Research Article

Higher Education Institutions' Preparedness for the Digital Era: Lessons from COVID-19 in South Africa

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The global COVID-19 pandemic declaration prompted widespread containment measures, including the adoption of online learning. South African higher education institutions swiftly transitioned to remote teaching and leveraged digital tools to mitigate academic disruption. This study explores the implications of this shift on higher education students' access to digital resources at the Buffalo City Metropolitan Municipality. The youth, including students, are positioned as technology drivers of change due to their presumed access to digital technology at various educational institutions. The pedagogical pivot to online learning presented both opportunities and challenges, offering innovative solutions while also unveiling digital disparities. Drawing from interviews conducted with students across different institutions between March and April 2021, this paper illuminates the complex landscape of COVID-19's impact on education, drawing lessons for digital era preparedness. Data collected were analyzed both qualitatively and quantitatively, revealing heightened student anxiety about their digital literacy and access. Online learning underscored the important role of digital resources and connectivity in academic success, magnifying disparities in availability and quality, hence the digital divide.

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1. Introduction

After COVID-19 was declared a global pandemic in March 2020, national governments worldwide implemented various containment measures, including lockdowns and physical distancing protocols. Subsequently, many countries, including South Africa, closed schools and higher education institutions to curb the spread of the disease, thereby significantly impacting the learning of millions of students. In

 doi.org/10.32388/V6F7QV

response, online learning emerged as a viable pedagogical method, supported by organizations like UNESCO. However, this transition highlighted issues of digital access and digital literacy, particularly for students in rural areas or lacking necessary equipment and connectivity. The isolation from educational institutions exacerbated disparities in sociocultural support and capital available in students′ home settings[1].

The reliance on digital tools during the pandemic underscored the need to prepare students for safe and responsible online communication and collaboration. This imperative elevated the significance of digital access, which encompasses behaviors ensuring the legal, safe, ethical, and responsible use of technology. As students increasingly interacted with digital tools, particularly in higher education settings, the concept of digital literacy gained prominence over digital access. In addition, digital technologies are evolving at an unprecedented rate, although there is evidence that pedagogical changes or transformations are slow, calling for targeted educational interventions (Okoye, Hussein, Arrona-Palacios, Quintero, Ortega, Sanchez, Ortiz, Escamilla and Hosseini, 2023).

While digital technology and literacy can heighten the transformation of teaching and learning in higher education institutions, the transitioning of these institutions has been difficult during COVID-19 in South Africa. This shift not only ensured academic continuity but also fostered digital literacy skills among students and lecturers. Within this transformative landscape, there has been a growing interest in enhancing the way in which students access digital technologies, perhaps by making sure that higher education institutions are in a position to hold enough digital resources. It became essential to distinguish between digital literacy and digital learning. Digital literacy encompasses the competencies and skills required to navigate a fragmented and complex information ecosystem[2]. Turner (2012) further explains it as the ability to understand and use information in multiple formats from a wide range of sources when it is presented via technology devices such as computers. Gilster (1997) referred to traditional literacy as “social practices and conceptions of reading and writing” (Street 1984). The OECD (2006) defined this literacy as “understanding, using and reflecting on written texts, in order to achieve one’s goals, to develop one’s knowledge and potential and to participate in society.” “Literacy is no longer considered an ability only acquired in childhood during the early years of schooling. Instead, it is viewed as an expanding set of knowledge, skills and strategies which individuals build on throughout life in various situations, and through interaction with their peers and with the larger communities in which they participate.” On the other hand, digital learning appears to be often subsumed into justifications for strengthening or

transforming the shortcomings of current education systems, be it graduation rates or the provision of new learning resources.

This distinction highlights the necessity for tailored pedagogical approaches to address specific competencies among students in higher education institutions. However, as argued by Akcil and Bastas[3] and Madini, Bank, and Sibanda[4], efforts on approaches that have been applied, especially during the difficult times of COVID-19, faced significant challenges. While measures such as the provision of internet data and Wi-Fi aimed to facilitate digital learning, they posed substantial obstacles, particularly for students from disadvantaged backgrounds. Students faced limited access to essential equipment, and the internet data provided was often insufficient due to their geographic locations. Additionally, conducive learning environments were lacking, further hindering effective participation. For instance, students who returned to their homes in townships reported issues with noise, while those in very rural areas struggled with connectivity. These challenges highlighted a critical gap that needed to be addressed: to ensure equitable access to online education, timely educational content, methodological support, and technical assistance are imperative[5].

The sudden shift toward digital learning necessitates reflection on access to relevant infrastructure and how digital literacy influences students′ inclusion or exclusion from digital access. Internet connectivity became crucial not only for education but also for accessing various services and employment opportunities during the pandemic. Thus, understanding students′ experiences and perceptions of digital access, skills, literacy, and internet connectivity is essential for shaping equitable educational practices and policies (Lemanski, 2019).

This study centers on digital literacy and access among youth, specifically focusing on students in selected higher education institutions at the Buffalo City Metropolitan Municipality (BCMM) in South Africa. The concept of digital literacy, as articulated by scholars like Ribble and Bailey (2007), highlights online behaviors that ensure the legal, safe, ethical, and responsible utilization of information and communication technologies. In contemporary times, digital literacy and access are predominantly embraced by youth, with students serving as the primary agents of change[6], given their heightened exposure to digital tools, especially within higher education environments. According to Haleem et al. (2023), students play an important role in driving digital literacy education. This education endeavors to empower students through the cultivation of competencies necessary for active engagement and participation in a digitally enriched society, as argued by Parent and Community Impact, Technology (2018), Ranchordas (2020), and Tan (2011). Therefore, by focusing on students as the driving force, this

study seeks to contribute to the digital access, skills, and literacy discourse and its implications for educational practices and policies in the context of higher education.

2. Literature review

2.1. Intergenerational technology, gaps, and literacy in the COVID-19 era

Choroszewicz[7] addresses the concept of 'digital natives' and the debate surrounding a tech-savvy generation of youth. This generation's expertise in online communication, interaction, and networking is often attributed to being raised in an era where the internet is ever-present. Despite challenges in connecting in rural and remote areas, lifestyle changes and adaptations have made internet connectivity vital, even in these regions. The drive for connection and digital access is perceived as a common characteristic of the younger generation (youth), who are seen as more digitally cautious and eager than older individuals. Consequently, the younger generation is often described as tech-savvy, while older individuals are sometimes referred to as digital immigrants or natives. Choroszewicz[7] also highlights the intergenerational gap between these 'digital natives' who are less technologically literate and the "tech-savvy" youth. This gap has fueled concerns and anxieties, often labeled as moral panic, about the pace and scope of technological change and its perceived negative impact on young people. While youth are presumed to be the primary drivers of new technologies, the COVID-19 pandemic has revealed that this is not always the case[8]. This revelation is largely due to the digital divide, which refers to the gap between individuals who have access to technology and the skills to use it effectively and those who do not[9].

Despite this divide, students who have grown up using computers and related technologies possess an inherent advantage. Their familiarity with technology positions them as essential anchors for technology access and literacy[10].

Given their environment at educational institutions where technology is readily available, students are uniquely positioned to bridge the digital divide. They can leverage their skills not only for their own learning purposes but also to assist others in their communities, thereby fostering greater technological literacy and access[11]. This role is critical in ensuring that technology serves its intended purpose of enhancing communication, learning, and development for all, especially in times of crisis like the COVID-19 pandemic.

As technology increasingly permeates every aspect of daily life, especially for youth, the ability to navigate and accomplish tasks using technological tools has become essential. Being digitally able and connected

was particularly pronounced, re-introduced, and emphasized in South Africa and other countries during the COVID-19 pandemic as an alternative to better operate, especially during the hard lockdown when physical contact and appearance were prohibited to limit the spread of the virus. In higher education institutions, online learning, where the internet and connectivity are most needed, then became a necessity. In the context of the growing importance of technology in daily life, particularly accentuated by the COVID-19 pandemic, the acquisition of digital literacy skills has become increasingly critical. Individuals at all educational and professional stages must develop these skills to effectively communicate and perform various tasks in an interconnected, information-rich world[12]. The growing reliance on online content and digital connections for information gathering presents additional challenges for students, who must now organize and compose information while often integrating visual and technological methods to synthesize it.

2.2. Digital literacy

Digital literacy encompasses a range of cognitive thinking strategies utilized by consumers of digital information (Eshet, 2004). This concept is often discussed alongside or synonymously with terms such as 21st-century literacies, Internet literacies, multiliteracies, information literacy, information communication technologies (ICT) literacies, computer literacy, and online reading comprehension. While each term has specific definitions, they share common assumptions that unite them under the theoretical framework of new literacies, as suggested by Osterman[12]. Leu *et al*[13] identified four shared assumptions across various literacies, including digital literacy: (a) new literacies encompass the skills, strategies, dispositions, and social practices necessitated by emerging technologies for information and communication; (b) new literacies are essential for full participation in a global community; (c) new literacies continually evolve with technological advancements; and (d) new literacies are multifaceted, benefiting from multiple perspectives. Furthermore, Cervetti, Damico, and Pearson[14] articulate that new literacies theory operates on two levels: uppercase (New Literacies) and lowercase (new literacies). Coiro et al.[15] define "New Literacies" (with an uppercase "N") as the overarching research field encompassing various forms of literacy studies. This broad field of research is interpreted differently by various scholars. For instance, some researchers view New Literacies as social practices and conceptions of reading and writing[16][17], while others see it as a set of skills, strategies, and dispositions for handling online content[18][19].

Additionally, some scholars focus on new semiotic and multimodal contexts[20][21], multiliteracies[22], new discourses[23], changes in technologies and associated cultural practices (Coiro et al., 2008), and research that combines several of these orientations[24]. Conversely, "new literacies" (with a lower-case "n") refer to specific skill sets and practices utilized with or without technology that involve collaboration and participation to create and communicate meanings. The term "new" in literacies can be understood in both paradigmatic and ontological senses. According to Lankshear and Knobel[24], the paradigmatic sense involves researching new literacies using a particular sociocultural approach[25] (Street, 1993). The ontological sense, forming the core of new literacies, corresponds to the substance and character of new social practices of producing, distributing, and sharing meanings. Students engage in these practices through participative and collaborative activities associated with digital literacy.

Digital literacy functions as a lower-case dimension within the broader, more inclusive concept of upper-case New Literacies. Upper-case (New Literacies) refers to the comprehensive understanding of new skills and practices required for using new technologies and digital tools (West, 2019). This perspective focuses on the big picture and overall trends in how literacy is evolving in the digital age. In contrast, lower-case (new literacies) concentrate on the specific skills and abilities needed to use technologies or perform specific tasks online[26]. They encompass the detailed, everyday actions and strategies people employ to interact with digital content.

Research conducted in various lower-case fields, such as digital literacy, information literacy, and online reading comprehension, informs the larger field of New Literacies. Ba *et al.*[27] provide a broad definition of digital literacy, describing it as a “set of habits through which youngsters use information technologies for learning, work, and fun”. This general definition highlights a key paradox in contemporary education: Osterman[12] asserts that the skills necessary for increasingly technological and evolving workspaces are not being acquired in higher education institutions but rather outside the formal educational environment. This situation calls for significant intervention in higher education institutions to bridge the gap between preparing students for the workforce and their actual entry into the job market. The responsibility of readying students for the work environment is ostensibly placed on higher education institutions; however, this preparation is currently inadequate, creating a noticeable gap.

Addressing this gap is crucial, as fostering digital skills within higher education institutions is important. Ensuring that students acquire these skills before entering the workforce will not only enhance their readiness for the technological demands of modern workspaces but also contribute to their overall professional competence. By prioritizing digital skills training in higher education, institutions can better

equip students for the challenges and opportunities they will face in their careers, thereby aligning educational outcomes with industry requirements.

As the Internet has become this generation's defining technology for digital literacy and learning, educational institutions have been slow to integrate its usage into the classroom and to commence instruction in the new literacy skills the Internet demands[28]. Ferdig, Richard, and Kathryn[29] report that states such as Idaho, Alabama, Florida, and Michigan require students to complete online education courses to graduate. This practice serves as an instructive example and suggests a strategy that South African higher education institutions can adopt.

Incorporating online education courses as a graduation requirement would ensure that students develop the essential digital literacy skills necessary for contemporary learning and professional environments. By adopting this strategy, South African higher education institutions can better prepare their students for the digital demands of the modern world, aligning educational practices with the technological realities of today.

Considering this, policymakers must recognize that the pervasive growth of the internet in education, work, and home settings presents a significant reading comprehension (cognitive) issue, not merely a techno-procedural one. For example, students today often turn to the internet for research and learning, encountering vast amounts of information that require critical reading and comprehension skills to navigate effectively. Teaching students how to use technology is not enough; they must also be equipped with the cognitive skills to understand, evaluate, and synthesize the information they find online. Policymakers need to address this by integrating digital literacy into the curriculum, focusing on developing students' ability to critically engage with online content.

The digital divide between education institutions, home, and the workplace is highly problematic, creating a discord between the learning experiences in each environment. Lecturers therefore need to correlate students' digital literacy habits from their personal lives with instructional practices during teaching. For example, many students are skilled at using social media and various online platforms for communication and information sharing. Lecturers can leverage this familiarity by incorporating similar digital tools into their teaching strategies, such as using discussion boards, collaborative online documents, and multimedia presentations. By aligning instructional practices with the digital habits students already possess, lecturers can create more engaging and effective learning experiences that resonate with students' everyday use of technology, thus enhancing their overall digital literacy (Leu et al., 2011). This

correlation would begin to address the disconnect between home and school technology use and make the curriculum more relevant to students' lives.

The aim of this paper is to draw lessons from the challenges and difficulties faced by higher education institutions during the COVID-19 pandemic in adapting to the digital era. By examining the experiences of students who were expected to be proficient in digital technologies, the paper seeks to identify key insights that can help prepare higher education institutions for the growing digital era. The insights gained from this analysis will guide the design of curricula that effectively enhance digital literacy and access. Ultimately, this will enable the education system and policymakers to better equip and prepare higher education institutions for the digital era.

2.3. Digital Access, Skills, and the Digital Divide

Digital access encompasses the ability to engage with available digital technologies, while digital skills refer to the specific competencies required to utilize these technologies effectively. The integration of technology into educational systems has significantly transformed teaching and learning methodologies. The COVID-19 pandemic necessitated a rapid adoption of technologies such as computers and the internet to facilitate educational activities in the absence of traditional face-to-face learning environments. Despite these efforts, the transition has not fully achieved its intended objectives due to the persistence of the digital divide. This divide continues to hinder equal access to digital resources and the development of necessary digital skills, thereby impacting the overall effectiveness of technology integration in higher education institutions.

Amidst the global digital transformation of educational institutions, digital technology has emerged as a significant area of interest among scholars. Such technologies have played an instrumental role in enhancing learner performance and improving the effectiveness of teaching and learning[30]. A key challenge is the lack of preparedness for students entering the digital era.

3. Method and Approach

The study applied a mixed-methods design. A survey was conducted in collaboration with the Human Sciences Research Council (HSRC), online interviews were performed, and questionnaires were distributed to public universities, colleges, and private colleges located in the Buffalo City Metropolitan Municipality (BCMM). These surveys and questionnaires were administered among students at universities and colleges from March to April 2021. The aim was to provide insights into the challenges and potential

solutions that could arise through engagement in the digital world during the COVID-19 pandemic in the municipality.

Integrating case studies with qualitative and quantitative methods enabled the study to harness the nuanced, contextualized insights from qualitative data alongside the broadly applicable, valid insights from quantitative data. As revealed by Dawadi, Shrestha, and Giri (2021), the mixed-methods design employed in this study caters to diverse questions, gathers varied data types, and yields multifaceted answers. In this specific study, diverse viewpoints and comprehensive insights were acquired, underscoring the advantage of using both qualitative and quantitative approaches. A total of 274 students from Walter Sisulu University (WSU), the University of Fort Hare (UFH), Buffalo City TVET College, and four private post-school colleges (I-College, MSC College, Damelin, and Academy) participated in the interviews. The focus of the interviews was to assess their digital access, skills, literacy, and experiences with online learning and the internet. The interviews were carried out using open-ended questions, which were administered online for students who were unable to meet physically. Case studies were created with students within the BCMM. Additionally, we conducted telephonic interviews based on referrals from students who had been interviewed in person. The collected data were analyzed both qualitatively and quantitatively.

4. Case Studies: Barriers to Full Digital Access

4.1. Students' Residential Status During Lockdown

The survey revealed that a significant number of students in the inner Buffalo City Metropolitan Municipality were concerned about various issues, including the lack of access to devices, data, electricity, or stationery necessary to facilitate remote learning. Significantly, these challenges were not just prevalent among specific students; the survey also uncovered that those encountering similar difficulties primarily hailed from similar residential places. For instance, students compelled to relocate from university residences to rural homes as a precaution against the virus faced notably greater challenges than those who moved within the city or were already situated outside of university accommodations.

It became apparent that students residing within urban areas, who could still go to campus, could have access to e-learning in comparison to their counterparts living outside the city limits, with no way of accessing places that had free Wi-Fi in the city or on the campus itself. In addition to these observations, the case studies further highlighted the diverse experiences of students, emphasizing the stark reality of

the digital divide during the COVID-19 lockdown. These case studies vividly illustrate the varied challenges faced by individuals, shedding light on the profound impact of unequal access to technology and resources during this critical period. Figure 1 depicts the residential status of students interviewed during the lockdown, providing a visual representation of the disparities in digital access and its effects on students' educational experiences.

When students were asked through the online survey and face-to-face interactions where they resided during lockdown, the following responses emerged.

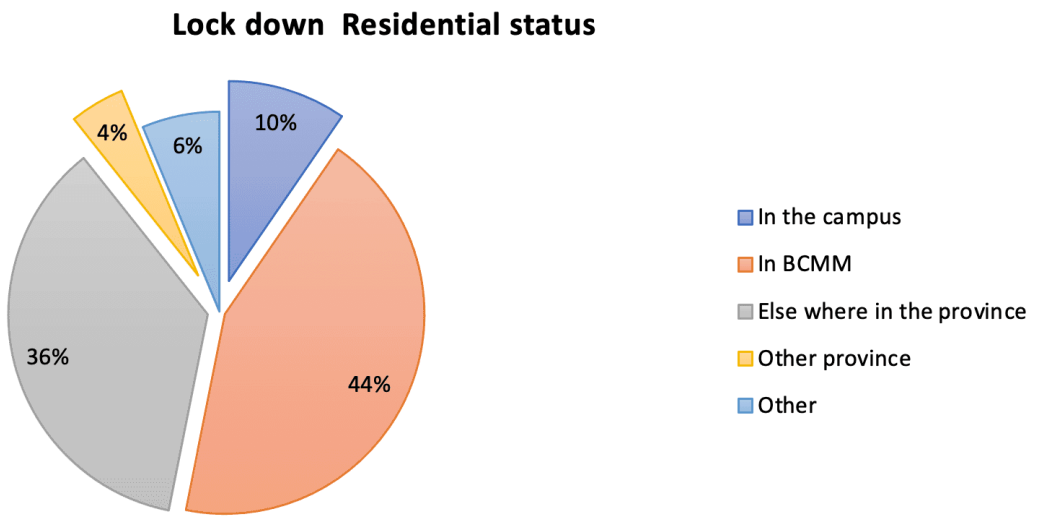

Figure 1. *Lockdown residential status of participating students*

Under COVID-19 restrictions, as face-to-face teaching and learning fell away, some students were trying to adapt to online learning while others had to find ways of learning at home. Many students had previously lived near their higher education institutions to be able to attend classes. Of the interviewed students, 54% had access to student Wi-Fi, provided by their institutions, as they had remained in the BCMM or were still in campus residences. However, numerous students relocated and started with remote learning. These had either moved to their homes within the province or had relocated elsewhere, away from the Eastern Cape, as shown in Figure 1.

doi.org/10.32388/V6F7QV

4.2. Lack of Tools, Digital Skills, and Services for Online Learning

Insufficient resources, expertise, and services for the effective utilization of online learning became apparent from the survey findings. When students were displaced from classrooms during the lockdown, accessing online education became a significant challenge. Many lacked laptops, and even among those who possessed them, access to internet data in their homes was limited. Some students fortunate enough to reside within the BCMM could access free Wi-Fi hotspots. However, even though accessing a free Wi-Fi hotspot was an advantage, they still encountered hurdles in navigating new applications like Zoom and Teams, which were introduced without prior instruction. Case studies consequently indicated that attendance in online lectures dropped, with most students struggling to comprehend these unfamiliar tools essential for learning. Additionally, inadequate electricity supply, particularly in rural areas, further impeded students' access to online resources. Despite efforts from institutions, these measures did not make much of a difference because of the challenges. A final-year student from WSU had this to say:

> *At home where I come from, we always have problems with electricity that just shuts for days. Before I can mention the issue of the internet, how does one work or connect to the internet if there is no power at all? When the power is back, I then struggle to connect because the area where my home is situated does not have a network at all, we always struggle to connect even with our phones, the internet is the worst, there was no way I could have managed to do anything at home during lock down. Being away from the campus and the university residence where I reside when I am at school made everything difficult for me. As a result, I am repeating two modules I should have done and passed in 2020 (WSU final year engineering student,2021).*

The above illustrates how students' digital access was affected by access to the resources, skills, and services necessary to navigate the challenges posed by the transition to online learning. Some issues, such as electricity provision and network coverage, required external intervention from government and service providers, as they were beyond the control of students or their institutions. For example, students in remote areas struggled with frequent power outages and poor internet connectivity, which hindered their ability to participate in online classes. To facilitate this transition, higher learning institutions equipped students with laptops or tablets and provided data, enabling connectivity during the challenging lockdown period. However, despite this intervention, some students still experienced challenges that affected their full participation in the academic discourse.

The case studies indicated a divide in access to connection and digital resources, which was dependent on where students resided during the transition to online learning. Students who lived far from the inner city and campus during the lockdown experienced different challenges, primarily due to connectivity issues. Their institutions were limited in their ability to assist them, as there were underlying problems outside their control.

For example, one student shared:

> *"I am not staying at res, and it has been two years since I stopped staying there. I am renting my own place about 6 km away from the institution. I have experienced a huge change since we were restricted access to the campus. I started subscribing to Rain (network provider), but the internet most of the time was slow, and sometimes I would miss lectures and submission deadlines. Before lockdown, I would go to the campus when I do not have internet data, even on weekends" (WSU student, 06/04/ 2021).*

Another student, a law student from Fort Hare who had to return home to the townships, had a different perspective on being away from campus and university residence. This student noted:

> *"On campus and in university residence, we were always connected to Wi-Fi, even though it would be down and slow sometimes. But now, as I must study from home, I see that being on campus is much better than here at home. There are many disruptions here; internet connection is not the only problem. Sometimes, the noise from the streets can be a huge disruption, taking me away from focusing on my studies. I also must make sure that chores around the house are done because I am home, which is different when I am at res. Another major problem was internet data; sometimes I could not buy data, and I would miss classes and could not download study material. I think lockdown was tough for us all because we had no access to the campus and could not even access the university library while we were supposed to do our assignments and attend classes" (Fort Hare student, 08/04/2021).*

These case studies illustrate the significant impact of the digital divide based on students' residential locations during the lockdown. They reveal how external factors such as internet connectivity and access to digital resources created disparities in students' educational experiences, highlighting the limitations of institutional support in addressing these broader issues.

In contrast to students living in the inner city, this situation presents a notable divergence. While being away from campus posed challenges for everyone, the specific experiences varied depending on the

students' locations. Another student said:

> *We have access to the internet on both campus and our places of residence. But sometimes it does not work or becomes slow and that is when I must buy my own data. More recently, I do not have to buy data at all because our institution is providing internet data to students every month; so, when the internet is slow, I switch to my cell phone data (WSU student, 08/04/2021).*

From these responses, it is evident that institutions of higher learning made strides in bridging the divide for those students who encountered challenges in transitioning to new modes of learning. The students were subsequently asked about their expenditure on data, and their answers proved instrumental in enhancing the analysis of their circumstances concerning their access to online learning.

4.3. Cost of data

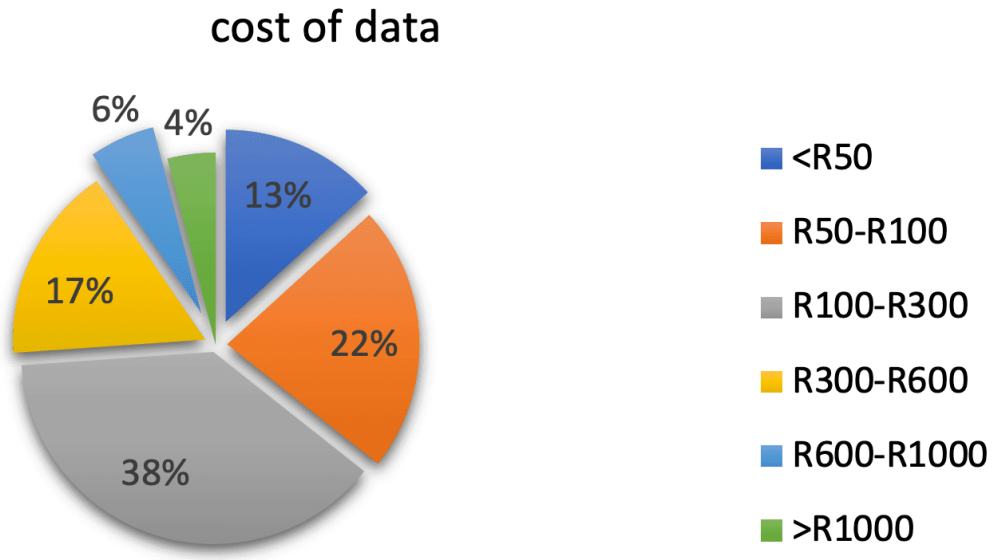

Figure 2. *Internet access for students from different types of institutions*

As shown in Figure 2, even though some students residing in campus accommodation had access to free Wi-Fi, most students still spent between R50 and R300 per month on data. This expenditure can be attributed to several factors, such as connectivity issues within the residences or the Wi-Fi being restricted to certain educational websites, excluding other necessary internet sources. As a result, students were compelled to purchase their own data. For example, a student might find that the campus Wi-Fi is too slow

for video calls required for online classes, or it might not support accessing non-educational sites needed for broader research. Notably, approximately 22% of respondents who needed to purchase data were spending more than R300 monthly, and a smaller but significant 4% of students reported monthly data expenses exceeding R1,000. Markedly, despite receiving free data bundles from their institutions, students at UFH and WSU still had to allocate between R50 and R300 for additional data each month. In contrast, TVET students, who did not benefit from subsidized data, and students at private colleges, who also did not receive data packages, had to purchase their data independently.

The study findings also highlighted that the students who derived the greatest benefit from these provisions were those enrolled in public institutions, as illustrated in Figure 3.

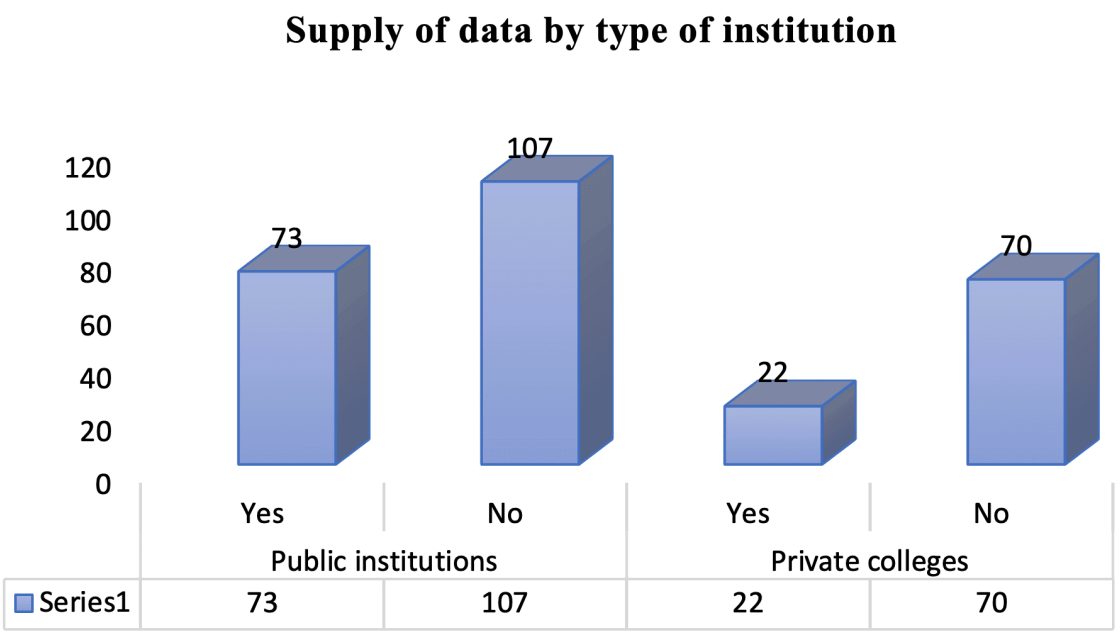

Figure 3. *Data supplied to students by type of institution.*

Figure 3 illustrates that while a few students faced challenges in accessing data, the majority received data assistance from public institutions compared to private institutions. While the case of resource provision appeared distinct for public institutions, it was evident that a divide existed between public universities and public colleges. This disparity indicated a notable difference between universities and colleges, despite both being government institutions. A public administration student from BCTVET college had this to say:

doi.org/10.32388/V6F7QV

> *I spend more than R700 per month on internet data for me to do my assignments and download materials for studying online. Since we are a public institution, I was expecting that the institution will assist us with internet data, but no, that did not happen (BCTVET college 12/04/2021)*

The above demonstrates that the type of educational institution, whether public or private, also influences students' ability to participate in the digital community. Where a student is registered becomes a critical factor in determining their access to digital learning. However, the development of students should not be constrained by the type of institution they attend, especially within the same city, province, or country. To ensure that all students can fully participate in the learning process, policies that address these disparities should be formulated and implemented.

For instance, during the COVID-19 pandemic, many students at private universities struggled with inadequate internet access compared to their peers at public institutions. This situation underscores the necessity of taking e-learning seriously and implementing initiatives to promote digital inclusivity. Higher education institutions must learn from the evidence of negative experiences during the pandemic. The study examined the amount of time students dedicated to internet usage for their studies to understand the increased importance of connectivity for e-learning since the onset of the pandemic. This examination highlights the need for robust policies and infrastructure to support effective digital learning for all students, regardless of their institution.

4.4. Internet dependence

When students were asked how many hours they spent studying online each day, the following responses, illustrated in Figure 4 below, emerged.

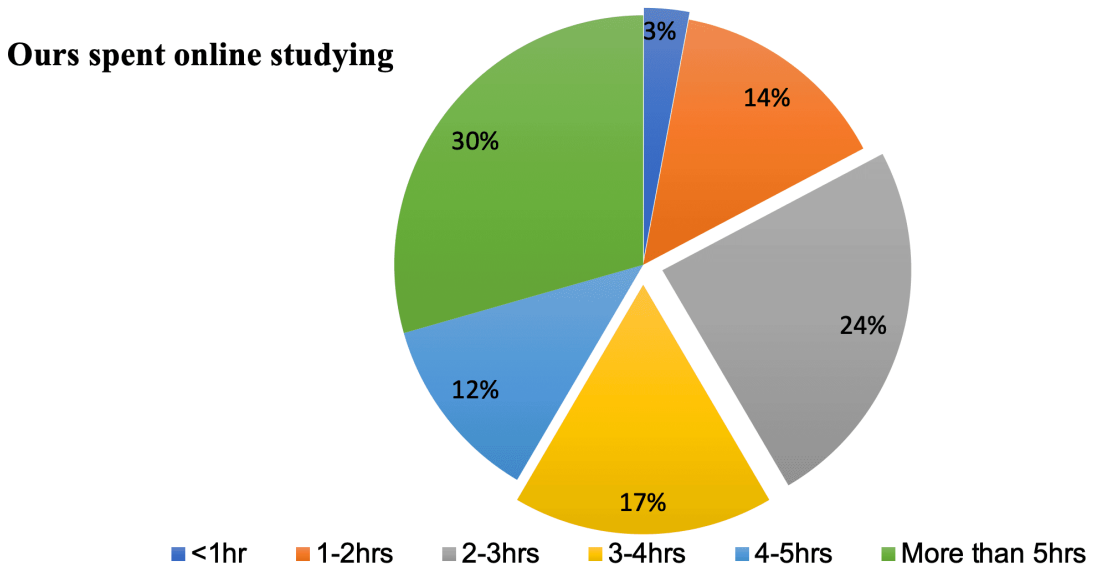

Figure 4. *Hours spent online as reported by participating students.*

Figure 4 shows a significant amount of time students spent online, underscoring the importance of internet access in their studies. The internet has made research easier, allowing students to revisit lectures and participate in continuous assessments. However, the adaptability of South African universities to this shift varied significantly. Well-funded, historically advantaged institutions, such as those in provinces like the Western Cape, adjusted more swiftly compared to historically disadvantaged ones, particularly universities in the Eastern Cape. As argued by Mtshweni[31], COVID-19 exposed systemic issues that have long existed between Historically Black Institutions (HBIs) and Historically White Institutions (HWIs). The pandemic highlighted challenges in internet access, often linked to the nature and landscapes of the provinces, which limited the rapid adaptation of HBIs. This study reveals that these systemic disparities were exacerbated by the pandemic, underscoring the urgent need for policies and interventions to address the digital divide and support equitable access to digital resources across all institutions.

The hurdle in transitioning to online teaching resulted in students rotating their attendance and sharing notes, and WSU faced challenges on campuses that are outside the inner city within BCMM, leading to the extension of the academic year in 2021. All these challenges made a huge contribution to students' inability to access online learning that promotes digital literacy and access.

4.5. Institutional support for internet data access

The support received by higher education institutions varied significantly, particularly in terms of internet data provision. Data collected for the study indicated that only 22 out of 92 students were supplied with data by their institutions, while the remaining students had to purchase data for their studies. Figures 5 and 6 below illustrate the amount of internet data expenditure by students at public and private higher education institutions. This disparity highlights the differing levels of support provided by various types of institutions, underscoring the need for more consistent and equitable access to digital resources across all higher education institutions.

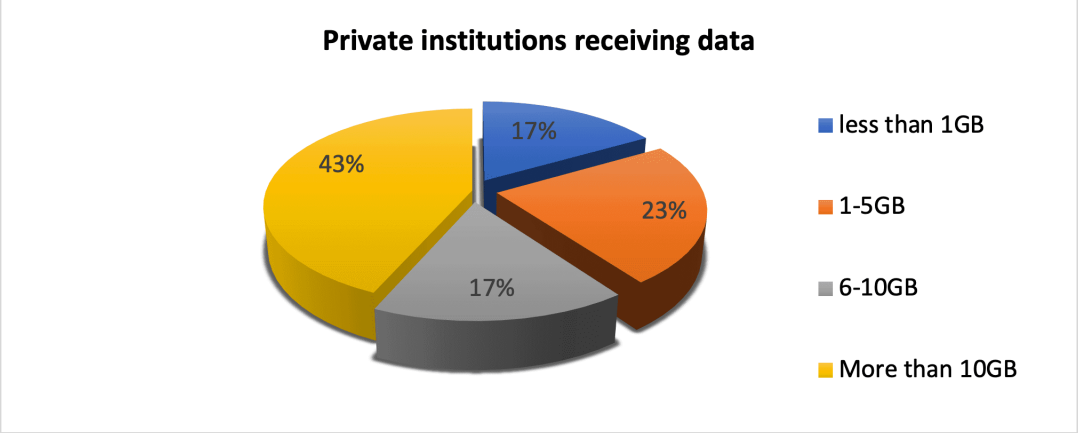

Figure 5. *Private institutions receiving data as reported by participating students.*

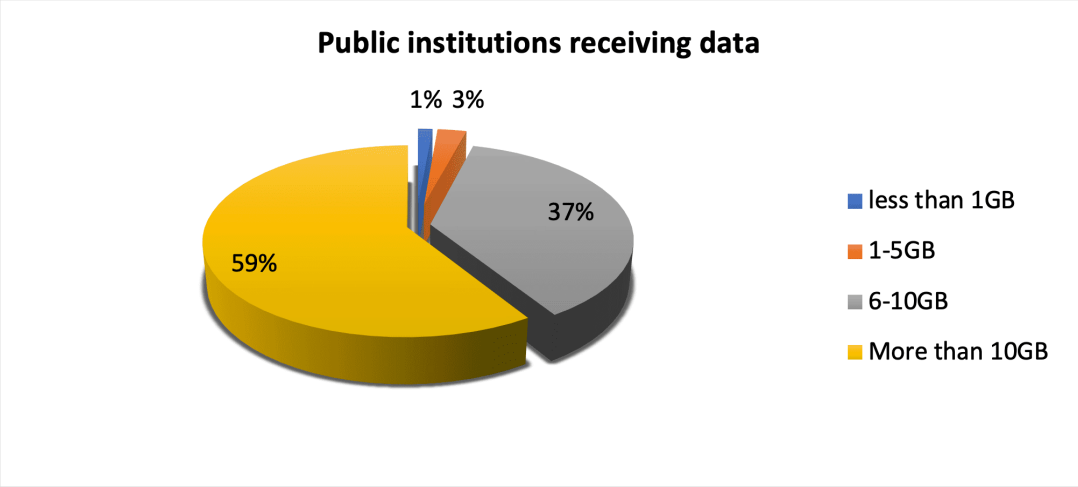

Figure 6. *Public institutions receiving data as reported by participating students.*

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Figures 5 and 6 reveal a significant contrast in data usage between students at public and private institutions. Nearly 60% of university students at public institutions consumed more than 10GB of data each month. Consequently, only 43% of private college students report data consumption exceeding 10GB monthly. Students from WSU and UFH, who typically receive 6GB to 10GB of data from their institutions, tend to spend less on data. Conversely, students from private colleges, which generally do not provide data to their students, constitute the majority of those who incur significant data expenses.

4.6. Access to study materials, quality of online education provision and infrastructure support

When students were asked about their access to study material online, the following responses emerged.

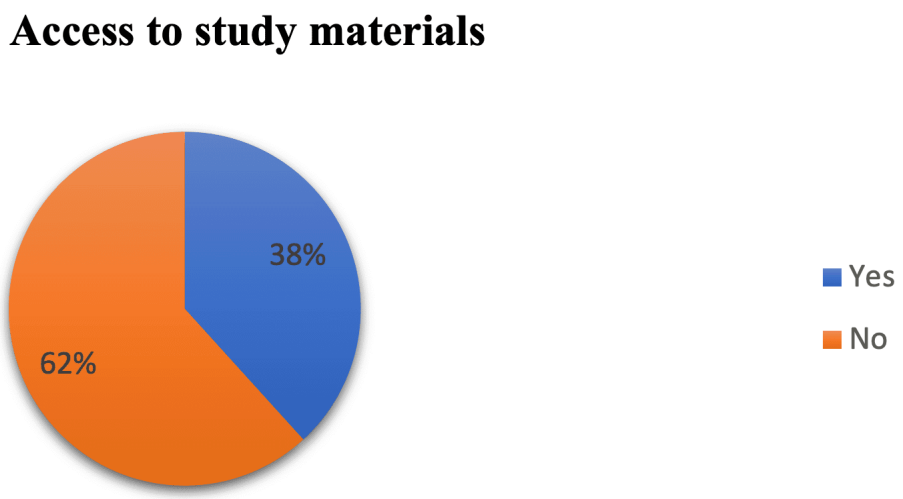

Figure 7. *Student access to study materials*

Figure 7 illustrates that 62% of the interviewed students lacked access to study materials, while only 38% had access. These students highlighted significant issues related to affording data, particularly during the lockdown phase when institutions were still strategizing on intervention processes.

The students were also asked about their perceptions of online learning as a viable alternative to traditional face-to-face education. The results revealed that 56% of respondents found online learning less feasible than in-person teaching. This highlighted the unpreparedness of higher education institutions for the pandemic-induced changes. For example, some institutions struggled with inadequate digital infrastructure and a lack of training for students. While adaptation rates varied among institutions, the

consensus from the interviews showed that the challenges faced were more prevalent than the solutions implemented. This suggests that many institutions were caught off guard and struggled to address the rapid shift to online education effectively. A significant hurdle was the inadequate infrastructure for comprehensive online education. Consequently, this study identified infrastructural challenges as an emerging concern for digital literacy and access. The study also revealed that during lockdowns, access to connectivity in rural areas was significantly hindered by insufficient infrastructure. For example, many remote regions lacked the necessary network towers and high-speed internet cables, which severely impacted their ability to engage in online learning or remote work. This lack of infrastructure created substantial barriers to connectivity and digital participation.

5. Enhancing digital connectivity and education through infrastructure development

As part of its infrastructure development efforts, BCMM aimed to boost its digital connectivity by integrating with global internet networks through an undersea cable destined for its development zone. This initiative promised to bring high-speed internet to the city and upgrade the network to 5G[32]. Such advancements are crucial for preparing higher education institutions in the BCMM to effectively utilize digital tools and enhance educational experiences. For example, the installation of fast internet and the transition to 5G were expected to support more robust online learning platforms, improve access to educational resources, and enable real-time collaboration among students. This infrastructure development could significantly streamline digital education, making it more efficient and accessible.

To assess the impact of these advancements, the study included a question for students about their universities' readiness for the introduction of 5G, which began rolling out across South Africa in 2020. The goal was to gauge students' understanding of how infrastructure influences their access to digital tools and the potential effectiveness of 5G technology in their educational environments. The results indicated that 78% of students felt confident about the city's preparedness for this technological leap, based on their observations of other high-tech companies operating within the area. Although 5G coverage was limited in South Africa, there was considerable anticipation for its full rollout and expanded coverage. About 64% of students were already informed about 5G and its associated benefits.

Students were also asked about the potential advantages of 5G, particularly in the context of the increasing reliance on online teaching and learning during the COVID-19 pandemic. They highlighted that faster internet speeds and improved connectivity could greatly enhance their learning experiences. For instance,

a university with upgraded infrastructure could facilitate seamless virtual classrooms, high-definition video lectures, and interactive online resources, thereby preparing students better for a digitally driven world. However, concerns were raised about the outdated infrastructure within the city and its educational institutions, which could hinder the effective adoption of new technologies. Despite their optimism about 5G, students recognized that overcoming existing infrastructure limitations would be essential for fully leveraging the benefits of advanced digital connectivity.

6. Discussion

This study has illuminated the significant factors and challenges that affect students' digital inclusion and exclusion within the BCMM. By highlighting discrepancies in how students are treated across different institutions, it reveals that those in public institutions received more support from the government compared to their counterparts in private colleges, who were marginalized. The research emphasizes the integral role of digital literacy and access, presenting digital literacy as crucial alongside digital access. This dual focus is essential for ensuring that students are fully incorporated into the digital environment. The findings highlight the necessity for policies that promote the full participation of all students in the digital space, thereby guaranteeing their rights and responsibilities associated with digital literacy, access, and skills. The study also highlights the unpreparedness of higher education institutions for the digital era, as evidenced by the experiences of students during the COVID-19 pandemic. These disparities, particularly in digital literacy and access, were exposed and exacerbated by the pandemic.

A crucial element highlighted in this study is the role of students as anchors of technological change. Youth, often presumed to be the primary drivers of new technologies, possess a unique advantage due to their assumed familiarity with digital tools and environments as compared to the older generation. Students who reside close to cities, have access to the internet, and have better access to computers and related technologies, such as students residing in university residences, are positioned as essential anchors for technology access, skills, and literacy. This generational advantage places them at the forefront of driving digital inclusion and innovation within educational settings and beyond. In contrast, the older generation, often referred to as 'digital immigrants', faces more significant challenges in adapting to new technologies. Therefore, empowering youth with robust digital literacy skills not only benefits their personal and academic growth but also enables them to serve as catalysts for broader technological advancements in their communities.

The study therefore suggests that a more inclusive and collaborative education system is required to bridge the digital divide. This includes fostering partnerships between public and private institutions and enhancing infrastructure to support digital adoption and connectivity. The study advocates for the implementation of digital literacy courses across all levels of education to better prepare students for future disruptions. By integrating digital literacy into curricula, higher education institutions can ensure that students are equipped with the necessary skills to navigate and thrive in the digital era.

A model like the Triple Helix, which involves interactions between academia, industry, and government, could be instrumental in driving this inclusive education system. The model is particularly valuable for drawing lessons related to adaptation to online and digital learning environments, which would also promote a collaborative approach to innovation and problem-solving by integrating universities, businesses, and government entities, facilitating a more coordinated response to challenges related to digital infrastructure and online learning[33]. During instances such as the pandemic, the model would enable institutions to partner with technology companies to improve digital resources, while government bodies provide the necessary funding and policy support.

This approach would lead to more comprehensive and effective solutions to the issues encountered. Since the Triple Helix model ensures that resources are allocated more efficiently and effectively by involving multiple stakeholders[34], institutions that faced significant challenges with digital access and infrastructure would be assisted in gaining access to additional resources and expertise, addressing these challenges more swiftly. For instance, collaborations would result in better internet connectivity solutions and the development of digital platforms that enhance the learning experience. The Triple Helix model would support the development of sustainable innovations by fostering long-term relationships between academia, industry, and government[33]. This is crucial for higher education institutions that need to adapt to ongoing digital transformations, as the model encourages continuous dialogue and collaboration, helping institutions remain resilient and adaptable in the face of future challenges.

By leveraging such a model, higher education institutions can position students as pivotal drivers of digital change, both within educational settings and in broader communities. This collaborative approach will not only address current disparities but also equip students with the necessary skills to navigate and lead in the evolving digital landscape.

7. Conclusion

This study highlights the critical lessons that higher education institutions in South Africa can learn from the COVID-19 pandemic to better prepare them for the digital era, the importance of which was exposed during the pandemic. By analyzing the challenges and responses during the pandemic, valuable insights essential for fortifying the resilience of educational institutions against similar crises can be derived.

Statements and Declarations

Conflicts of Interest

No conflicts of interest exist that need to be declared within this work.

Ethics

Ethics clearance for the study adhered to the guidelines set by the Human Sciences Research Council (HSRC) as an integral component of the Buffalo City Knowledge and Innovation District (CID) Feasibility Study within the BCMM, undertaken by the HSRC. One of the chapters by the current authors, focusing on the digital divide, was contributed to a monograph curated by the Eastern Cape Socio-Economic Consultative Council (ECSECC).

Authors' Contributions

The authors affirm complete responsibility for the following aspects: the conception and design of the study, the analysis and interpretation of results, and the manuscript.

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Declarations

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.