBs are optimally deployed near the centre of user clusters for mobile broadband services to provide high data throughput, while maintaining a bias towards serving IoT health clusters to support low-data-rate IoT service.

Insights from the ground

The network environment varies dynamically, as networks are spontaneously and sporadically demanding over time and space. Temporary and intermittent medical sites require network connectivity only during the concerned time or locations. The network has to be resilient to the circumstances confronting the defect and malfunction due to natural disaster or temporary blackout. Accordingly, 6G initiative groups are pursuing the goal of sustaining ubiquitous network connectivity. In this regard, pop-out networking is more advantageous than fixed network infrastructure in dealing with unusual, temporary and intermittent data on demand. NIB is an excellent pop-out solution with limited but user-friendly hardware and software capability, which saves capital and operation expenditure in a mobile network. NIB perfectly fits in varying environments, owing to ease of deployment, mobility and network flexibility.

Ultra-low latency and ultra-high reliability will be the key indicators to evaluate the quality of physical experience in the private network sectors, based on the extended reality and nearly zero delay interaction in remote rescue and medical operations. Smart ambulances can be ubiquitously connected to the network and provide super-accurate medical assistance. Such potential networks must operate under 5G standards or 6G recommendations. Bearing in mind the advantages of NIB, one consideration will be the manner in which cost-effective NIBs can be used to support these 6G use cases in rural areas.

Key recommendations

- The proposed mathematical modelling of two different communication systems for combining broadband and IoT service enables researchers to further analyse and optimize mobile and heterogeneous networks with latency constraints. If the user distribution and clustering for the target remote areas are modelled precisely, the network operator can deploy and operate a cost-effective, NIB-based network rather than a conventional fibre- optic-based network.
- The proposed algorithm for NIB deployment is a suboptimal solution for finding the positions of NIB to be deployed in the specific network model under user distribution and clustering in sparsely populated areas.
- We should carefully consider the interoperability and coexistence of NIB-based networks along with conventional cellular networks operated by mobile network operators. The mobile broadband users in the town centre and nearby in the rural areas are most likely supported by traditional cellular networks. Spectrum management techniques – such as spectrum sharing, spectrum allocation, or cognitive radio – are required.
- Finally, the user's distribution and clustering in rural areas can vary drastically over time, since the users are sparsely populated, and commercial and residential areas are separated irregularly. The deployment scheduling of NIBs can be dynamically designed over time thanks to the mobility of NIBs.

Improving resilience in developing countries: Digital health provision through telemedicine ecosystem against the pandemic, epidemics and natural disasters in sub-Saharan Africa

Background

Primary objective: To create an understanding of the dynamics of the telemedicine ecosystem and proffer recommendations to facilitate the sustainable adoption of telemedicine in sub-Saharan Africa (Fig. 4).

Specific objectives

- To determine the state of the telecommunication and telemedicine ecosystems in sub-Saharan Africa.
- To examine how telemedicine has been diffused to vulnerable groups (older persons, disabled and poor) in sub-Saharan Africa.
- To examine how the telemedicine ecosystem has been leveraged to improve resilience to pandemics, epidemics and natural disasters.
- To determine the challenges and successes of expanding access to telemedicine in sub-Saharan Africa.

Research methodology

The study examines secondary data on the topic across various sub-Saharan African countries, and then concentrates on the telemedicine ecosystem of Ghana using in-depth qualitative tools, including community and focus group discussions, to address its objectives. Primary data were obtained through one-on-one interviews with 63 relevant stakeholders in the telemedicine ecosystem using a semi-structured questionnaire. Stakeholders in the health and telecommunication sectors, and community members constitute the target population.

Fig. 4. Improving resilience in developing countries: Digital health provision through the telemedicine ecosystem against the pandemic, epidemics and natural disasters in sub-Saharan Africa

Research findings

• Even though telemedicine was not formally in place, people used various digital means to address their health challenges and seek clarifications regarding some symptoms they were feeling during earlier phases of the COVID-19 pandemic.

• Digital penetration, trust and convenience are among the key success factors for a telemedicine ecosystem.

• A telemedicine ecosystem is faced with challenges that hinder the deployment of telemedicine. These include:

– poor telecommunication and road networks, low ICT capacity of health-care professionals, ICT illiteracy of community members, and financial constraints;

– the most prominent among these challenges, poor communication network connectivity.

• Government, non-governmental organizations (NGOs) and philanthropists are the main sources of funding for telemedicine interventions. This finding contradicts those studies that conclude that some telemedicine pilots in Ghana were not successful due to lack of funds and little government support.

Results and outcomes

• The telemedicine ecosystem of Ghana is in its early stage and, even though there is improvement in telecommunication services, there are some communities in Ghana with poor network connectivity, which hampers the agenda to expand telemedicine to rural communities.

• Generally, at the policy level, the results show that the telecommunication infrastructure deficit, which has created a digital divide, and policies that do not allow health practitioners in rural communities to attend to some health situations and prescribe certain medication, are the hindering factors to the deployment of telemedicine in Ghana.

• Even though most people are not aware of the existence of telemedicine, they have resorted to various digital means, such as calling friends, health workers they know etc., to seek health advice during the COVID-19 pandemic.

• The success of any telemedicine infrastructure in sub-Saharan Africa will depend to a large extent on the creation of awareness and trust that the digital health services received are of the same quality as those that would have been provided at a health facility.

Insights from the ground

Relevant quotes from participants/interviewees:

• One community member stated: "In my community, the main challenge is network connectivity and the high illiteracy rate. If the people in the community get education about telemedicine and a good network, there will be no issues with it being initiated… the availability of the hardware, not just availability, but its maintenance to be consistent."

• A District Health Director said: "Telemedicine can be used for emergencies and things that are beyond the level of whoever the client is seeing… If somebody collapses, if a pregnant woman is bleeding, if a pregnant woman is convulsing, you can use it. You are attending to someone; you realize the condition has changed and you need to make a call for information; you can use telemedicine."

Key recommendations

Based on the research findings, the study proffers the following recommendations for policy action:

• Health-care policy-makers should constantly collaborate with academia to undertake evidence-based studies to support health-care policy-making in Ghana.

• The Government, in consultation with health-care policy-makers and other policy-makers, should develop a

national telemedicine policy to aid in the implementation of telemedicine.

- Health-care professionals and community members should be sensitized to the need to mainstream telemedicine into the health-care delivery system.
- Government should work with the telecommunication companies to address outstanding inefficiencies, such as poor communication networks.
- Ghana Health Service (GHS) is encouraged to consult, design and implement appropriate training modules on telemedicine to build the capacity of health-care professionals.
- The Government should work with the telecommunication companies to implement a toll-free system for telemedicine-related services.
- Ghana Investment Funds for Electronic Communication should expedite action to ensure that telecommunication services are extended to rural communities to support the adoption of telemedicine.
- GHS, through district health directorates, should work with the National Communications Authority to organize clinics to enhance ICT literacy in rural communities.

SECTION 2: DIGITAL INCLUSION IN EDUCATION

2.1. Making higher education truly inclusive

Background

ICT infrastructure has proven vital in helping countries and citizens adapt and respond to the COVID-19 pandemic. Whether this reliance has resulted in greater immediate and longer-term inclusion of marginalized communities is an important question in terms of equitable access to higher education.

This report investigates the response to the COVID-19 pandemic by three higher education systems. It also describes the outcomes of these interventions in terms of the inclusion (or exclusion) of marginalized students. Finally, it dissects further the situation as to whether the disruption to higher education – particularly the uptake of new modes of instruction, learning and assessment – results in greater inclusion in the future provision of education (Fig. 5).

Report findings and outcomes

Three countries – Australia, the Philippines and South Africa – were selected to study the effects and future outcomes attributable to the COVID-19 pandemic in relation to ICT infrastructure, access and inclusion in higher education. A case study approach was used to study and compare the countries.

Three observations emerge from the South African experience:

- The first is the realization that, as predicted by scholars, neither technology nor open resources necessarily lead to the anticipated democratization effects. Instead, in highly unequal societies (and university systems), an increase in the uptake of technology and open resources is more likely to exacerbate existing inequalities.
- The second observation is that the pandemic has made the invisible visible, especially the historical, economic and geospatial inequalities within and between countries studied. Regardless of the availability of data and devices, the quality of online and other forms of digital educational provision during the pandemic remains open to question.

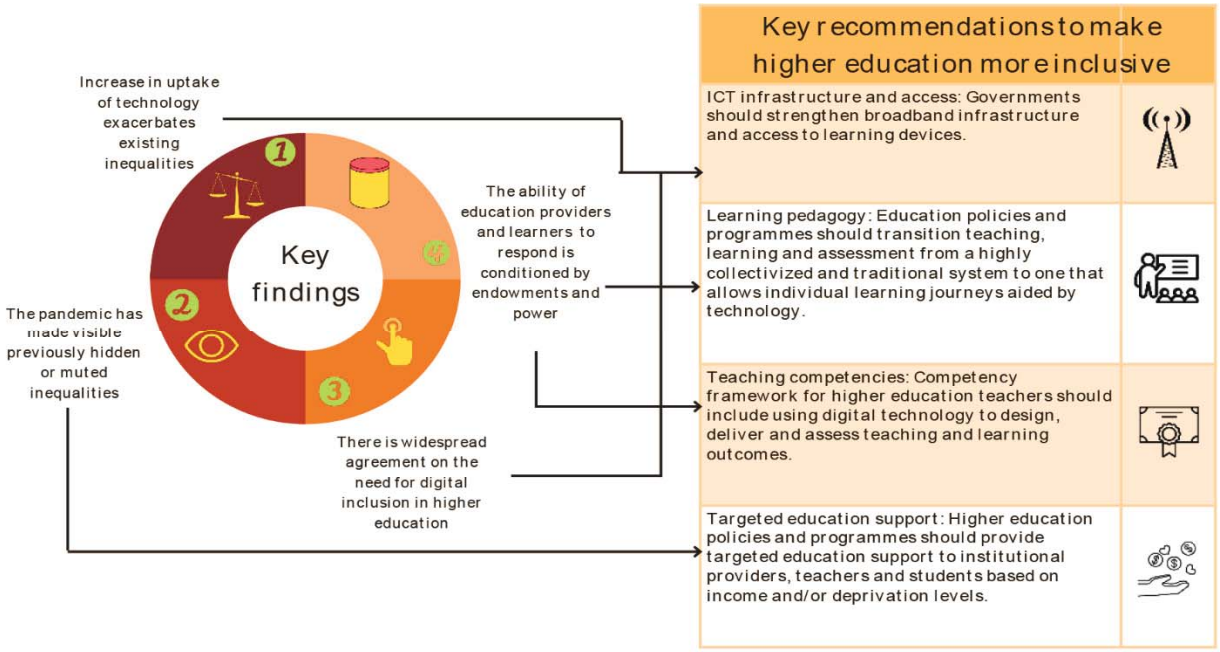

Fig. 5. Making higher education truly inclusive

• One more positive observation is how the pandemic has brought together government, higher education institutions and private mobile operators in acknowledging the greater need for digital inclusion. This atypical cooperation resulted in the provision of devices to students in need as well as "zero-rated" (free) access to university learning platforms and other educational websites and resources.

The case of the Philippines, a system more diverse in its mix of both public and private institutions compared with South Africa, suggests that the capacity of institutions and individuals to adapt to, cope and mitigate the impact of COVID-19 on teaching and learning is significantly differentiated; well-resourced, well-connected, and strategically located actors were more able to transition to new modes of education delivery. Several studies have pointed out that there are differences in processes and outcomes, not only due to resources, but also due to actors such as political leadership, social security provisions, degrees of autonomy and centralization, as well as underlying capacity. Education policies in the country have not considered these differences in capacity, leaving actors to respond and cope on their own.

In the case of Australia, the biggest impact on the higher education sector was the result of the international travel ban and the resultant decline in student fee income from international students. The foreign student market is the third biggest export industry in Australia and the country's largest service-sector export. In terms of the impact of the pandemic on social exclusion, the perilous position of international students stranded in Australia attracted the most attention. Despite some measures taken by the Government of Australia to support these students, the Government's response was seen as largely unsympathetic, vividly expressed by the "go home" response. In general, the effects of COVID-19 on the higher education system in terms of the exclusion of segments of the student population received only cursory attention in the media and the academic literature compared with South Africa and the Philippines.

Insights from the ground

By not succumbing to the hype and allure of new digital educational technologies, and by providing a context-sensitive synthesis of the literature and the surveys conducted during the COVID-19 pandemic, the team has taken a step towards making more explicit the actual conditions and their effects on specific segments of the higher education student populations in South Africa, the Philippines and Australia. By providing an account of how the responses of governments, institutions and the private sector impacted on students with limited resources or abilities, this report has shown the limitations of an overreliance on ICTs for education purposes. Report findings and outcomes

Five of the oldest universities – including Hawassa University, Addis Ababa University, Arba Minch University, Jimma University and Bahir Dar University – were selected, presumably for their relatively better experience of using ICT. The exploratory sequential mixed method was used in the research. Thus, the research began with in-depth interviews with 15 staff members, including teachers, college deans and ICT directors chosen purposefully from the five universities. The interviews included questions about the respondents' background, ICT access, digital literacy, ICT use and motivation, students' ICT usage, and opinions on barriers of ICT use in education.

The COVID-19 pandemic has shown that the rapid deployment of technology by various stakeholders is possible. Theoretically, the availability of technologies to a broader segment of the population should result in greater inclusion (that is, participation in communication networks for educational purposes). However, the evidence provided in this report shows that, without the capabilities – many of which are non-material and do not relate to technical skills or access alone – and without an acknowledgement of the social dynamics of systems and networks, parts of the population will always remain excluded.

Key recommendations

Any future integration of online learning as complementary to contact modes of instruction will require substantial investment in the following areas:

• ICT infrastructure and access: In a context where access to technology is challenging, governments should strengthen broadband infrastructure on the one hand, and access to learning devices on the other.

• Learning pedagogy: From a pedagogical perspective, there is a need to formulate policies and programmes that transition teaching, learning and assessment from a highly collectivized and traditional system to one that allows individual learning journeys aided by technology. More research is required to understand better the outcomes and impacts of these new modes of teaching, learning and assessment about COVID-19.

• Teaching competencies: The competency framework for higher education teachers should include using digital technology to design, deliver and assess teaching and learning outcomes.

• Targeted education support: Higher education policies and programmes should provide targeted education support to institutional providers, teachers and students, based on income and/or deprivation levels to transition towards better use of technology in education.

Determinants of digital inclusion in higher education: Exploring the Ethiopian context

Background

ICTs support the United Nations Sustainable Development Goal 4 (Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all) by providing an alternative route to education, as shown during the COVID-19 pandemic, when face-to-face

communication becomes inconvenient. However, that requires identification and removal of the digital divide that would create inequalities in ICT access and use. This study aims to explore the digital divide in the Ethiopian higher education context, and recommend solutions that could be used by higher education institutions and policy-makers.

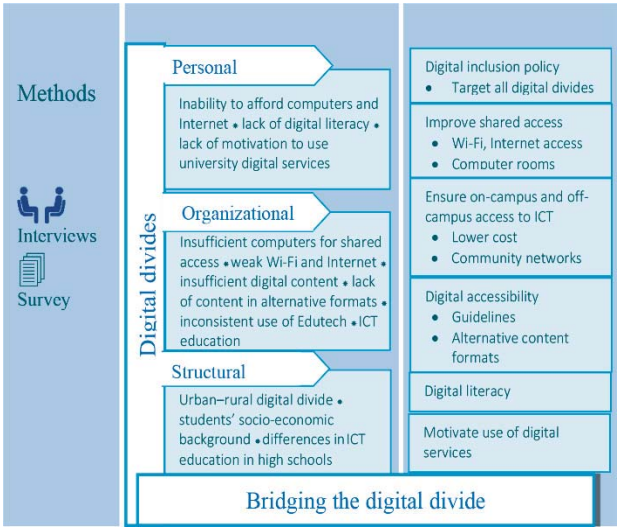

Fig. 6. Determinants of digital inclusion in higher education: Exploring the Ethiopian context

The interview data was used to design a questionnaire, which was completed by 418 undergraduate students selected from the universities using a stratified proportionate sampling technique. A total of 43 per cent of the students said that they owned PCs, and 90 per cent said they owned smartphones, while 7 per cent said they had tablets. Those who didn't own computers made use of shared access facilities, such as library computer sections (22 per cent) and computer labs (22 per cent), while 10 per cent said they borrowed laptops from friends.

The study identified problems related to ICT access, digital content, accessibility, digital literacy, ICT use and ICT policy. The access-related problems included students' inability to afford computers and Internet connection, an insufficient number of computers in computer rooms, weak Wi-Fi and weak Internet connections. The universities had digital libraries that were not well developed and not accessible outside of university compounds. Learning management systems (LMSs) were underutilized, though they saw improved utilization during the COVID-19 shutdown. The e-learning attempted during the shutdown remained largely inaccessible for undergraduate students, since most of them were from rural areas where there was no access to the Internet. Efforts to address the needs of students with disabilities were limited to production of content in Braille form, and provision of audio recorders to students with visual impairments. There was a lack of knowledge on accessibility and accessibility guidelines.

There are differences in digital literacy among students as well as teachers. Teachers' digital literacy levels have affected the production and delivery of digital content as well as the utilization of LMSs. Those with better ICT literacy would include multimedia content and links to other sources, whereas others were limited to PDF documents and PowerPoint slides.

A related problem was inconsistency among teachers in the use of educational technology – for instance, some used LMSs, while others did not. That reflects a lack of institutional norms that govern consistent use of educational technology.

Underutilization of digital services is the other problem. When asked about tools for content sharing, 52 per cent of the respondents said they preferred Telegram, 36 per cent said they would like the materials sent via e-mail, and 11 per cent said they would use university portals.

The little motivation to use university portals was attributed to platform complexity, lack of digital literacy, and teachers' low expectations on the use of LMSs by their students.

Insights from the ground

As one student put it: "I mostly am dependent and feel comfortable with high-end smartphones and I use them instead of computers." The prevalence of smartphones and students' preference of least interactive technologies such as Telegram imply the importance of incorporating user needs and preferences to develop usable and accessible educational applications.

Removing barriers of access is an important step to digital inclusion. Nevertheless, barriers are revealed through usage. In this research, there were students who did not own computers and had no Internet connection, but said they had not faced barriers. On the other hand, there were others with computers and access to the Internet who listed a number of barriers.

Higher education institutions, therefore, would have to promote usage of their digital services and actively work to identify and remove barriers. Maximizing ICT use would require dealing with motivational issues. The use of ICT policies and guidelines would enforce a consistent use of ICT in higher education institutions. Digital literacy programmes would intrinsically motivate students as well as teachers to use ICT to their best advantage.

Key recommendations

The first important step could be the development of a digital inclusion policy that recognizes the technical, socio-demographic and socio-economic barriers that are explored in the study. This would help to create a shared understanding of digital inclusion, and institute consistent practices that maximize the use of available educational resources.

Thereafter, implementing digital literacy programmes (including computer literacy, ICT literacy, information literacy and media literacy) that target different groups would be important. It would also be important if the existing continuous professional development for teachers incorporated courses and trainings on digital literacy. Establishment of inclusive ICT infrastructures that incorporate the needs of persons with disabilities, working with different governmental and non-governmental partners to ensure on-campus and off-campus access to ICT resources, could be important steps to expand access to ICT and digital services.

Digital inclusion in education will not be complete without accessible digital content. Thus, utilization of accessibility guidelines to produce content that can be accessible to all, including students with disabilities, would be important. Moreover, production of content in alternative formats (such as PDF, HTML and audio) would help to address the needs of students with different needs and preferences.

Abbreviations

AFRALTI	African Advanced Level Telecommunications Institute
BDT	ITU Telecommunication Development Bureau
COMESA	Common Market for Eastern and Southern Africa
CWN	community wireless network
DM	diabetes
DSA	dynamic spectrum access
GHS	Ghana Health Service
HTN	hypertension
ICT	information and communication technology
IDP	internally displaced person
IoT	Internet of Things
ISP	Internet service provider
ITU	International Telecommunication Union
ITU-D	ITU Development Sector
LMS	learning management system
MSMEs	micro, small and medium-sized enterprises
NGO	non-governmental organization
NIB	network-in-a-box
SIDS	Small Island Developing States
UN-Habitat	United Nations Human Settlements Programme
VSAT	very small aperture terminal

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References

[1] ITU, Connect2Recover Research Competition – Winning Projects Booklet, available at www.itu.int/en/ITU-D/Documents/connect2recover/research-competition/Connect2Recover-winning-projects-booklet-final.pdf.

[2] ITU, "Information Sessions on Connect2Recover: Research Competition Papers focusing on Africa", available at www.itu.int/en/ITU-D/Pages/events/connect2recover/infosessions-research-competition-papers-focusing-on-Africa/default.aspx.

[3] ITU, "ITU's 'Best practices and recommendations for digital inclusion through resilient infrastructure'", available at www.itu.int/en/ITU-D/Regional-Presence/Africa/Pages/EVENTS/2022/P2C_Addis.aspx.