Covid-19: Interdisciplinary Explorations of Impacts on Higher Education

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THE ROLE OF AFRICAN HIGHER EDUCATION INSTITUTIONS IN DRIVING A COVID-19 RESPONSE THROUGH INNOVATION TECHNOLOGIES

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Introduction

The epidemic of the coronavirus disease 2019 (Covid-19), originating in Wuhan, China, has become a major public health challenge for not only China, but also countries around the world. While the early transmission appeared to affect China, South Korea, much of western Europe, and the United States, the virus is now spreading rapidly across the African continent, presenting a major threat to already-stressed health systems. When the World Health Organisation (WHO) declared the Covid-19 pandemic to be a Public Health Emergency of International Concern on 30 January 2020, countries around the globe were prompted to make means to prepare. Preparation for Covid-19 was difficult, more especially in developing countries such as the African countries. Not all African countries were well equipped with appropriate diagnostic kits and Personal Protective Equipment (PPE) to handle the pandemic so WHO became concerned. WHO, realising the challenge, identified 13 top-priority countries; Algeria, Angola, Cote d'Ivoire, the Democratic Republic of the Congo, Ethiopia, Ghana, Kenya, Mauritius, Nigeria, South Africa, Tanzania, Uganda, as well as Zambia which have direct connections to China.

Over the last decade, 87% of the continent has had at least one epidemic (Kapata, Ihekweazu, Ntouni, Raji, Chanda-Kapata & Mwaba, 2020). West Africa experienced an Ebola epidemic outbreak between 2014 and 2016 (Out, Ameh, Osifo-Dawodu, Alade,

Ekuri & Idris, 2017). Due to previous experience with an Ebola epidemic outbreak, significant improvements in digital technology, as well as clinical and laboratory capacity across the African continent were observed. The challenges included the lack of diagnostic equipment, as well as strategies to flatten the curve.¹ We hope that the 2020 pandemic will give rise to improved technologies, increasing digital technology innovations, as well as entrepreneurship in higher education institutions. And the students will learn to create and tackle every challenge which perplexes the world today. Our focus in this chapter will be ground-breaking innovations from the African countries from Higher Education Institutions (HEIs).

Through a desk study via Google Scholar, using keywords such as Covid-19, Africa, higher education, innovation, and technology, this chapter discusses how innovation technologies can drive Africa's response to Covid-19 by mirroring the role of higher education. By reviewing relevant literature sources, documents and news items, the chapter examines the readiness of the higher education sector in South Africa by focusing on the status quo and how the sector has been handling Covid-19 related issues. The chapter also addresses the response of academics to the shift and the preparedness of South African institutions in order to capacitate academic staff members. The challenges and response strategies of the HEIs in the current spectrum are also discussed and recommendations are provided.

HEIs in South Africa: Status quo and sector readiness

HEIs are expected to change due to external factors such as:

1. socio-economic issues,
2. political & economic issues and (Fraser 1997), and
3. globalisation (Fraser 1997, 2000 and 2003).

Internal factors driving the change include:

1. policy makers and
2. standardised curriculum.

These changes encouraged the academics to embrace a learning society in all aspects. It was also crucial to implement both formal and informal ways of teaching and establish collaborative projects in order to create a platform for students to exchange practical and theoretical knowledge abroad and encourage the learners to be innovative. Due to the aforementioned factors, the world is transitioning towards a knowledge economy.² The HEIs in response to both internal and external

1 A public health strategy to slow down the spread of Covid-19.

2 An economy where growth is determined by the quantity, quality and accessibility of available information instead of the means of production.

factors have now focused on development of technology innovations. In the past, the HEIs used to only focus on traditional learning approaches and basic research at technology readiness level one (Figure 10.1). Socio-economic, political, and economic issues have redirected the focus of the academics towards generating new commercial products (Fraser 1997, 2000, 2003 & Mowery 2005). Research and development conducted in academic institutions must be redesigned in such a way that the research begins from basic level, Technology Readiness Level 1 (TRL1), and escalates through other levels to TRL9. And the resulting innovative products must be sold in local and international markets. Technology readiness levels (TRLs) are a method for estimating the maturity of technologies during the acquisition phase of a program, developed by National Aeronautics and Space Administration (NASA) in the 1970s. The use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology. A technology’s TRL is determined during a Technology Readiness Assessment (TRA) that examines programme concepts, technology requirements, and demonstrated technology capabilities. TRLs are based on a scale from 1 to 9 with 9 being the most mature technology.

Figure 10.1 Heder (2017) Technology readiness level (TRL)

This approach to research encourages generation and commercialisation of patents which is essential for the economic growth of the country (Hawkins, Langford & Sidhu 2007). Tech transfer officers assist in technology transfer operations. Academic institutions have a tech transfer officer to channels these transactions. The institutions

are also encouraged to establish spin-off companies to generate the third stream of income in line with the National Development Plan. Currently, the University of Cape Town (UCT) and Stellenbosch University (SU) have established several spin-off companies in response to this change and we expect other universities to also transition towards knowledge economy as it is essential for economic growth in South Africa.

Public academic institutions are funded by big corporations such as the World Bank. External drivers to the change include initiatives set up by United Nations Environmental Program (UNEP), Millennium Development Goals, Africa Agenda 2063, as well as the 17 Global Sustainable Developmental Goals, to name but a few. The national priorities are shaping the research focus areas in the academic space. The academic staff members are required to identify the “niche areas” which are priority sectors in South African government, write proposals and secure funding for creative projects (McMeekin, Green, Tomlinson & Walsh 2002). Areas of focus include Fourth Industrial Revolution (4IR) topics, data modelling projects, bioeconomy initiatives, renewable energy, climate change, waste beneficiation, water scarcity, HIV-AIDS, big data management and other health related projects.

In addition, the South African government has also established agencies to encourage the academics including the researchers to focus on specific areas of research. The agencies do this in the form of competition for funding, which only funds directed and relevant research to drive the outcomes towards the targeted areas of research. To secure funds, academics are required to pitch ideas in writing and verbally in line with South African government priorities. Several funding agencies and incubation programmes to assist academics and students are, but not limited to the following:

1. Technology Innovation Agency (TIA) for SMMEs
2. Department of Science and Innovation (DSI)
3. Global CleanTech Innovation Program (GCIP)
4. Leaders in Innovation Fellowship (LIF)
5. Transnet Enterprise Development Hub
6. Red Bull Amaphiko Academy
7. Aurik Business Accelerator
8. The Techstars Foundation
9. Anglo’s Zimele
10. Shanduka Black Umbrellas
11. SEDA Ekurhuleni Base Metals Incubation Programme, etc.

Exhibition programmes such as Innovation Bridge and trade conferences are hosted in South Africa to help academics showcase their products for marketing and to attract investors. These platforms are made available to both scholars and the

private sector with the mission to drive the country towards income generation. The approach is mandated to train the younger generation to create sustainable income/jobs, as well as establish a profitable Small, Medium and Micro Enterprise (SMME). To be quite honest, academics are under increasing pressure to respond to the rapidly changing market environment. The unique growth, complicity, and competitiveness of the global economy along with its consequential socio-political changes have been placing pressure on HEIs to adopt market-oriented initiatives. As the anointing flows from the head to the tail, academic staff must be well trained and prepared for the workforce.

The response of academics to the shift and the preparedness of South African institutions to capacitate the academic staff

Target skills and competency are now required in order to build and develop highly skilled human capital. As much as this will bring the academics under pressure, they must adjust to accommodate the change. Bilateral collaborative projects with developed countries, such as the United States and the European Union, as well as developing countries, such as China and India, are some of the approaches academics must embrace to build and develop highly skilled human capital. Such collaborations will allow exchange programmes where the learners are sent abroad to broaden their perspectives and exchange knowledge.

Global economy, the new managerialism³ and corporatism⁴ on institutional structures put the academics under pressure and the academics were obliged to comply. For example, the impact of globalisation has stimulated the academic institutions to transition towards entrepreneurial economy for the purpose of generating profit. The HEIs have adopted the strategy in order to help the university to generate the third stream of income. The higher education system adopts the principles emanating from the corporate world in response to the external factors such as changes in economic spheres. HEIs are aggressively engaged in the knowledge-based economy and the academics continue to analyse the efforts of the institutions to develop, market, and sell research products, educational services, and consumer goods in the private marketplace.

Managerialism allows the staff members in the academic space to shift towards an entrepreneurial culture. Government entities, such as the Technology Innovation Agency, have been indirectly used to encourage the academics to innovate in a competitive manner in order to drive this theory. Innovative projects whose TRL is

3 The reliance on the use of professional managers in administering or planning an activity.

4 The control of an institution by large interest groups.

closer to technology demonstration or prototypes development are often funded. There is an organised consortium in place to drive and implement South African government concern from the funding entities to the academic management. Managerialism is a great initiative as it also teaches the students to learn to translate research and development findings into new products for commercialisation. However, the value of academics is affected by the institutional changes taking place. As this seems like a beautiful initiative, providing the academics with better opportunities, they are also facing increasing student enrolment due to increasing demands for higher education and expansion of the sector.

Academic institutions are taking the entrepreneurial side of things in a post-industrial economy; they focus on knowledge less as a public good than as a commodity to be capitalised on in profit-oriented activities. This theory also allows changes in policy and practice, revealing new social networks and circuits of knowledge creation and dissemination, as well as new organisational structures and expanded managerial capacity to link HEIs and markets.

Changes in the academic space due to academic capitalism, managerialism, as well as corporatism are as follows:

1. There was a significant increase in the national student enrolment which resulted in increased workloads.
2. The workload of the academic staff teaching undergraduate studies was significantly increased as opposed to those supervising master's and PhD students.
3. There were observed changes in the academic profession as the academic staff were forced to take duties related to administration and management.
4. The academic institutions rely heavily on hiring staff on a part-time basis. The idea behind hiring academic staff on a part-time basis is the need to save costs. In addition, the students, master's and PhD, are given departmental duties, to serve respective departments eight hours every week to balance the rising workload due to political and economic factors. Key Performance Indicators (KPI) have changed drastically in response to these external factors. Conformity seems like the best approach. We will then learn to deal with uncertainties, overcome and prevail.
5. The workload also affects the research outputs and therefore the academic profile. It was however reported that the young academic staff feel the effect more as they are tasked to teach the undergraduate students. The effect is less significant with regards to senior lecturers and professors as they are mainly tasked to supervise master's and PhD students. One's career development takes time as a result. So, most academic staff prefer the supervision of post-graduate students as opposed to teaching undergraduates as the demand and pressure in terms of planning and administration continues to increase.
6. The standards and the quality in terms of supervision and teaching are therefore compromised as the number of students increases and therefore there is a need for manpower. The line managers also put pressure on the academic staff members to improve the pass rates.

HEIs challenges and responses

The HEI with the aid of local universities has reflected on the impact of the Covid-19 pandemic and has devised tools which activate magnificent digital transformation in education. The study pursues the 4IR tools that were implemented by various institutions. The concept of 4IR tools introduced in this study are technological innovations that are meant to serve specific purposes by reducing incidents of human error and operational disruptions, especially within the context of Covid-19. The admission of students to higher education has been a challenge in South Africa, due to limited number of spaces and funding provided. This pandemic has intensified human suffering in the world. This has offered an opportunity in increasing and presenting successful practice of technologies, outlays, and improvement of these technologies (World Economic Forum, 2016).

These technologies (4IR) represent the latest ways of learning which involves being introduced to our society and our human nature. Teaching and learning is expected to be a face-to-face interaction with students and teachers. In the unforeseen circumstances, such as this Covid-19 pandemic, teaching and learning activities were disrupted and turned to digital learning. The students in higher institutions were required to incorporate distance education which does not require teachers and learners to be in the same classroom. The learners were expected to do self-learning. The teaching and learning materials are offered online using platforms such as Microsoft Teams, Zoom, Skype and WhatsApp. Data has been a challenge in African HEIs, and research facilities are scarce. Zero-rated data was provided for students through different network coverages, but this was also a challenge. The national financial aid assistance provided student with laptops to facilitate teaching and learning.

The above-mentioned learning platforms have increased access to digital content and continuous assessment activities are conducted in supporting curriculum delivery with Information and Communications Technology (ICT) facilities. This pandemic has transformed teaching modes in the education sector. The pandemic has influenced all education sectors in South Africa to use various 4IR tools. The delays in learning were experienced in rural areas in which data and computers must be provided to students. The Walter Sisulu University (WSU) in the Eastern Cape, South Africa is a historically black disadvantaged institution that experienced challenges with online learning as no systems were active. The laptops for students and lecturers must be arranged for learning to continue. The distribution of laptops for students was funded by the National Student Financial Aid Scheme (NSFAS). Collection of the laptops was a challenge as many of the students are from deep rural areas.

The university was working with local police stations and the nearest schools for collection of the laptops and students were notified. The data is sent through their cell phones for learning and teaching to occur. A technical task team was formed which is pioneering the project. The experienced lectures in online teaching are working together with ICT. The staff members were trained in online teaching and learning, including how to upload study materials for students. A research and innovation team could not be formed at this institution as there is a lack of resources and structure. The lack of funding has limited researchers creating and implementing new ideas/technologies that would benefit society. These technologies will bridge the lines between InfoTech and biotechnology. The novel coronavirus has swept around the continent affecting millions of citizens. The authorities in health, scientists and innovators have rushed into discovering ways to minimise the spread of the virus. The universities contribute a part in preventing and regulating this virus by being part of innovation teams which could devise tools for assisting our society and creating long-lasting healthcare systems.

The African universities in higher education also took part in online learning. The colleges in Ghana were operative in making sure e-learning programmes continue smoothly. However, some students in the Gambaga College of Education would walk two kilometres to attend classes due to lack of accommodation on campus. They have experienced challenges with online learning such as poor internet connectivity, irregular power outages which disrupt synchronous lessons and damaged electronic gadgets when power is active again. The Makerere University in Uganda faced similar challenges as other education institutions in Africa. The different online programmes are continuing, though not yet successful. The research and innovation unit are focused on immunity responses and their implications in the prevention of Covid-19 infections. The social and economic structure of the world has suffered, and the United Nations Secretary General has highlighted that Covid-19 is the worst global crisis since World War II. The Covid-19 pandemic not only affects health issues, it is also a contributing factor in disrupting learning, cultural and economic accomplishments.

In response to the lockdowns and the challenges of responding to the pandemic, the innovative use of technology and new ways of working in health and other non-health sectors are being piloted. For instance, drones are being used to transport test kits and samples from hard-to-reach areas, thus reducing the sample transport time from many hours to minutes; there is a boom in locally manufactured face masks; an explosion of locally produced soap and hand sanitisers; and training, meetings, and workshops have moved online. Many governments have realised the need to

improve hazard payments and provide insurance for staff on the frontline of the infection. African businesses have teamed up to donate in cash and kind to support country efforts, such as the \$70 million donated by a coalition in Nigeria.

Technology has shown the potential to drive the response to the pandemic in different ways from the rise of e-Health, Telehealth, Telemedicine, mHealth, e-learning, robotics, drones, etc. This subsection focuses on technologies deployed to ease the response against Covid-19 in different sectors across the African continent, in higher education and the private sector. Besides innovations, Africa has seen the paced adoption of some technologies, which were not mostly used before Covid-19. Through a desk study which involves the collation of information already available mainly on the internet, an overview of how different universities developed technology innovations to combat Covid-19 is outlined below:

e-learning

South African universities have implemented multi-faceted solutions including the adoption of e-learning as an appropriate alternative since the banning of contact learning, boosting the pace of future classrooms, which are virtual but more efficient. The most-reported challenge with e-learning across South African universities has been technological readiness, especially those in rural areas, which includes connectivity issues and lack of electronic devices for students. Various measures, including the distribution of electronic devices and internet service provision to students were taken to accommodate students with various backgrounds through this technological transformation in the higher education sector.

Artificial intelligence and big data

Big data, one of the major 4IR technologies, has gained more applications during the pandemic to collect, process, analyse and interpret Covid-19 related data, and to help generate heatmaps, trace contacts and make useful projections for experts to advise relevant authorities and communities. Certain universities, like Nelson Mandela University (NMU) have implemented projects specifically focusing on this (NMU, 2020). The modelling of viral activity studies and guiding of policymakers are highly assisted by big data-analytics. Deep learning and Artificial Intelligence enhance the diagnosis and detection of Covid-19. This is important as some African countries do not have tests and resources to accurately distinguish between common flu and Covid-19 (Ting, Carin, Dzau & Wong, 2020).

3D printing

Some companies, universities and government institutes use 3D printing to print medical equipment, face masks and PPE. The Durban University of Technology (DUT), Central University of Technology (CUT), NMU, UCT and North-West University (NWU) are among the South African universities who either already have prototypes and are undertaking research projects on its potential use to curb the Covid-19 pandemic or are currently producing medical equipment using 3D printing. The materials printed include face masks, face shields, PPE, autoclavable swabs, and oxygen connectors to aid large scale manufacturing processes, oxygen splitters, valves for Continuous Positive Airway Pressure (CPAP) and Bilevel Positive Airway Pressure (BiPAP) functionality, etc. (Universities South Africa, 2020). Durban University of Technology (DUT) already has raw materials for 3D printing of their respective medical equipment. Two hospitals have reviewed over 20 face shield prototypes produced by the University of Djibouti using 3D printing and laser cutters, with their government already benefiting from their supplies, respectively (Africa Renewal, 2020).

Self-sanitising mask (South Africa, Uganda)

The masks that are widely used physically minimise the number of exhaled droplets reaching surrounding individuals, objects or surfaces. Researchers at North West University (NWU) are designing masks that can deactivate viruses on contact using anti-viral chemicals built into the masks that sanitise passing respiratory droplets, minimising the number of viruses in the droplets exhaled by an infected wearer, and consequently protecting anyone around. Students at Makerere University, Uganda have also developed a self-sanitising face mask.

In addition, experts at Central University of Technology (CUT) in the Free State contributed their innovation in fighting the Covid-19 pandemic. The university contributed towards protective equipment demand and designed a non-invasive ventilation helmet/mask. The ventilation masks were produced and certified through the Centre for Rapid Prototyping and Manufacturing (CRPM), the Product Development Technology Stations (PDTs), and the Centre on Quality of Health and Living (CQHL) and CUT Innovation Services (CUTIS).

Ventilator unit (Ghana, Kenya, Somali, South Africa, Zimbabwe)

Uganda are modelling the Covid-19 pandemic to organise and intervene with environmental studies and sampling for public health at risk. They have discovered a low-cost ventilator using an open-source design collaborating with the University of Florida. The Kenyatta University in Kenya with vibrant researchers responded to

Covid-19 innovation by building a mechanical ventilator that assists patients that have difficulty breathing. It operates in two modes, Intermittent Positive Pressure Ventilation (IPPV) mode for patients who cannot breathe on their own and Synchronised Intermittent Mandatory Ventilation (SIMV) mode to assist patients who can breathe on their own but cannot acquire sufficient volumes of oxygen. The machine comprises pressure sensors, flow sensors and oxygen sensors to monitor and regulate the respective parameters based on the settings. The Harare Institute of Technology in Zimbabwe also manufactured a prototype of an oxygen ventilator unit which is currently undertaking clinical tests, to serve as a first response unit for less critical cases to address the shortage of Intensive Care Units ventilators.

The Jomo Kenyatta University of Agriculture in Kenya added another contribution by inventing two portable solar powered ventilators, which uses 12 voltage batteries with contact tracing applications. A team from the Academic City University College in Ghana has developed a mechanical ventilator prototype, while a Somalian engineer developed a home-made respirator with autonomous ventilators (PLOS, 2020). The students of NMU and the Engineering Design Group also invented the intubation units. The ventilators were delivered to the Anaesthesiology staff at Livingstone Hospital, a local hospital in Port Elizabeth. This assisted in minimising the tension experienced by the local hospital because of shortages of ventilation systems. It could be argued that Covid-19 revealed hidden potential going by the many technology innovations devised by African researchers to respond to the pandemic.

Mobile payments (Ghana, Kenya, Nigeria)

As banknotes may be spreading the virus, technologies that minimise the physical exchange of money have received recommendation and adoption in some African countries as part of the measures to curb the spread of Covid-19 (Shahbaz, Bilal, Moiz, Zubair & Iqbal, 2020). Kenya and Ghana are two of the first African countries to turn to mobile money. The Bank of Ghana, mobile money operators, and other banks agreed to promote digital payment platforms for more efficient payments (Bank of Ghana, 2020). Safaricom, the largest Kenyan telecommunications provider, implemented a fee-waiver on M-Pesa, the leading mobile-money product in East Africa, for person-to-person transactions under 1 000 Kenyan Schillings (TechCrunch, 2020). The President of Kenya, Uhuru Kenyatta, pleaded with banks “to explore ways of deepening mobile-money usage to reduce the risk of spreading the virus through physical handling of cash” (TechCrunch, 2020). Paga, a mobile money company based in Nigeria with over 15 million users, lowered fees in response to a call to minimise cash exchange (Thomson Reuters Foundation, 2020).

Telehealth, e-Health, mHealth, telemedicine (Ghana, Nigeria, South Africa, Uganda)

Widespread national lockdowns have impacted the accessibility of health services, leading to the high adoption of digital health technologies to deliver health information to patients. Telehealth modalities such as teleconsultation, telepsychiatry, call centres and smartphone health information sharing have increased across the continent since the Covid-19 pandemic (Kamulegeya, Bwanika, Musinguzi & Bakibinga, 2020). E-Health, telehealth, m-Health and telemedicine minimise doctor/physician-patient visits and utilise efficient means to share Covid-19 related information, such as Short Messaging Services (SMSes), smartphones, apps and the internet. South Africa and Uganda are some of the many countries that have adopted this transformation. Redbird, a Ghanaian e-health startup, provides epidemiologists with data for Covid-19 contact tracing in real-time. The platform collects user data when users report their symptoms and it instantly tags the user location and contact number. Identified potential cases are mapped and sent to hospitals for records and triage (PLOS, 2020). Two UCT alumni developed an app, Coronapp, to provide users with reliable information about Covid-19 in South Africa to help prevent unnecessary panic (Thomson Reuters Foundation, 2020).

The development and adoption of smart digital solutions plays a crucial role in efficiently responding to the pandemic in different ways, including mobile apps, AI-powered e-health assistants and chatbots. The mobile apps deployed allow health professionals to communicate with patients through Video Observational Therapy (VOT) which plays an important role in enhancing social distancing and pace the adoption of e-health, and mHealth, across the continent (University of Zululand, 2020).

Monitoring, surveillance, and detection (Nigeria, South Africa)

A free online Covid-19 Triage Tool, developed by a Nigerian company, Wellvis, uses users' disclosed symptoms and their exposure history to assess their coronavirus risk. The user then receives remote medical advice or is directed to a nearby healthcare facility. The platform has helped to drop the number of curious callers. South Africa uses a WhatsApp service, which runs an interactive chatbot that provides answers to common Covid-19 related myths, symptoms, treatment, and stats (World Economic Forum, 2020). These tools form part of e-health and m-health, which also plays a crucial role in responses to the Covid-19 pandemic across the continent. Internet of Things (IoT) platforms, such as Worldometer, have been used to allow public health authorities to access data to monitor the Covid-19 pandemic more efficiently.

Worldometer gives access to real-time updates on Covid-19 related statistics worldwide, such as daily new cases and distribution by countries (United Cities and Local Governments, 2020).

Testing (Ghana, Nigeria, Senegal, South Africa)

Countries have scaled up molecular testing progressively across the continent for Covid-19 testing, with the likes of South Africa and Nigeria leveraging and scaling up the diagnostic capacities currently used for certain diseases such as HIV, Lassa fever and drug-resistant Tuberculosis. Ghana addresses the shortage of diagnostic reagents by pioneering pooled testing, which is faster and increases population coverage (Ihekweazu & Agogo, 2020). Researchers at the Pasteur Institute in Dakar, Senegal are developing a 10-minute testing kit for potential use across the continent. They collaborated with a British company, Mologic, to develop a saliva swab test and a finger prick test for identifying previous exposure to non-infected people (The World, 2020).

Sanitisers

Hand sanitisers have the highest demand in the continent with many private and government institutions producing their sanitisers. South African universities currently producing or undertaking projects on the production of sanitisers involve NMU, CUT, Rhodes University, Tshwane University of Technology (TUT), University of Johannesburg (UJ) and University of Cape Town.

In addition, Kenya has developed a digital system which predicts Covid-19 infections and an automatic solar-powered hand washing machine. The materials to manufacture these innovations were brought from local equipment suppliers. The material is reliable and can operate for two weeks without maintenance. Another group of students devised a Contact Tracing and Case Management app that identifies where and when a person gets into contact with a Covid-19 positive person. Also, another student developed Rona, an AI solution that responds to Covid-19 pandemic inquiries (IEEE Entrepreneurship, 2020).

CUT responded and accepted the call from WHO to increase their manufacturing of protective wear (masks) by 40% in order to assist the government with protecting human lives against the spread of Covid-19 globally. Currently, patients, healthcare workers, doctors and frontline workers depend on PPE against infection of the life-threatening disease (IEEE Entrepreneurship, 2020).

The hand sanitisers in KwaZulu Natal, approximately about 1 000 litres, have been supplied and produced by DUT. The pioneer of the project emphasised that FastSan uses 80% ethanol as opposed to other sanitisers that contain 70% ethanols. A humectant moisturiser is added to prevent drying of hands. Hydrogen peroxide is added to sterilise the bottles and sanitiser.

Face shield and oxygen machine

Additional PPE is needed and should be increased in production. Face shields are manufactured at TUT to assist medical staff in the Tshwane district. The different staff members have formed a team to produce these protective wears and donated them to local hospitals in the region, such as Kalafong Hospital. A CUT team manufactured an additional oxygen connector, referred to as a “Christmas tree connector”. It has a two-way splitter with an added safety feature that ensures the pipe does not dislodge from an oxygen machine. The oxygen machine is needed for admitted patients in need of an additional oxygen supply due to Covid-19 related complications.

The research unit producing Covid-19 testing materials and prototypes positions South African scientists in global biotech innovation. The reliable reagents material must be accessed locally to produce research material, which are safe, reliable and strengthen product market and cooperation globally in fighting pandemics and saving lives. The expansion of locally researched projects will be effective in applications far beyond this current virus. The students’ exposure and experience in partnering with local and global market environments develop critical understanding of what is needed in society (real life) and encourages the application of theoretical knowledge. The National Ventilator Project led by the government to produce medical goods assist students in entailing these skills. The ventilator prototype is a required health item and as the number of positive cases increase, so do the number of patients who need ventilators.

The interactive app which provides real time data on Covid-19 infections, including number of people infected, recovered or those that have passed away, was invented. This was done in affiliation with WHO and the Centres for Disease Control and Prevention in the United States of America, via GitHub, which uses an online repository tracker. The Centre for Epidemiological Modelling and Analysis from SU, in collaboration with researchers at the London School for Hygiene and Tropical Medicine, developed models to evaluate the spread of Covid-19 in African countries. The model predicts which countries will encounter cases between 1 000 and 10 000 when not adhering to the measures taken for minimising the spread of Covid-19.

The University of Witwatersrand (Wits) has performed tests in tracking, modelling, and testing for the virus. The National Institute for Communicable Diseases and WHO collaborated with the university to develop an intuitive and interactive dashboard to track and model the spread of the virus based on information provided, such as demographic information and cases of the various transmission routes. The dashboard shows a day-by-day account of the tests and recorded infections and variations in the data by province.

Concluding remarks

In response to the challenges posed by the Covid-19 pandemic, innovative use of technology and new ways of working in HEIs and in the Department of Health are being piloted. Drones are being used to transport test kits and samples from rural areas, thus reducing the sample transportation time. University students on the African continent have been driving the development of technology. Innovation from mechanical ventilators to medical equipment, PPEs, face masks, sanitisers, as well as smart digital solutions to boost online trading and facilitate online learning for higher education students. It is the argument of this chapter that innovative technologies could help control the spread of Covid-19 as we have seen in the efforts of HEIs in combatting the virus. In countries such as South Africa, Nigeria, Uganda and Ghana, certain innovative measures have been established and it is the recommendation of this chapter that HEIs in South Africa should invest heavily in technological innovations that will gradually lead to the end of the Covid-19 insurgence. Importantly, future research could dwell on aspects of innovation not mentioned in the chapter and how such innovative ideas contribute to the fight against Covid-19.

Health authorities, policymakers, scientists, and innovators in Africa are racing to invent ways to contain the further spread of the virus. Innovative technologies and connectivity are critical keys to fight the novel coronavirus disease on the African continent. Advanced machine learning models present solutions for data management from areas where data has been historically difficult or impossible to access in Africa. Digital technology has been used to help businesses boost online trade, build intelligent networks to support agriculture and food chain delivery, practice online medical consultancy, carry out online job searches and provide contactless loans to SMMEs. With ground-breaking university innovations, including autonomous robots to help deliver care and services, a steriliser that removes up to 99.99% of different infectious viruses, creative solutions to screen pupils for Covid-19 using cell phones and more, the ideal technological response to tackle the insurgence of the coronavirus is just on its way.

References

- Africa Renewal. 2020. *Digital space for migrants supplies 3D-printed face shields to hospitals treating Covid-19 cases in Djibouti*. Available at: <https://bit.ly/31qUuMX> (Accessed 11 June 2020).
- Bank of Ghana. 2020. *Monetary policy committee press release*. Available at: <https://bit.ly/2QMaEyx> (Accessed 21 July 2020).
- Ebenso, B. & Out, A. 2020. Can Nigeria contain the Covid-19 outbreak using lessons from recent epidemics? *Correspondence*, 8(6):E770. [https://doi.org/10.1016/S2214-109X\(20\)30101-7](https://doi.org/10.1016/S2214-109X(20)30101-7)
- Fraser, N. 1997. *Justice interruptus: Critical reflections on the 'postsocialist' condition*. London: Routledge.
- Fraser, N. 2000. Rethinking recognition. *New Left Review*, 3:107-20.
- Fraser, N. 2003. Social justice in the age of identity politics: Redistribution, recognition and participation. In: N. Fraser & A. Honneth (eds.), *Redistribution or recognition? A Political-Philosophical Exchange*. London: Verso, 7-109.
- Gray, L. 2018. Exploring how and why young people use social networking sites. *Educational Psychology in Practice*, 34(2):175-194. <https://doi.org/10.1080/02667363.2018.1425829>
- Hawkins, R.W., Langford, C.H. & Sidhu, K.S. 2007. *Science, technology, and innovation indicators in a changing world: Responding to policy needs*. Ottawa: OECD Publishing.
- Heder, M. 2017. From NASA to EU: The evolution of the TRL scale in public sector innovation. *The Innovation Journal*, 22:1-23.
- IEEE Entrepreneurship. 2020. *Kenyatta university students innovate ventilator in response to Covid-19*. Available at: <https://bit.ly/3fnKHIP> (Accessed 3 June 2020).
- Ihekweazu, C. & Agogo, E. 2020. Africa's response to Covid-19. *BMC Medicine*, 18(151):1-3. <https://doi.org/10.1186/s12916-020-01622>
- Kamulegeya, L.H., Bwanika, J.M., Musinguzi, D. & Bakibinga, P. 2020. Continuity of health service delivery during the Covid-19 pandemic: The role of digital health technologies in Uganda. *The Pan African Medical Journal*, 35(2):43-46. <https://doi.org/10.11604/pamj.supp.2020.35.2.23115>
- Kapata, N., Ihekweazu, C., Ntoumi, F., Raji, T., Chanda-Kapata, P. & Mwaba, P. 2020. Is Africa prepared for tackling the Covid-19 (SARS-CoV-2) epidemic. Lessons from past outbreaks, ongoing pan-African public health efforts, and implications for the future. *International Journal of Infectious Diseases*, 93:233-236. <https://doi.org/10.1016/j.ijid.2020.02.049>
- McMeekin, A., Green, K., Tomlinson, M. & Walsh, V. 2002. *Innovation by demand: An interdisciplinary approach to the study of demand and its role in innovation*. Cheltenham: Edward Elgar. <https://doi.org/10.7228/manchester/9780719062674.001.0001>
- Mowery, D.C. 2005. The Bayh-Dole act and high-technology entrepreneurship in U.S. universities: Chicken, egg, or something else? In: G.D. Libecap (ed.), *University Entrepreneurship and Technology Transfer (Advances in the Study of Entrepreneurship, Innovation and Economic Growth)*. Bingley: Emerald Group Publishing Limited, 39-68. [https://doi.org/10.1016/S1048-4736\(05\)16002-0](https://doi.org/10.1016/S1048-4736(05)16002-0)
- Nelson Mandela University. 2020. *Data analytics and research information*. Available at: <https://bit.ly/2PGvjne> (Accessed 10 June 2020).

- Out, A., Ameh, S., Osifo-Dawodu, E., Alade, E., Ekuri, S. & Idris, J. 2017. An account of the Ebola virus disease outbreak in Nigeria: Implications and lessons learnt. *BMC Public Health*, 18:3-11. <https://doi.org/10.1186/s12889-017-4535-x>
- PLOS. 2020. *African countries set the tone in technological innovation to fight Covid-19*. Available at: <https://bit.ly/3u5c4lQ> (Accessed 18 July 2020).
- Shahbaz, M., Bilal, M., Moiz, A., Zubair, S. & Iqbal, H.M. 2020. Food safety and Covid-19: Precautionary measures to limit the spread of coronavirus at food service and retail sector. *Journal of Pure and Applied Microbiology*, 14(6203):749-756. <https://doi.org/10.22207/JPAM.14.SPL1.12>
- Shilo, S., Rossman, H. & Segal, E. 2020. Axes of a revolution: Challenges and promises of big data in healthcare. *Nature Medicine*, 26:29-38. <https://doi.org/10.1038/s41591-019-0727-5>
- TechCrunch. 2020. *Kenya Turns to Safaricom's M-Pesa Mobile-Money to Stem the Spread of Covid-19*. Available at: <https://bit.ly/31rCLVM> (Accessed 21 July 2020).
- The World. 2020. *Researchers in Senegal are developing a coronavirus test kit to be used across Africa*. Available at: <https://bit.ly/3u2SYwY> (Accessed 5 June 2020).
- Thomson Reuters Foundation. 2020. *Coronavirus seen as trigger for mobile money growth in West Africa*. Available at: <https://tmsnrt.rs/3dgoqRs> (Accessed 15 June 2020).
- Ting, D.S.W., Carin, L., Dzau, V. & Wong, T.Y. 2020. Digital technology and Covid-19. *Nature Medicine*, 26(4):459-461. <https://doi.org/10.1038/s41591-020-0824-5>
- United Cities and Local Governments. 2020. *Digital technologies and the Covid-19 pandemic*. Available at: <https://bit.ly/3m3LN4H> (Accessed 15 April 2020).
- University of South Africa. 2020. *Research projects in support of the struggle against Covid-19*. Available at: <https://bit.ly/39niaGv> (Accessed 30 May 2020).
- Wilmott, C., Fraser, E. & Lammes, S. 2018. I am he. I am he. Siri rules: Work and play with the Apple Watch. *European Journal of Cultural Studies*, 21(1):78-95. <https://doi.org/10.1177/1367549417705605>
- World Economic Forum. 2016. *What is the fourth industrial revolution?* Available at: <https://bit.ly/3rtnyhC> (Accessed 25 May 2020).
- World Economic Forum. 2020. *Here's how Africans are using tech to combat the coronavirus pandemic*. Available at: <https://bit.ly/3cuVG8D> (Accessed 25 May 2020).