Experiences of Biomedical Sciences Students and Staff in Blended Learning during the COVID-19 Pandemic Lockdown in a University of Technology, Durban, KwaZulu-Natal

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DECLARATION

I hereby certify and declare that "The experiences of Biomedical Science students and staff in blended learning during COVID-19 pandemic lockdown in a university of technology in Umlazi Township, Durban, KwaZulu-Natal, South Africa" is my own researched work, except where I have acknowledged herein, and has not been submitted to any other university for degree purposes.

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ABSTRACT

This study explored and described the experiences of biomedical sciences students and staff who used blended teaching and learning during COVID-19 pandemic. To follow social distancing protocol, limited number of students and staff were permitted on campus at a time, while others were online to limit the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2 virus). The objective of this study was to determine and recommend the necessary resources and skills needed by biomedical sciences students and staff for blended learning at a historically disadvantaged university of technology and better prepare for future pandemics. The aim is to help the university stakeholders to budget, invest, and direct resources and skills for blended teaching and learning appropriately.

Purposeful sampling was used to select 14 participants from biomedical science population of 100 students and 14 staff (eight lecturers, 3 laboratory technicians, two laboratory assistants and one secretary). Purposeful sampling was chosen as it is characterized by the intentional selection of units pertinent to the study issue as it strategically focuses on traits within a population, enabling researchers to gather rich, contextual data. Qualitative descriptive content analysis research method was chosen to make replicable and valid inferences of the phenomenon from texts. Semi-structured individual interviews were used to collect data and data was analyzed continuously using descriptive content analysis. Participants were interviewed until data reached data saturation.

The results of this study showed that staff and students were unprepared for the emergency transformation. There were disparities in students' device access and availability, students' digital skills; some had basic knowledge of computers, while others had none. Students and staff had challenges of poor internet connection due to load shedding and poor infrastructure, but students in rural areas had worse network connections than those in urban areas. Students and staff had to learn how to navigate

the learning management systems (LMSs) on the run, as most of them were unfamiliar with those systems.

Laboratory practical experiments took longer as students were divided into small groups to observe social distancing protocol of COVID-19 pandemic, students worked individually rather than in pairs, and load shedding occasionally caused tests to be postponed. Online assessments compromised the quality of education, and some students cheated as staff could not monitor students online due to a lack of electronic-proctoring tools. At times, students could not submit assignments and tests on time due to poor network connections or load shedding. Despite the challenges and unpleasant experience that students and staff faced during COVID-19 blended teaching and learning, blended learning achieved the learning objectives.

The report makes several recommendations for infrastructure support, including giving out laptops and/or data to students in need, upgrading lecture halls to smart classrooms, offering computer training on learning management systems and continuous support to students and staff, to increase proficiency and preparedness, and lastly designing a blended learning approach suitable for biomedical science.

Key words: Blended learning, COVID-19 pandemic, blended Learning in universities or higher education.

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LIST OF ABBREVIATIONS

BL	Blended learning
COVID-19	Coronavirus Disease 2019
e-Learning	Electronic Learning
HDIs	Historically Disadvantaged Institutions
HEIs	Higher Education Institutions
4IR	4th Industrial Revolution
ICT	Information and Communication Technology
IT	Information Technology
LMSs	Learning Management Systems
MTN	Mobile Telephone Network
MUT	Mangosuthu University of Technology
NSFAS	National Student Financial Aid Scheme
PPE	Personal Protective Equipment
SARS-CoV2	Severe Acute Respiratory Syndrome Coronavirus 2
STEM	Science, Technology, Engineering, and Mathematics
WIFI	Wireless Fidelity
WIL	Work Integrated Learning

GLOSSARY

Term	Definition
Blended learning	A combination of traditional classroom and online learning.
Coding	Highlighting sections of texts or phrases into meaningful units or codes.
Confirmability	Degree to which study results are derived from characteristics of the participants and study context.
Credibility	Quality of being trusted and believed in.
Dependability	Quality of being trustworthy and reliable.
Digital divide	A gap between individuals with access and skills to use technology and those without such access and skills.
Platoon system	Division of one group into smaller groups.
Transferability	Extent to which findings can be applied in other contexts and studies.
Triangulation	Using multiple datasets methods, theories and / or investigators to address a research question.
Trustworthiness	Degree of confidence in data, interpretation and methods used to ensure the quality of study.
Virtual labs	Computerized models simulations and instructional technologies to provide practical skills of science to the learners.
Zero-rated app	Application or website is free when it does not count the usage of internet data or Wi-Fi.

CHAPTER ONE: INTRODUCTION

1.1 Background

Teaching and learning have changed because of the use of technology. Computers and the internet are being used by educational institutions to improve instruction and learning (Inyere, Ibezim and Ikehi, 2021). In contrast to the past, when people had to travel a long way to visit a physical library or receive traditional classroom instruction, the use of information and communication technology (ICT) for teaching and learning has made the transmission of knowledge faster and easier (Inyere et al., 2021).

Prior to COVID-19 there had been sporadic attempts by the South African education sector to increase the amount of online learning, but the pace was slow (Mhlanga and Moloi, 2020; Simamora, De Fretes, Purba and Pasaribu, 2020). In situations akin to crises, such as human-made or natural disasters, or pandemics like COVID-19, the "anytime, anywhere" nature of online learning is advantageous (Dhawan, 2020). However, the education sector was unprepared for diseases like the COVID-19 pandemic (Mhlanga and Moloi, 2020).

Teaching and learning suffered greatly since the virus required social distancing. To abide with social distancing protocols, people had to keep about 1.5 to 2 meters distance apart to limit transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2 virus) that causes coronavirus disease. Less people were permitted on campus at a given time to adhere to the social distancing protocol, which impeded physical learning activities (Mhlanga, 2021).

The education sector survived the COVID-19 pandemic through adopting various 4th industrial revolution (4IR) technological instruments that helped facilitate teaching and learning (Mhlanga, 2021). Both educators and students had to adjust to the changing times and learn how to utilize various educational applications (Sharma, 2022). Marongwe and Garidzirai (2021) reported that the COVID-19 epidemic brought about enduring modifications to the methods of instruction and evaluation. However, poor students' ability to fully benefit from electronic learning (e-learning) was hampered by

several issues, including the digital divide (Mpungose, 2020).

The digital divide is the difference in access to and proficiency with technology between people with and without these attributes (Faloye and Ajayi, 2021). Without warning or negotiation, students were instructed to switch to learning management platforms (LMSs) like Moodle and Zoom for their coursework, and other online resources, including PowerPoint presentations and WhatsApp, were made available for their usage (Mpungose, 2021). During the COVID-19 pandemic lockdown, instructors and students filled the void left by less-than-optimal working conditions, but staff commitment and student resiliency should not have to be relied on for bridging systemic divides (Cook et al., 2021).

Therefore, the purpose of this study was to explore and describe the blended learning experiences of biomedical sciences students and staff during the COVID-19 pandemic lockdown. It also aimed to identify and recommend the resources required in a historical disadvantaged university of technology beyond the COVID-19 pandemic.

1.2 Research Problems

Teaching and learning in universities moved online when everything closed due to the COVID-19 pandemic with people having to stay at home. Universities moved to blended learning (combination of online and face-to-face learning also known as hybrid learning) during partial lockdown. To follow social distancing protocols, a restricted number of staff and students were allowed on campus while others were online. This required rearranging the schedules to make time for all the small groups to attend in-person classes and practical sessions while adhering to COVID-19 protocols.

COVID-19 lockdown restrictions took the country and education sector by surprise, and changes had to be implemented to save the academic year. The challenge was that staff and students were not assessed for digital competence or resource availability before beginning online coursework. Universities were ill-prepared for the emerging advances in online teaching and learning.

The Department of Higher Education and Training neglected to consider semi-functional or rural universities, which were previously disadvantaged due to their lack of resources and inadequate infrastructure, when addressing the issue of remote teaching and learning brought about by COVID-19 (Tanga, Ndhlovu and Tanga, 2020).

Considering the students' access to digital resources, educational institutions could not just go to an online delivery model and hope that all their students would take part (Pather, Booi and Pather, 2020). Students and staff face-to-face classes gradually went back to normal with the control of COVID-19. It is helpful to explore and describe the experiences of biomedical science students and staff with blended learning to develop policies for online teaching and blended learning that can strengthen learning systems and withstand the challenges of COVID-19 lockdown restrictions or any other future pandemics.

The study sought to ascertain the existing resources and skills that biomedical science students and staff at a township university of technology possess, to identify and suggest the resources and skills needed to completely maximize the use of 4IR.

1.3 Research Aim and Objectives

1.3.1 Aim

Regarding blended learning during the COVID-19 pandemic lockdown, this study explored and described the experiences of biomedical sciences students and staff. The objective of this initiative was to determine and recommend the necessary resources and skills for biomedical sciences students and staff at a university of technology located in Umlazi Township, Durban. The aim was to help the university stakeholders to budget, invest, and direct resources appropriately.

1.3.2 Objectives

1. To explore and describe the experiences of biomedical sciences students and staff of blended learning during COVID-19 pandemic at a university of technology in Umlazi Township, Durban, KwaZulu-

Natal.

2. To identify the resources and skills required for blended teaching and learning in a historically disadvantaged university of technology.

1.3.3 Research Questions

1. What was the experience of biomedical sciences students and staff of blended learning regarding infrastructure – device availability, internet access and connectivity, digital literacy, content delivery and LMS, laboratory practical experiments, and assessments at the university of technology?

2. What are the resources and skills required by biomedical science students and staff for blended teaching and learning in a historically disadvantaged university of technology?

1.4 Significance of the study

For biomedical science students to be efficient as scientists in the workplace, they must possess both theoretical knowledge and hands-on experimentation skills. Practical experiments provide students with laboratory skills, and regular experiments enhance those skills. COVID-19 limited movement of students and staff, with blended learning and social distancing resulting in one group attending online while the other group was on campus, which affected regular experiments and skills development. To limit transmission of the virus, countries went on full lockdown, borders were closed, mass gatherings were suspended, and non-essential businesses were closed including schools and universities (World Health Organization, 2020).

The findings of this research may help university stakeholders budget, plan, and direct funds, resources, and skills appropriately. Additionally, findings could help universities better prepare for pandemics like COVID-19 or similar pandemics or disasters, preventing staff and students from physically attending classes. Finally, policymakers may find this study useful in making evidence-based decisions policies on blended

teaching and learning.

1.5 Structural Outline

Chapter 1: The context of the study has been introduced. The research problem, aim, objectives, and questions have been identified, as well as the significance and limitations of the study.

Chapter 2: The existing literature will be reviewed within the context of the research topic, and the necessity of the study will be discussed.

Chapter 3: The theoretical framework will be presented, the qualitative approach, data collection method, and analysis will be justified, including ethical considerations of the chosen approach.

Chapter 4: Findings of data collected from the study will be analyzed and presented to identify patterns or trends.

Chapter 5: Data will be discussed to get a deeper understanding of phenomena and interpreted to draw meaningful conclusions. Study will make recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Improving teaching and learning is an ongoing process. Universities keep seeking better methods to achieve educational goals. For years, teachers have been teaching the same way they were taught, using a traditional classroom approach, which worked well for a very long time (Oleson, and Hora, 2014). That approach was cheap and reusable, it required students to attend classes while teachers used a board with chalk, marker, and a duster (Oleson, and Hora, 2014). Then came transparencies with overhead projectors, followed by Microsoft PowerPoint. As technology evolved, it presented new opportunities for meeting educational goals (Rubeen, Zareen, and Hashmi, 2012). The COVID-19 pandemic reshaped the education brought distance learning with the to use technology when face-to-face classes were prohibited (Kang, 2021).

The modern technology introduced online methods which involve computers or laptops, internet, LMSs like Moodle, Blackboard, and Google Classroom, email, mobile learning, social media platforms, for example, WhatsApp, and platforms like Zoom and Microsoft Teams (Sumadevi, 2023). These tools promote student engagement, personalized learning, and collaborative interactions, ultimately leading to a deeper understanding of the subject matter (Sumadevi, 2023). The COVID-19 pandemic is speeding up the digital transformation of education. Teachers, students, politicians, and other stakeholders are now actively working to alter education, not just in Japan but also globally (Kang, 2021).

This literature review explores relevant themes of blended learning in universities using existing research and connect it to this research study. The following themes were identified: blended learning in universities or higher education during COVID-19 pandemic, ICT infrastructure for blended learning, LMSs and content delivery, laboratory practical experiment in blended learning, and assessment in higher education using blended teaching and learning.

2.2 Brief Background on Blended Learning, Benefits, and Challenges

Blended learning has the unique characteristic of teaching and learning combining in-person and online classes, requiring a partially virtual and partially tangible pedagogy (Glazer, 2023). The COVID-19 pandemic lockdown restrictions fueled the change in teaching and learning from traditional classroom to blended learning; faculties had to choose activities that could be done face-to-face and those that could be done online to create a single, unified course. Blended learning like any other change has benefits and challenges and has been studied by scholars with various recommendations emerging for how to mitigate challenges and maximize the benefits. The current study focused on the challenges, benefits and opportunities facing the biomedical sciences.

2.2.1 Benefits of Blended Learning

Blended learning is a transformation from an instructor-centered to a learner-centered type of education. Blended learning supports independent learning through analysis, innovation, and knowledge enquiry using an interactive and motivational teaching approach (Wahab, Othman and Warris, 2016). The combination of blended technology with face-to-face instructional method can stimulate the development of employability skills for independent learning with continuous improvement and enhancement of critical thinking skills that are essential in today's graduates (Wahab et al., 2016). Biomedical scientists need innovative, analytical, and critical thinking skills in the working environment, therefore blended learning could be beneficial to them.

Fitriani, Herman, and Fatimah (2022) confirm that blended learning is the right choice and solution as it increases independence. Fitriani et al., found that the application of blended learning in mathematics during COVID-19 pandemic greatly helped teachers in delivering material to students with good results. Fitriani et al., indicate that blended learning worked as the teaching and learning solution in mathematics during the COVID-19 pandemic, hence the study aims to find experiences of biomedical science department.

Blended learning is flexible as it overcomes geographical and physical barriers. It gives

students flexibility to study and engage in tasks anywhere at any time and there is no pressure of time because students can learn online for as long as they want to. Students can learn at their own pace and are encouraged to lead their own learning through blended learning. Flexibility can be afforded to time, space, and pace through blended learning designs. Mulyadi, Arifani, Wijayantingsih and Budiastuti (2020) confirm that flexibility to access and engage in academics tasks allows learners to use the material at their own pace and learn creatively from several sources. Students have more control of completing learning activities.

While students enjoy teaching and learning anywhere, anytime, blended learning also gives flexibility to repeat activities which help students with confidence, knowledge and understanding. Irum, Bhatti, Abbasi, and Dilshad (2020) revealed that students gain confidence and become self-dependent when they complete their academic tasks through a blended mode. Warren, Reilly, Herdan and Lin (2021) state that student forums suggest that the ability to work on practice examples and receive instant feedback provides students with a flexible opportunity for multiple mastery experiences, and the interactivity of the platform facilitates the repetition of examples until such a point that the student is confident in a particular area. Repetition when online can allow biomedical science students to understand the medical concepts better at their own pace.

Flexibility encourages enrolment of broader society, therefore increases access to learning. Students who are working may have an opportunity to study knowing that they have access to web resources anytime and anywhere without the need to visit libraries or classrooms. Blended learning increases options for higher education enrolment (Badaru and Adu, 2022). Blended learning enables access to a broad range of reading materials which can help students understand complex concepts of any subject instantly (Irum et al., 2020). Instead of gaining information only from the lecturer in the classroom, students can also access information online which can be from other institutions, researchers, electronic books, or videos.

Blended learning provides the education industry with more affordable and accessible

teaching and learning (Mhlanga, 2021). Blended learning is cost-effective, and it encourages students to conduct more extensive online research (Dahmash, 2020). Muhuro and Kangethe (2021) point out that the possibility of implementing remote learning in rural-based higher education institutions (HEIs) has many potential benefits for institutions to continue delivering quality education and for teachers to continue engaging with students in the COVID-19 era, where the traditional face-to-face method is proving to be impossible. Students can be taught and learn online anywhere, and they can search for more information online which can help them understand better without spending extra money on libraries or campus.

Blended learning helps students improve professional skills. The more students use the computer for online platforms when blending, the better they become. Students can develop the skills necessary for the 4IR while also benefiting from an improved learning environment (Muhuro and Kangethe, 2021). Dangwal (2017) confirms that with blended learning students improve their digital fluency and become more tech-savvy. Additionally, students' writing abilities are enhanced (Muhuro and Kangethe, 2021; Dahmash, 2020). Blended learning helps students acquire professional traits like discipline, self-motivation, and self-responsibility (Dangwal, 2017). The above-mentioned skills can empower biomedical scientists in the competitive world.

On the other hand, as lecturers must conduct lessons online, upload notes and videos in blended learning, their computer skills also improve. Lecturers have been exposed to computers prior to COVID-19 pandemic as they were lecturing using PowerPoint and projectors, however the COVID-19 pandemic lockdown restrictions facilitated the use of LMSs and platforms like Zoom or Microsoft Teams. LMSs like Blackboard and Moodle were available prior to the COVID-19 pandemic, and they were used as additional tools for traditional classrooms, but they became the major teaching and learning tools during the COVID-19 pandemic lockdown restrictions. Blended learning improves lecturers' technological literacy (Mulyadi et al., 2020).

Blended learning gives students and staff more opportunities to communicate. In blended learning, communication is not just limited to lecture hours only, but students

can also communicate with lecturers via WhatsApp, emails, or ask questions via learning platforms anytime, anywhere. PowerPoint presentations are used widely to support presentations, and the Whiteboard in the classroom is a useful interactive communication tool. Virtual communication allows both private and public communication where users engage in lively discussions and activities over the internet (Allan, 2007). Virtual tools could be used to exchange information and ideas, work together on a common theme or issues, and work collaboratively in teams (Allan, 2007). Virtual tools could be LMSs, videoconferencing, e-mails, podcasts, social networks, polling, online questionnaires, videoclips, virtual tours, instant messaging, and phone calls (Allan, 2007).

According to Dahnmash (2020), the university profited from blended learning with the use of online assessments, synchronous virtual classrooms, and learning resources available on learning platforms. In blended learning, students can write tests, exams, tutorials, or assignments either in class or virtually. Assessments can be submitted on campus or online via email or uploaded on the learning platform. The staff can give students hard copies for contact classes or soft copies online and send feedback online and vice versa. Blended learning presents more opportunities for assessments and marking, without limitations of space and time.

2.2.2 Blended learning challenges

However, the emergent switch had several challenges which could have been mitigated with proper planning, resources, skills, and policies. The sudden transition from in-person to online delivery owing to the COVID-19 pandemic differed from a planned online learning experience; even experienced online staff had to adopt novel teaching strategies to cope with the issues presented by mass-scale (Johnson, Veletsianos and Seaman, 2020). Muhuro and Kangethe (2021) state that there is currently little access to resources, ineffective blended learning, motivation, and instruction in rural universities. There are several challenges facing blended learning in South Africa, such as the country's high levels of inequality, the widening digital gap, lack of resources, and skills scarcity (Mhlanga, 2021).

Online classes limit interaction and the ability of instructors to read students' faces. Off-line classes are preferred over online classes since student-teacher-peer interactions are better (Sharma, Sood, Darius, Gundabattini, Darius Gnanaraj and Joseph Jeyapaul, 2022). When teaching in classrooms, it is easy for instructors to see when students do not understand through their facial expressions, but online classes have limitations in this regard. Online classes are preferred when off-line classes cannot be conducted, especially during situations like the pandemic, because this helps students stay safe by following safety protocols (Sharma et al., 2022).

Universities experienced challenges on academic assessments. The challenges were inadequacy, academic integrity, learning environment, and family burden (Bdair, 2021). Blended learning played a huge role in academic teaching and learning during COVID-19 pandemic lockdown; however, challenges need to be attended to ensure sustainability and that the quality of education is not compromised. Information on how biomedical sciences students and staff survived the unplanned difficult times of the pandemic will help universities invest in what they need for smooth, planned, and sustainable blended teaching and learning.

2.3 ICT Infrastructure Access and Availability

The infrastructure for teaching and learning online consists of all hardware, networks, and storage systems (Sharma, 2022). Availability of adequate network infrastructure which includes high speed (bandwidth) of internet, adequate service and support, reliable and affordable internet connection, hardware, and software are essential in a blended learning environment (Olayiwola and Alimi, 2015). Olayiwola, and Alimi (2015) concluded that successful implementation of blended learning by an education system needs to fulfil certain criteria, one of which is the acquisition of adequate technological structure. The education system must invest in ICT infrastructure to fully maximize the use of technology in the 4IR. Infrastructure problems, resource constraints, and curriculum deficiencies have negative effects on the blended learning model and pedagogy (Muhuro and Kangethe, 2021).

2.3.1 Digital resources

Unlike the old traditional method which required students to come to class with pen and paper, blended learning requires gadgets. Blended learning requires a device to access online learning such as a tablet, smartphone, laptop, or desktop computer (Sharma, 2022). Mobile phones and laptops are the most utilized gadgets among university students in South Africa, while many of them do not use desktop computers (Pete and Soko, 2020). Blended learning and COVID-19 have increased demand for computers, and in some families' laptops and desktops must be shared by multiple family members (Pete and Soko, 2020). The use of smartphones in higher education come with interruptions like social media, emails, and instant messaging that easily steal the students' attention from what is happening during class (Pattermann, Pammer, Schlögl, and Gstrein, 2022).

Students who did not have laptops or desktops used mobile phones (smartphones) for online classes. Participants who used their mobile device highlighted the desire of students to be able to maintain access to their academic work and materials while travelling, commuting, and working (Milheim, Fraenza and Palermo-Kielb, 2021). One may contend that not all mobile devices are equipped with the bare minimum capacity needed to carry and access online education systems (Majola and Mudau, 2022). Students have said in previous studies that mobile devices are not ideal, but many of them did not have access to another tool (Milheim et al., 2021). Websites, documents, and additional resources must also be designed in a mobile-friendly way to increase the accessibility and user experience of self-initiated mobile device learners (Milheim et al, 2021).

As the capabilities of smartphones are increasing, mobile technology-supported educational opportunities are evolving (Nikolopoulou, 2022). Educators need to be aware of students' mobile phone practices when they design pedagogical interventions in mobile environments; it is important to plan and organize appropriate activities and create good quality digital resources (Nikolopoulou, 2022). Student mobile phone-mediated educational practices can be encouraged in blended learning education, in

universities with limited infrastructure, or with socially disadvantaged students as mobile phones are usually cheaper than PCs or laptops (Nikolopoulou, 2022). Blended learning and COVID-19 restrictions presented a need for device ownership for studying, that is, smartphone, tablets, laptops or desktop. The current study will explore the experience of device ownership for biomedical science students and staff during COVID-19 era blended learning.

Universities have computer laboratories that students can use to source information from the internet and type their assignments on campus. This system bridges the gap for students, providing and protecting students who cannot afford to buy laptops. Pather et al. (2020) agree that prior to the COVID-19 pandemic, universities expanded the availability of on-campus learning resources, and students could utilize resources inside the campus environment to achieve effective academic outcomes. This system worked well for years and students had access to computers on campus, but it could not work for the COVID-19 pandemic since students and staff had to work from home, and when movement was possible, the number of individuals on campus at a given time was limited.

Digital equality is still a barrier to blended learning, as evidenced by the fact that students in urban and rural locations vary in capacity to access computers and the internet (Pete and Soko, 2020). Lembani, Gunter, Breines and Dalu (2020) found that students in non-urban areas frequently made use of ICT resources in universities and places of employment. There is inequality in device ownership among students in universities, with students from rural areas not being able to access ICT resources during the COVID-19 pandemic lockdowns compared to students in urban areas. The universities and government need to work together to bridge geographic ICT resource inequality.

All university stakeholders were aware of device inequality when online classes started during the COVID-19 pandemic, but academic classes needed to continue despite this. While many countries suffered from disruptions in education, countries like India were more vulnerable because of the digital divide which is still one of the greatest threats

to the implementation of successful online/blended modes of education (Bordoloi, Das, and Das, 2021). Universities were forced to acknowledge the existence of the South African digital divide when a national lockdown was imposed, and universities closed their physical campuses while still teaching and learning via digital platforms. The reality was that digital agency was significantly reduced outside of the campus physical environment (Pather et al., 2020).

The pandemic provided the government with an opportunity to confront the inequalities and outdated nature of South Africa's educational system, which has long harmed rural residents (Mhlanga, 2021). The National Student Financial Aid Scheme (NSFAS) is working towards bridging the digital divide gap by supplying laptop devices for beneficiaries (Motala and Menon 2020). Although the global pandemic caused immense suffering for people, it also offered a chance to evaluate the costs, benefits, and drawbacks of implemented systems as well as the possibility of scaling them up to increase access (Mhlanga and Moloi, 2020).

All citizens should have equitable access to the nation's educational resources and opportunities. Maintaining equity in the delivery of curricula is vital. For this reason, all electronic learning programmes ought to be accessible to all students (Mahaye, 2020). If HEIs focus on the optimization of ICT infrastructure and software and promote ICT knowledge and sustainable values among users, institutions can successfully implement blended education (Suleri and Zwaal, 2022). The current study aims to identifiy resources that biomedical science needs for blended learning in a historically disadvantaged university of technology.

2.4 Electricity

Electricity is vital in blended learning infrastructure to charge the device and for the internet connections to work. There is unequal distribution in rural areas with some rural areas having poor or no infrastructure. The distribution system of electricity in Pakistan is not fair; thus, students who reside in rural areas suffer more compared to urban areas (Kakepoto and Jalbani, 2021). The same applies in South Africa, where the post-apartheid state has not developed ICT infrastructure and delivered electricity

fairly. The hardship faced by many students could have been avoided as it was in nations that had invested in power supply and ICT infrastructure (Hlatshwayo, 2022).

On top of unequal distribution of electricity, South Africa is negatively affected by loadshedding. Loadshedding is the interruption of electricity supply to avoid excessive load on the generating plant. The load shedding of electricity is a barrier to online learning in this fast-growing age of information technology. Loadshedding differs from one place to another, which means that students and staff have electricity at different times because different areas have different loadshedding timetables. Loadshedding affects internet connections and charging of devices. Because of the long hours of online classes students need to be able to charge mobile phones and laptop batteries frequently (Kakepoto and Jalbani, 2021).

Loadshedding affected online assessments because students could not submit on time. Thus, loadshedding had a negative impact on student performance, grades, competencies, self-study, and ability to complete assignments or tests on time (Malik, Memon, Ali, Mallah, Bux and Hag, 2022). Findings of this study will provide evidence-based data for government and universities to direct infrastructural resources appropriately.

2.4.1 Internet Access and Affordability

To access and utilize digital educational resources online, one must have an internet connection. Most universities offer free internet access to staff and students on campus. Campuses are the locations where students and staff use the internet the most; hence, it was worrying that during the COVID-19 pandemic lockdown, access to campus amenities was prohibited (Lembani et al., 2020). Students had challenges with internet access outside campus. One of the primary obstacles impeding nations' progress is the internet (Paschal and Mkulu, 2020). Experiences of internet access information from students and staff on how they survived during COVID-19 blended teaching learning from home which can help focus on solutions.

Bandwidth also affects internet connection when using learning platforms. Bandwidth

is the maximum amount of data transmitted over an internet connection in a certain amount of time. Poor bandwidth quality is another issue that many rural communities in Uganda deal with, which makes utilizing the internet more difficult (Olum, Atulinda, Kigozi, Nassozi, Mulekwa, Bongomin and Kiguli, 2020). To enable rural universities to address some of the issues, it is critical that Southern African governments allocate a larger portion of their budgets for internet for educational institutions (Muhuro and Kangethe, 2021). Providing good data bandwidth must be budgeted for by the government, as service providers need to be paid (Muhuro and Kangethe, 2021).

The speed of the internet is an important factor for blended learning. Video-based systems like Zoom, which depend on a robust internet connection, were significantly impacted by the internet connectivity issues during COVID-19 (Kakepoto and Jalbani, 2021). Slow internet can be a barrier to online learning, and it can cause psychological distress for students taking exams or lectures online. Students are required to turn in their response scripts within the allotted time frame, and they are unable to upload their exam scripts on time if their internet connection is slow (Kakepoto and Jalbani, 2021). Students and staff need good internet connection to attend online classes and submit tasks.

Another important factor for blended learning is internet affordability as students cannot afford expensive packages. Mhlanga and Moloi (2020) indicated that during the COVID-19 pandemic, universities and the South African government partnered with private network providers to deliver zero-rated applications and instructional websites. Zero-rated is when the network operator does not track data usage, meaning that using it is essentially free. These applications and websites were supplied by several network carriers, including MTN, Cell C, and Vodacom. Students from different South African universities used these applications and websites on a regular basis (Mhlanga and Moloi, 2020).

Not all learning platforms were zero-rated. Consequently, during the COVID-19 pandemic shutdown, universities supplied a monthly package of 30 Gigabytes (GB) of data to students (Motala and Menon, 2020). This comprised10 G anytime data and 20

G nighttime data. Mpungose (2020) identified several obstacles that could prevent students from fully utilizing e-learning; in the context of COVID-19, proposing that alternative pathways such as free data bandwidth, free physical and online resources, and the use of an information center for blended learning can address these obstacles. All departments need to be well informed and well prepared for the 4IR changes.

According to Mhlanga (2021), Muhuro and Kangethe (2021), and Paschal and Mkulu (2020), most students and instructors feel that online learning is ineffective and is disliked by them due to lack of resources, lack of electricity, lack of facilities, poor network, shortage of skills, and a lack of policies that encourage the use of online learning in African universities.

Dhawan (2020) contends that educational establishments must try to ensure that all personnel and pupils have access to the resources they want. This is because many students could miss out on educational possibilities if they do not have access to Wi-Fi, internet connectivity, or the required digital tools. This digital divide causes inequality disparities to widen (Dhawan, 2020).

Medina (2018) indicates that though network opportunities are still limited in many regions, teachers and students must learn to integrate these in increasingly blended classrooms which reflect an increasingly blended world. It is recommended that African universities and HEIs invest in technology infrastructure to strengthen internet capabilities and initiate policy implementation regarding the introduction of online education in African universities (Muftahu, 2020).

The last thing that any country needs is to widen the gap between the haves and the have nots. Research studies are important as they provide data that all departments can work with to invest and distribute resources appropriately.

2.5 Digital Literacy

Students and staff must have adequate digital skills in the era of blended learning. For lecturers to be able to teach online and attach notes and videos online, they must have digital skills. The required computer skills, particularly in content delivery on e-learning

platforms, should be taught to lecturers (Inyere et al., 2021).

These skills include the ability to start interactive e-learning lessons, set up webinars (video/audio conferences, chat-based), start or stop virtual classroom sessions, control, and end class sessions, attach, and modify printable documents like electronic books (e-books), journals, technical glossaries, templates, learning manuals, and start user comment threads (Inyere et al., 2021). The same applies to students who need digital skills and should have lessons on how to download and upload scripts online and how to navigate online content and classrooms.

Studies indicate that many first-year students lack computer skills when they enroll in the university. Some students encounter computers for the first time when they enroll in universities. As a result, these students have limited or no prior computer experience and only acquire these skills while attending the university (Oyedemi and Mogano, 2018).

Zimu (2020) conducted an information literacy study on first year MUT students and found that 71.8% of first-year students had never used a computer, 40.6% of the students had never used a library, and 91.2% of the students had never received any kind of library orientation or instruction before starting classes at MUT. To prevent throwing students in the deep end when teaching using blended learning, training students during orientation can help.

The inequality in digital skills must be considered and addressed when blended learning continues beyond the strict COVID-19 restrictions. A "one-size-fits-all" strategy for using ICT to support teaching and learning is bound to have limits in a developing country like South Africa, considering the realities of the digital divide (Lembani et al., 2020). Students had a negative response to online learning. They were unprepared for the transition to remote teaching and learning because they lacked training and experience (Agormedah, Henaku, Ayite and Ansah, 2020). Hence the study was done to identify and attend any digital challenges that affected blended teaching and learning during COVID-19 which could results negatively to academic success.

The university needs to be patient and compassionate with those students who might be experiencing digital constraints. Students must build their digital competencies to use various learning platforms and be aware of their opportunities for material delivery, learner engagement, and student interaction (Kovačević, Anđelković Labrović, Petrović and Kužet, 2021). Students who possess digital literacy will be more inclined and will find it easier to utilize mixed teaching and learning (Kovačević et al., 2021). Students and staff with good digital skills will find it easier to navigate the learning platforms, while those with limited skills will find it difficult. Gaps need to be identified through research and be attended to so that all stakeholders can move smoothly together with a positive attitude towards blended learning.

Computer-literate students and staff will be faster and produce better results if they know what they are doing. Since lecturers are the first to hear from students when they have issues, it is crucial that they acquire training in technology tools and online LMSs (Majola and Mudau, 2022). Trained teachers will be able to assist students who have technical difficulties (Harris, 2017). Dahmash (2020) proposes that training workshops by people with expertise in blended learning approaches and strategies could address the issues related to instructors' performance. Training workshops whenever there are changes in the system are necessary to boost users' confidence and make learning platforms easy to use. Students and staff can utilize the maximum capacity of what platforms can offer if they are well-trained.

Findings of Castro-Rodríguez, Marín-Suelves, López-Gómez and Rodríguez-Rodríguez (2021) indicate that there is potential for improving online platforms and resources to allow for much more personalized learning, but better training in digital skills is necessary. Administrators would do well to promote digital competence in all members of the education community (Castro-Rodríguez et al., 2021). Teachers and students must possess expert knowledge of navigating technology platforms used for implementing blended learning for effective online teaching (Angwaomaodoko, 2023). COVID-19 pandemic facilitated the use of technology due to lockdown and social distancing; this is a great opportunity for universities to maximize the use of technology.

In addition to training, ICT support structures are important in blended learning. These will assist students and staff with any challenges that may arise when using the platforms even after training. An ICT support unit should be established to assist educators and students in acclimatizing to the new online learning environment (Sobaih, Salem, Hasanein and Elnasr, 2021). Teachers will embrace the change more readily if they are trained and given necessary support (Harris, 2017). Continuous support from ICT expertise is important to assist students and staff with digital challenges when blending, it may increase acceptance of digital changes in higher education.

Sustainability of blended learning requires all stakeholders to be on board, accept changes, and commit themselves to driving excellent teaching and learning. Technology requires a high degree of commitment, management, and leadership in addition to social development upgrades to maintain teaching and learning beyond the pandemic (Okoye and Pillay, 2022). The study findings may enable all relevant parties to invest and allocate funds and resources appropriately, promoting high-quality and long-lasting blended teaching and learning for biochemical science students and staff in a historically disadvantaged universities of technology.

2.6 Content Delivery and Learning Management Systems

When teaching and learning changed from traditional classroom to blended learning, delivery of content changed as well. Learning management platforms for online classes are different from the usual traditional classroom. Instead of a lecturer standing in a classroom on campus, lecturers taught online via computers while based at their homes. COVID-19 had a significant impact on the use of various 4IR tools in the education sector as universities stepped into online learning using digital satellite television, YouTube, Microsoft Teams, Zoom, Skype, and WhatsApp (Mhlanga and Moloi, 2020).

Most universities had learning platforms of choice prior to COVID-19, but the teaching and learning was mostly traditional classroom at that time because students and staff hardly used online learning platforms. Google Classroom, Moodle, and Blackboard are

platforms where lecturers can upload notes, videos, and tasks; institutions decided which platforms best suited their teaching and learning style (Sumadevi, 2023). The most effective teaching method depends on what provides the optimum balance between the interaction and integration of technology-based models in education (Megahed and Hassan, 2022).

Lecturers should be taught how to integrate their curriculums and learning platforms for effective content delivery. The online learning process is made more organized by text, video, and graphic materials (Boychuk, Novikova, Opanasenko, Olena and Kostina, 2022). The popular learning platforms are discussed below.

Present generation students are digital natives so blended learning approaches can be pivotal as these will improve the quality of teaching and learning (Lakshmi and Lakshmi, 2020). Google Classroom is an application that connects Gmail, Google Drive, and Google Docs. Lakshmi and Lakshmi (2020) identified how technological tools like Google Docs, Sheets, Slide, Forms, Meet, Hangouts are integrated in blended learning in higher education. Google Classroom could be used for uploading notes, tasks and scripts can be uploaded onto the platform (Okmawati, 2020).

Both teachers and students benefit from the Google Classroom platform. Teachers can create assignments and load them into Google Classroom (Okmawati, 2020). Teachers can administer exams, monitor, systematize, evaluate, review exercise outcomes, apply various forms of assessment, provide comments, and have effective real-time communication with students via chat rooms (Boychuk et al., 2022). Students have unrestricted access to the content, regardless of time or location (Okmawati, 2020). Students can watch videos and gain knowledge from a notification page that contains announcements and teachers' discussions (Okmawati, 2020).

Blackboard LMS provides students with a straightforward learning experience; it ensures that teaching and learning are effective whenever and wherever they occur (Dahmash, 2020). Synchronous classes (the instructor and the students in the course engage with the course content and each other at the same time, but from different locations) can be recorded and uploaded to Blackboard. Asynchronous classes offer

learners the flexibility to study in a self-paced manner and give students who are having trouble connecting to the internet the opportunity to watch and assess lectures at their own pace (Dahmash, 2020).

Some people found Blackboard user-friendly while others had difficulties. Blackboard is a user-friendly LMS with a fully responsive design that is modern and intuitive (Xin, Shibghatullah and Abd Wahab, 2021). However, Nassar and Rajeh (2022) found that even with an abundance of training offered by the university, participants in their study still needed to look for tutorials and videos to help them become more familiar with the Blackboard system. Blackboard has limited space. The Blackboard system does not allow the uploading of anything larger than 600 MB, such as PowerPoint presentations, videos, and audio files. Consequently, this leads to dissemination of media that has low resolution and poor quality (Nassar and Rajeh, 2022).

Moodle was also used by some institutions for distributing teaching materials, tasks, and communication. Esnaola-Arribillaga and Bezanilla (2020) state that the use of Moodle among lecturers at the University of Deusto was extensive but was more of a teaching tool than a learning tool. Moodle was used to facilitate the distribution of teaching material, hand in papers and make any relevant announcements that helped the smooth running of the course (Esnaola-Arribillaga and Bezanilla, 2020).

Moodle is useful for creating and marking assessments. Moodle saves time and lets instructors utilize their imagination to make course-specific resources for students because of its randomly generated exams, multiple-choice questions, automated marking systems, and automatic summative and formative feedback (Gamage, Ayres and Behrend, 2022). Test papers can be generated automatically which gives lecturers time to attend toother things such as research or supervision of postgraduates (Gamage, Ayres and Behrend, 2022).

According to Ghazal, Aldowah and Umar (2018), there is a highly positive relationship between system quality of the LMS and student satisfaction. The authors state that the user interface is a space where a high level of interaction happens; a user-friendly, well-designed interface becomes one of the most crucial factors in identifying the

students' satisfaction when using the LMS (Ghazal et al., 2018). It is important that the university chooses a learning management system that is appropriate for the programmes they offer. Students prefer user-friendly and interactive designs.

The literature indicates that all the LMSs mentioned above, that is, Google Classroom, Blackboard, and Moodle, are useful for teaching but lack a learning mode. Microsoft Teams and Zoom were used for teaching and learning along with LMSs during COVID-19 pandemic where contact classes were not possible.

Students and staff used Microsoft Teams to attend online classes. Microsoft Teams is a collaboration application tool built for hybrid work so that the team stays informed, organized, and connected online. It is a useful tool for the delivery of content and helps students gain an appropriate learning experience online because it is like a classroom setting. The lecturers and students started using Microsoft Teams during the COVID-19 pandemic and learnt the navigation of the application during classes. Sobaih et al. (2021) confirmed that students that used Microsoft Teams contended, however, that they did not have enough support or training in Microsoft Teams.

The perception among students was that Microsoft Teams was an inadequate means of obtaining assistance from teachers and fellow classmates (Sobaih et al., 2021). Students argued that they did not have good support and participation in activities using Microsoft Teams. This meant that they did not find Microsoft Teams to be a sufficient tool to receive proper support and to participate in course activities (Sobaih et al., 2021).

Some students suggested improvement on interaction using technology learning tools such as Pad-lets to share ideas, class videos, calling each other or lecturer, and enables everyone ideas to be considered thus improving the learning experience (Nasir, Hussain, Mohamed, Mokhtar, and Karim, 2021). This demonstrates that there is no one ideal platform to create a distinctive learning experience (Sobaih et al., 2021). Although LMSs have a place in the solution, it is crucial to keep in mind that students still need to build capacity to use LMSs and other recently implemented online learning tools, as not all of them are equally skilled (Mpungose, 2020). Training is important for

students and staff to explore the full capacity of applications.

Teachers also used Zoom for teaching online, where contact classes were not possible. Zoom is a service for online meetings and video conferencing that may be used for both individual and group lessons (Mpungose, 2021). The programme is available for use on tablets and smartphones as well as on computers (Boychuk et al., 2022).

According to Rianto (2020), most students also had a positive view of the face-to-face activities in their blended courses, indicating their agreement with certain advantages of this learning mode. In addition to improving communication, subject understanding, and learning interactions, face-to-face activities help students retain subject information better (Rianto, 2020). Both teachers and students perceive there was a lack of personal contact and fundamental human communication during online learning in the pandemic era (Kacetl and Semradova, 2020).

Social networks like WhatsApp are used along with learning platforms to communicate with students. WhatsApp acted as a conduit to enhance academic performance, which may have lessened some of the digital gaps in higher education that were previously present (Madge, Breines, Dalu, Gunter, Mittelmeier, Prinsloo and Raghuram, 2019). Students could now transfer and translate information in ways that were previously unattainable, thanks to WhatsApp (Madge et al. 2019).

Social networks play a huge role in communication as part of teaching and learning. A study by Simbolon (2021) found that students experienced some benefits from blended learning using social media like WhatsApp and from the feedback on the work they received from the lecturer. It also reported that there was an improvement in students' vocabulary, suggesting the potential of social media to play the role of a main tool in blended learning. WhatsApp seems to have the potential to be used to practice language skills online (Simbolon, 2021).

One platform cannot completely replace traditional classroom teaching and learning; hence, lecturers mixed platforms to achieve learning outcomes. Mpungose (2020) advises against using the Moodle LMS as the only repository to provide interactive

lectures (both synchronous and asynchronous). The author recommends customizing it to link with social media sites (Facebook/WhatsApp), lecture-recording software (Cam-Studio), video and audio conferencing (Zoom, YouTube Live, Skype, Microsoft Teams), and other learning resources (Mpungose, 2020).

Within this rapidly changing technological landscape, contemporary educational technology can serve as helpful tools for instruction and learning and can be integrated into a comprehensive system for lifelong learning (Faloye and Jayi, 2021). It is critical to remember the lessons from the past and strike a balance between embracing contemporary teaching and learning methodologies and upholding ageless educational principles (Faloye and Jayi, 2021). For blended mobile learning, instructors should pay particular attention to instructional design, which includes objective identification, learner analysis, learning material design and development, and instructional evaluation (Sophonhiranrak, 2021).

Sophonhiranrak (2021), indicate that mobile learning does not only involve using mobile devices for transmitting information to learners, but instructors should also consider learners' learning styles, attitudes, or readiness for acceptance of mobile learning. Hence, analyzing the content, tools, objectives, and learners should be central for identifying how to deliver content, arrange activities, and conduct assessment (Sophonhiranrak, 2021). The scope and kind of content should determine appropriate types of media for transferring information to learners, as well as the length of each module or lesson (Sophonhiranrak, 2021).

Even though courses were successfully translated for LMS online teaching and learning, this did not mean that students were making equitable use of the platform or that the presence of data or a device suggested that learning was taking place (Motala and Menon, 2020). Teachers should have the ability to track in detail student activity in a blended learning course (number of visits to each resource, number of activity completions, number of participations in communication activities, etc.). Monitoring will ensure that students use LMSs regularly which will also help assess the teaching and learning (Gaftandzhieva, Doneva and Bliznakov, 2024). Studies will describe the real

experience that students and staff had with online teaching and learning during COVID-19.

According to Mahaye (2020), now is a good time for significant curriculum development and redesign. Blended learning pedagogy is being phased in as a means of transitioning from the traditional classroom, which follows orthodox methods, to the digital classroom, which uses digital technology, which will benefit future generations (Mahaye, 2020). To gain the benefit of both worlds, researchers, universities, and policy makers must investigate and identify a structure suitable for educational purposes.

COVID-19 facilitated the use of learning platforms and for digital natives it is easy to adapt to technological changes. It is time for higher education to take advantage of 4IR and enjoy the benefits of technology redesign. The education sector can develop curricula that include and use up-to-date technology.

2.7 Laboratory Practical Experiments

Laboratory exercises are a vital part of science learning and allow students to develop practical skills, connect content to real-world applications, and serve as the foundation for further knowledge beyond the classroom (Lahr, 2023). Blended laboratories are a method that incorporates technology and science content to create an experience for learners to engage with information and immerse themselves in the content (Lahr, 2023). Laboratory practical experiments are possible when using traditional classroom methods and blended learning methods, but it was impossible during the high levels of the COVID-19 pandemic when lectures were only online.

Online learning prohibited contact classes, which affected laboratory practical experiments; however, blended learning gave students opportunities to be on campus and covered most of the laboratory practical experiments. For science and engineering students' practical experiments are a major part of the curriculum. Elhaty, Elhadary, Elgamil and Kilic (2020) revealed that most teachers and students were afraid of missing the practical skills during the COVID-19 crisis as these abilities could not be

made up by e-learning methodologies; when students could not come on campus, practical courses were recorded.

YouTube videos and recordings were quite helpful in filling in the gaps that occurred during the lockdown. Innovative methods can aid in closing the gap, such as online simulations or recorded practical experiments (Motala and Menon, 2020). During laboratory practical training, students were able to understand procedures using video-based demonstrations (Khan, Patra, Vaney, Mehndiratta, and Chauhan, 2021). Videos played a huge role in helping students understand concepts when laboratory experiments could not be done in person.

Virtual laboratory simulation enables students to conduct practical experiments on the computer that simulate the real science laboratory, anytime and anywhere. Virtual laboratories are used to enable both teachers and students to achieve practical educational goals, teaching different scientific principles and techniques, and clarifying the experiment steps. Virtual laboratories, which use instructional technology and computerized model simulations to teach students practical science skills, were a useful method for supporting regular lab-based scientific education considering the COVID-19 lockdowns (Ray and Srivastava, 2020).

Virtual labs can be used in many faculties such as education, science, medicine, and engineering. Virtual laboratories help both lecturers and students to collect, analyze and interpret data that is generated from virtual experiments. Virtual labs can better prepare students and researchers for genuine training or research in the laboratory, in addition to acting as a precondition for lab-based courses that require expensive, sophisticated analytical instruments or harmful materials (Ray and Srivastava, 2020).

Blended learning accommodates students who need practical experiments in their curriculum. Higher courses in which laboratory activities are relevant to the training of students demonstrate the need to use the physical spaces of universities, considering that the exchange of experiences in activities of this type reflects the need for socialization and interaction between students, in real time, for the knowledge building (Carius, 2020). In this sense, hybrid education aims to present a balance between

activities that can be developed remotely or in-person (Carius, 2020).

In contrast, Almahasees, Husienat and Husienat (2022) concluded that blended learning can help deliver theoretical courses but is incompatible with practical courses that need to be delivered face-to-face. Biomedical science is a laboratory-based course and laboratory skills improve with in-person practical experiments. Online may not be compatible but blended learning allows practical experiments to be conducted during contact classes.

Students can do practical assessments and submit them online. Lecturers can mark online, or automated marking and feedback can be done online which reduces the workload on staff. Recent technological improvements have led to increased popularity of virtual labs as an essential part of hands-on training and assessment tools in science and engineering. Medical students consider online laboratory training to be feasible and entertaining when it features interactive activities and gamified assessment (Khan et al., 2021).

Walsh, Parry, and Larsen (2010) found in their study that the integration of laboratory data with published material was evident in all students' work and led students to take a deeper approach to learning and critical thinking. From a cohort of 43 students, there were no cases of plagiarism. If adding technology helped other fields with assessments and integration of laboratory data, this could help biomedical science students and staff as well.

The two main costs of virtual laboratories are purchasing applications and high-specification computer devices. Students can repeat experiments, learn from one another, and interact with virtual tools and objects without having to pay more for actual equipment. There are affordable online laboratory simulation activities available (Khan et al., 2021). Universities can try to demo virtual laboratories before purchasing the virtual laboratory that is suitable for each faculty or department.

Virtual laboratories can reduce the cost of conducting practical experiments while ensuring the safety of students. Lynch and Ghergulescu (2017) state that virtual

laboratories have been proposed to reduce expenses and simplify the maintenance of lab facilities while offering students a safe environment in which to obtain experience and spark an interest in STEM (science, technology, engineering, and math) fields. This approach avoids hazardous or corrosive chemicals, and experiments are replicable, so the risk for participants is reduced (Lynch and Ghergulescu, 2017).

Virtual reality training offers many advantages over traditional lectures because it can provide an immersive learning environment and can be repeated; furthermore, it can overcome time and place barriers (Han, Kim, Kong, and Cho, 2021). However, there is little evidence that virtual reality technology can completely replace current medical education curricula, which depends on real patients to supplement medical knowledge (Han et al., 2021).

Kaup, Jain, Shivalli, Pandey, and Kaup (2020) confirm that most virtual learning hands-on training cannot be imparted by online teaching alone. This can be partially handled by using online apps for simulation-based training, but still, for ophthalmology, the approach alone is not suitable (Kaup et al., 2020). Virtual laboratories may have benefits and could be the solution should the world face pandemics like COVID-19 in the future. However, Kaup et al., states that manual experiments are necessary in the science field; ophthalmology faces challenges, which could be the same for biomedical sciences.

As much as the virtual laboratories ensure the safety of students from dangers like hazardous or corrosive chemicals, they hinder students from learning and understanding health and safety in the laboratory. Hands-on laboratories teach students laboratory skills and handling of equipment and chemicals. Virtual labs have been criticized for not offering students health and safety education and for lacking multisensory, or smell, sound, and a real-life feel (Lynch and Ghergulescu, 2017). Students need to have good laboratory skills and techniques when they graduate in biomedical sciences.

The educational approach toward the blended learning environment requires the learners to be actively involved, hence science educators in a blended learning

environment should accommodate instructional strategy and materials and assess student's science practical skills (Hinampas, Murillo, Tan and Layosa, 2018). In accordance with the students' scientific practical skills development, various teaching methods should be adopted. Course content should be determined with the aim of improving practical skills of the science students (Hinampas et al., 2018). The in-person laboratory practical experiments can be mixed with simulation test and You-Tube videos to assist students with practical skills using different sources.

Gregory and Di Trapani's (2012) study on the Biotechniques Pre-laboratory Online Resource Centre showed that the capacity of second-year students to prepare for laboratory classes was improved. The combination of visual components (video demonstrations, photographic illustration, and animations supported with written textual references), theoretical background information, data analysis methodology and online pre-laboratory quizzes provide instantaneous feedback complement previous literary; the positive findings match those from other discipline areas (Gregory and Di Trapani, 2012). Using online simulations prior to contact laboratory practical can prepares students with knowledge and understanding of the hands-on experiment.

To incorporate the digital survival skills learnt in COVID-19 pandemic in education, research studies can design balanced blended learning using known traditional methods and evolving online learning methods. Understanding all sources that helps science students and lecturers in blended learning could have biomedical science benefit from the best of both worlds (traditional classroom and online).

2.8 Assessments

Assessment is the systemic process of measuring knowledge, skills, dispositions, or beliefs gleaned through instructional sequences, with the aim to improve all aspects of student learning (Koç, Liu and Wachira, 2015). The two main assessments are formative and summative. Assessing students' knowledge and career preparedness using both formative and summative evaluations tracks students' progress towards meeting learning objectives as they become ready for life in the real world. Summative assessment happens at the end of a learning sequence in the form of a project or a

test. It evaluates student learning, knowledge, proficiency, or success at the conclusion of an instructional period, like a unit, course, or programme (Koç et al., 2015).

Students can work simultaneously with technological tools, collaborating and editing in real time (Koç et al., 2015). Blackboard, Adobe Connect or Google Drive are some of the collaboration tools available. The instructor can place students in groups, send each group a handout in the form of project rubric, set a timer for students to meet online or personally to work with the project and students can present their work in class. LMSs like Blackboard, Moodle and Canvas have interactive rubric features. Rubrics are essential for embedded features assessments since they provide specific criteria when given prior to or with activity or assignments (Koç et al., 2015). Technology has advanced and students can work on projects anytime and anywhere.

Montenegro-Rueda, Luque-de la Rosa, Sarasola Sánchez-Serrano, and Fernández-Cerero (2021) state that there are several ways to assess students, such as having them turn in assignments online, send emails, use online tutorials, or create surveys using tools like Google Forms (Montenegro-Rueda et al., 2021). Lecturers can also use learning platforms like Moodle and Blackboard for assessment to create online quizzes or tutorials, but the disadvantage is that those platforms do not have cameras for supervision. One of Blackboard's drawbacks is that it cannot actively supervise and monitor students because there is no camera option which can lead to cheating on tests (Nassar and Rajeh, 2022).

Cheating compromises the quality of education as students may not study yet pass the test with distinction and leave the university with little or no knowledge. Maintaining quality is vital since the work done in universities is reflected in the competency of the graduates that are produced. Lecturers cannot rush into blended learning assessments just because the tool is available when the quality of education is compromised. Appropriate monitoring tools must be in place for lecturers to assess students online. Organizations need to use invigilator apps, or remote proctoring software, to supervise and ensure the integrity of the online test (Majola and Mudau, 2022).

Online assessments necessitate the implementation of an electronic-proctoring system, which is a remote monitoring system (Montenegro-Rueda et al., 2021). Video conferencing enables remote supervision during tutorials, oral exams, online exams offered via Zoom or Skype, and as a proctoring tool during exam time (Montenegro-Rueda et al., 2021). Both students and staff must download the proctoring application tool that their university uses for remote monitoring prior to assessments.

The proctoring tool requires screening of students prior to test or examination to identify students. This ensures that the registered students are examined, which eliminates other people writing on behalf of the students. The institution must make sure that each student successfully completes a screening procedure before taking the test, because biometrics are necessary for identifying people (Majola and Mudau, 2022). The integrity of the online test must be maintained and demonstrated through real-time invigilation. It is imperative that students are made aware of the academic integrity policy and that they sign it.

The COVID-19 pandemic presented a significant challenge to assessments in universities. On campus assessments are well structured and monitored but online assessments lack monitoring. This led to universities adjusting their policies to prioritize ongoing formative evaluation (Motala and Menon, 2020). Johnson et al. (2020) assert that educational institutions must implement long-term policies capable of handling the uncertainties and difficulties brought on by the pandemic.

Besides integration of technology in classes, efforts should also be made to include rigorous quality assurance methods (i.e., quality matters) and continuous quality improvement as this will allow faculty to think about changes that could be made to further enhance teaching and learning (Singh, Steele, and Singh, 2021). Blended learning supports the creation of meaningful assessment for sustainable learning and HEIs should provide plenty of blended learning training to improve lecturers' skills (Muawiyah, Yamtinah and Indriyanti, 2018). With proper technological tools and staff skills, the quality of education can be maintained.

Online assessments impact not only students’ learning outcomes but also influence

motivation, self-regulation, engagement, or reflection (Heil and Ifenthaler, 2023). The successful implementation of online assessments requires instructional support, transparent guidelines, and regulations, as well as alignment of assessment formats, modes, and types with expected learning outcomes (Heil and Ifenthaler, 2023). Staff and students can experience lots of benefits with online assessments.

Continuous information technology support and management support is vital when new systems are introduced. It is important in quality management that each university invests in technological tools and has policies in place for online assessments.

2.9 Conclusion

Lockdown measures linked to the COVID-19 pandemic compelled universities to drastically alter their course offerings. Brenya (2024) indicates that educators comprehend the blended learning approach and perceive its effectiveness in the delivery of instruction and student learning. Many students were able to finish their semesters despite the pandemic because of emergency remote teaching and learning; however, this type of instruction was not sustainable. Educators emphasize that blended learning challenges include inadequate technology resources, poor internet connections, inadequate professional development training and a dearth of incentives to promote blended learning initiatives in HEIs (Brenya, 2024).

Due to lack of policies, insufficient digital skills, and poor infrastructure, a significant percentage of students regarded blended learning as unpleasant during COVID-19 (Ferri, Grifoni and Guzzo, 2020). Similarly, Zitha, Mokganya and Manyage (2023) confirm that traditional face-to-face teaching is inevitable in Venda for science students because of rural settings, inadequate knowledge of students, lack of exposure to computer-based learning, and lack of basic internet skills. Blended learning seems to have several challenges, but as stakeholders invest and direct resources appropriately, the challenges may decrease, and universities will be able to fully maximize the use of technology in education.

Atwa, Shehata, Al-Ansari, Kumar, Jaradat, Ahmed and Deifalla (2022) revealed that

students agree on the benefits of online learning but prefer face-to-face and blended modes for their higher education. Educational adaptation in the form of online learning is obligatory during pandemics resulting in suspension of traditional (face-to-face) education as an alternative to maximize the safety of all stakeholders and provide easy and timely access to educational material and sessions, but this cannot be the future norm, especially in the study of medicine (Atwa et al., 2022). Pure online seems to be difficult for the science field but blended learning gives them benefits of both worlds.

Digital assessments are problematic for some students as they are expected to respond to the questions on the online space even though they may be unable to retrieve certain symbols and icons required in their responses to the assessments (Zitha et al., 2023). To swiftly adjust to various instructional methods, one must be well prepared but this switch to online training caught most people off guard (Megahed and Hassan, 2022). The universities were not prepared for such pandemics, but the teaching staff had to be creative with the tools at hand to keep up with the students' learning.

Stepanova (2020) agrees that a significant problem for university teachers is the choice of a blended learning model that contributes to improving the quality of education, interest, and motivation of students. Requirements for the content of the discipline and the level of using e-courses are increasing. A comprehensive approach is to constantly improve the course of the discipline, in which subsequent implementations can be based on the successful experience of implementing various models of blended learning (Stepanova, 2020). To make the most of the 4IR and successfully incorporate ICTs into the curricula, HEIs need to conduct more research with students and staff who are the main users of blended teaching and learning.

The effectiveness, efficiency, and quality of higher education's shift to remote teaching and learning have not yet been assessed (Motala and Menon, 2020). Effective blended learning must become more personalized, flexible, and serve as a support source to expand the scope of traditional instructional and learning actions while simultaneously fostering independent and lifelong learning skills and the practical uses of technology

(Medina, 2018). This has presented an opportunity to investigate blended learning and design it properly bearing in mind the tools that can be used and the limitations that affect university stakeholders.

A good combination of technological platforms and face-to-face may motivate students and staff towards blended learning. Johnson et al. (2020) propose that institutions must give staff and students the resources and tools they need to teach and study in blended and online situations. Megahed and Hassan (2022) indicated that any decisions made in this regard must consider the ongoing input from the students. Investigating staff and students' experiences in blended learning will help invest in proper tools and policies for blended learning going forward. The aim is to help biomedical science design their own specific blended learning programme to provide the best learning outcomes.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

In addressing the research questions of the study, a qualitative descriptive content analysis design was used. Qualitative research was chosen as it is primarily concerned with understanding human beings' experiences in a humanistic, interpretive approach (Jackson, Drummond and Camara, 2007). Descriptive content analysis is suitable for systematically and accurately describing the experiences of Biomedical Science students and staff in blended learning during the COVID-19 pandemic lockdown restrictions (Dulock, 1993). The qualitative method frames a problem so that it can be explored, generates appropriate data, and makes the logical link between the problem, the data generated and the data analysis, drawing inferences therefrom (Jackson et al., 2007).

A design is an accurate and systematic description of "something" or "someone" which explains why this strategy is the most appropriate one for the study's research issue (Dulock, 1993). The term "something" can refer to a variety of phenomena, events, or traits, including preferences, emotions, or attitudes. In this study, the "something" is blended learning experiences during the COVID-19 pandemic. The term "someone" can refer to a person, a community, or a group. In this study, the "someone" is the staff and students employed or studying biomedical sciences at MUT.

The study delved into the complete nature of the phenomenon, uncovering the true nature of events at the university of technology as well as the process by which these were developed or encountered. In-depth semi-structured interviewees described the dimensions of the occurrence, potential variations, and significance of the phenomenon in their responses (Polit and Beck, 2004).

3.2 Research Design

The qualitative technique organizes an issue for exploration, produces relevant data, and establishes a logical connection between the problem, the data produced, and the

data analysis, allowing the researcher to draw conclusions (Jackson et al., 2007). The sensations of the phenomenon are methodically and precisely described using descriptive content analysis (Dulock, 1993). Descriptive content analysis was the chosen research method to make replicable and valid inferences from texts (Drisko, and Maschi, 2016). Sorting textual material and making inferences about the topic of interest are signatures of qualitative descriptive content analysis (Lindgren, Lundman, and Graneheim, 2020). Descriptive content analysis can be used to identify and document attitudes, views and interest of individual, small groups, or large groups (Drisko, and Maschi, 2016).

3.3 Research Setting

Participants in the study included staff members and students lecturing or studying Biomedical Science at MUT, which is in the Umlazi township of Durban. During the apartheid era, Umlazi was established in 1967 specifically for black African people. MUT focuses on technical studies and was established in 1974 by the late Prince Mangosuthu Buthelezi. The university welcomed its first 15 students in 1979 (MUT). There are two campuses at MUT: the North Campus and the Main Campus.

Natural Science, Engineering, and Management Sciences are the three faculties that make up MUT. Most of the programmes offered by MUT are three- to four-year-long degree programmes, along with diploma, advanced diploma, degrees, and master's degree credentials. There are different entrance criteria depending on the course that a student wishes to study. In the year 2021, MUT had 13 524 registered students, of which 3 516 were new students (MUT). Natural science is the least popular major among students, followed by engineering and management sciences.

3.4 Ethical Approval

Permission to conduct research was requested from MUT (Appendix G) and MUT research ethics committee approved the ethical clearance. The ethical clearance number from MUT is RD1/ 16 / 2023 (Appendix I). At the time of this study the researcher is registered for master's degree with Durban University of Technology

(DUT) and the ethical approval was obtained from the DUT Institutional Research Committee (IREC) with ethics clearance number IREC 016/23 (Appendix H).

This study made certain that autonomy, beneficence, justice, and maleficence were covered (Varkey, 2021). Autonomy centers on respecting persons' capacities to make decisions for themselves (Trujillo Jr, 2021). To ensure beneficence means doing good, the study avoided mistreatment, reduced injury, and encouraged kindness toward participants. Justice concerns the distribution of benefits and burdens in society: people should get what is fair (Trujillo Jr, 2021). Maleficence means avoiding harm: the study avoided any harmful act or speech to participants (Trujillo Jr, 2021).

Ethics is an inherent and inseparable part of clinical medicine as the physician has an ethical obligation to benefit the patient, to avoid or minimize harm, and to respect the values and preferences of the patient (Varkey, 2021). Haddad and Geiger (2018) state that ethical principles are fundamental guidelines for behavior that direct researchers to uphold integrity and appropriate values. The researcher completed an ethics course online (Appendices C and D).

The identity and confidentiality of the participants were guaranteed by the researcher. When participants signed an informed consent form, numbers were allocated to them instead of names, and these numbers served as the participants' identification on all recordings, study notes, and other papers. Informed consent forms are maintained in a locked cabinet, with only the researcher having access to them. Passwords are used on laptops to protect privacy. Following the completion of the study, information will be retained for five years. Thereafter, the researcher will shred and dispose of the notes and transcripts with regular trash. The researcher will erase all computer files permanently.

3.5 Population and Sample Size

Due to laboratory space, Biomedical Science only accepts 40 - 50 first-year students annually. Approximately 100 students altogether studied using blended learning during the COVID-19 pandemic in 2021, as follows: 30 students in their first year, 50 in their

second, 26 in their third, and 20 in B-tech. The Biomedical Sciences department employs 14 people in total (academic and support staff), with eight academic staff, three laboratory technicians, two laboratory assistants, and a secretary.

Semi-structured individual interviews were used to collect data from a representative sample 14 participants (four lecturers and 10 students) from Biomedical science. Morse (2000) states that there is a lot of data for each participant in a phenomenological study when participants are interviewed one-on-one, thus probably just 6 to 10 individuals are needed. Each interview took approximately an hour and follow up were arranged when needed. The number of participants and the amount of useful data collected from each participant are inversely correlated. There will be fewer participants if each person provides more useful information, through interviews (Morse, 2000).

Data was analyzed continuously as participants were interviewed until it reached data saturation. Malterud, Siersma and Guassora (2016), suggest that a sample with enough information power depends on the study's goal, sample specificity, theory used, dialogue quality, and analytic approach. Roy, Zvonkovic, Goldberg, Sharp and LaRossa (2015), presented that the concept of sample richness, which is the basis for qualitative integrity, serves as a heuristic to address issues and promote further discussion regarding the crucial and complex topic of sampling in qualitative research. The sample interviewed in this study provided robust information that answered the research questions.

The cohort of study was chosen based on the experiences on the study phenomena which is biomedical science students and staff who used blended learning during COVID-19. When a known attribute of the sample frame needs to be thoroughly examined and the sample frame is small, purposeful sampling appears to be more suited (Rai, and Thapa, 2015). It starts with a purpose of the study and the sample is thus selected to include people of interest and exclude those who do not suit the purpose (Rai, and Thapa, 2015). The inclusion criteria and exclusion criteria are listed below.

3.5.1 Inclusion Criteria

- Were 18 years of age or older.
- Studied or taught using blended learning during COVID-19 and beyond.
- Were enrolled or employed as a Biomedical Science student or academic staff member at Mangosuthu University of Technology.

3.5.2 Exclusion Criteria

Participants were excluded from the study if they were:

- Under the age of 18 years of age.
- Students or staff who had not experienced blended learning.
- Not enrolled or employed in Biomedical Sciences at Mangosuthu University of Technology.

3.6 Research Recruitment and Sampling

According to Makwana, Engineer, Dabhi, and Chudasama (2023), purposeful sampling selects participants for a sample according to how well they fit the goals of the study. "Deliberate sampling" is another term that is frequently used. Another name for this sample method is judgmental sampling (Makwana, Engineer, Dabhi, and Chudasama, 2023). Convenience sampling is the process of selecting sample participants based on their accessibility (Makwana, Engineer, Dabhi, and Chudasama, 2023). Thus, the researcher purposefully selected only biomedical science faculty and students who used blended learning to teach and learn during the COVID-19 epidemic based on relevance to the research objectives.

Because the sample was readily available, purposeful sampling was employed, and it was believed that individuals who were specifically sampled exhibited knowledge of the phenomena. The sample was reasonable, appropriate for the goals of the research, and provided logical answers to research questions. An email inviting voluntary

participation was sent by the researcher to staff and student representatives, who then forwarded it to their peers in the biomedical sciences.

The researcher explained the study goals on information letter (Appendix A) and provided informed consent forms (Appendix B) for those who were willing to participate. The researcher completed an online course on informed consent (Appendix E). Four members of the academic staff and 10 participants from the student body were interviewed as closer interactions formed in smaller groups result in more organic dialogues and better data. Data collection continued until the data saturation point was reached. Data is saturated when no new trends or discoveries pertaining to the ideas being studied emerge during the coding process (Fusch and Ness, 2015).

3.7 Data Collection Methods

Data was collected via semi-structured interviews, where participants were individually interviewed by the researcher. In-depth semi-structured interviews explore in detail the experiences of participants and the researcher learn the phenomenon from other people's perspective (Rubin, and Rubin, 2011). Semi-structured interview was chosen as it aims to elicit information about what people's beliefs, thoughts, or feelings on the topic of interest and why (Karatsareas, 2022).

Semi-structured interviews are based on open-ended questions that prompt participants to develop their thoughts and ideas in depth expressing their views on the subject matter from their own personal perspectives, talking about their experiences and using their own words (Karatsareas, 2022). The semi-structured interview employs a blend of closed- and open-ended questions, often accompanied by follow-up questions, interviewing one participant at a time (Adams, 2015).

To help direct the discussions and keep participants on topic, the researcher prepared questions (Appendix J and Appendix K). To further understand the phenomenon, follow-up questions were asked after the participants' free discussion of their experience with blended learning during the two-way interview (Mack, Woodsong, MacQueen, Guest and Namey, 2005).

In the study, 14 participants were interviewed in English as the language used in university, 10 were students and 4 were lecturers from Biomedical sciences. The interview lasted approximately an hour for each individual and follow up interviewed were scheduled when there was a need after data analysis of the initial interview. Data collection took the whole year, it started on the 4th of December 2023 and the last follow up interview was on the 3rd of December 2024. The interviews were recorded using laptop and smartphone.

For confidentiality, some of these interviews took place in the participants' offices, while others took place in the researcher's office. Secondly, participants were given numbers to protect their identity, and the recordings were saved using those numbers instead of their names. Three people were interviewed using Microsoft Teams as the participants were doing experiential training in the laboratories further away from Durban, the video was switched on for identity, while the rest of the participants were interviewed face-to-face. Blended interviews worked well where some participants were interviewed in-person and others via Microsoft Teams, blending helped bridge the distance between the participant and researcher.

The audio recording was converted to textual data using Microsoft Word transcription software, examined, and then imported into NVivo R1 that is licensed by DUT and an Excel spreadsheet. Both NVivo and Excel spreadsheet were used to organize data, identify themes and codes which made data analysis easier and faster. For confidentiality the transcripts and recordings were encrypted.

3.8 Data Analysis

For elucidating the essence of the phenomenon and responding to study questions, the researcher concentrated on investigating the participants' experiences with blended learning during COVID-19 pandemic. Bengtsson (2016) states that to ensure the quality and reliability of the analysis, every step of the process needs to be repeated multiple times, with reading, rereading, cross-checking, and audit trails.

The researcher participated in a research integrity workshop online (Appendix F) and

understood the importance of trustworthiness. Trustworthiness is a method used in qualitative research to evaluate a study's level of rigor (Lincoln and Guba, 1985). Trustworthiness or rigor of a study refers to the degree of confidence in data, interpretation, and methods used to ensure the quality of a study (Pilot & Beck, 2014). According to Lincoln and Guba (1985), there are four factors to determine trustworthiness, namely: credibility, transferability, dependability, and confirmability.

The researcher sent audio recordings to the supervisor via email. Mr. Sibusiso Trevor Tshabalala, a control technician at the MUT Faculty of Natural Science laboratories, conducted an inquiry audit in data gathering, data analysis, and research study outcomes. This was carried out to verify the correctness of the results and assess whether the data supported the interpretation, conclusions, and findings (Lincoln and Guba, 1985). To maximize validity, a minimum of two investigators (the researcher, supervisor, and/ or inquiry audit researcher) looked at data collected to agree on findings. Bengtsson (2016) describes the validation process as triangulation.

Triangulation is getting information on a single factor or subject from a variety of sources and viewpoints, analyzing it, and cross-checking. The researcher interviewed participants, transcribed the audio recording using Microsoft and read the automated transcript to understand the phenomenon. Then, to address the research questions and clarify the purpose of the study, the researcher underlined relevant sections, phrases, and sentences. The phenomena were divided into more manageable chunks that each contained necessary insights. This approach is known as open coding, where researchers identify patterns or trends as meaningful units and code them (Bengtsson, 2016).

According to Drisko and Maschi (2016), coding is the process of highlighting specific phrases or sentences in a researcher's work and creating abbreviations or codes to represent the substance of those portions. Microsoft Excel was used to organize sentences during the manual coding process. Long, important units were shortened without sacrificing the unit's meaning. Multiple codes were combined into one detailed theme. When the research aim's reasonable explanation was achieved, the

categorization was deemed sufficient (Bengtsson, 2016).

Participant quotes attest to authenticity of the study, which is defined as the degree and quality with which the researcher faithfully captures the sensations and emotions of the participant's experiences (Polit and Beck, 2008). Moreover, inquiry audit was employed to prove dependability. Dependability tackles the idea of replicability, which characterized as “stability”, after accounting for deliberate and unanticipated variations in results over study iterations (Lincoln and Guba, 1985). The secret to dependability is an audit trail.

3.9 Costs and Funding

This research did not receive any specific grant from funding agencies from the public, commercial, or non-profit sectors.

CHAPTER FOUR: FINDINGS

4.1 Introduction

Biomedical students and staff were interviewed individually; interviews were recorded using a laptop and smartphone for backup. The recording was transcribed using Microsoft Word Dictate. The researcher went through the recordings and transcripts, and then the “patterns” that appeared the most in the recording was coded. The codes generated were used to build themes. “Participant L” denotes staff, with L as an abbreviation of lecturer while “participant S” denotes student. Four lecturers were interviewed and quoted as L1 to L4. Ten students were interviewed and quoted as S1 to S 10.

The findings answered the research questions; the first section explored and described the experiences of Biomedical Science students and staff in blended learning during COVID-19. The second section identified the resources and skills needed by Biomedical Science for blended learning. Both sections have themes and subthemes.

4.2 Demographic Characteristics

MUT Biomedical Science staff and students were interviewed to explore their experiences in blended learning during the COVID-19 pandemic. Out of eight lecturers, four participated, those being two males and two females aged between 41 and 60 years old. They were all employed by MUT during the COVID-19 pandemic lockdown, with three being permanent staff and one being a contract lecturer. They all had laptops from the university and were given data to conduct online classes at home as well as permits that allowed them to move around to attend face-to-face classes. Staff reported having basic computer skills at the start of COVID-19 pandemic.

From approximately 100 students, a sample of 10 students were interviewed individually, aged between 18 to 30 years old with one male participant and nine female participants. Eight students were in their 1st year and two students were in their second year of study when the COVID-19 pandemic lockdown started in 2020. Six students

had laptops and smartphones while four students did not have laptops and relied on smartphones for online classes. Two students could buy mobile data privately while eight students could not purchase mobile data, surviving on data provided by the university. The university gave students data to attend online classes and permits that allowed them to move so they could attend contact classes.

Findings of blended learning experiences from students and staff interviews presented the following themes: unpreparedness, ICT infrastructure access and availability, digital literacy, learning platforms, laboratory practical experiments and assessments which tackled research question number one of exploring and describing blended learning experience of Biomedical Science staff and students.

4.3 Theme 1: Unpreparedness

The universities were not prepared for a pandemic such as COVID-19as it put countries on lockdown, limiting the movement of people hence lessons in universities were suspend. The university first moved to online then changed to blended learning as the lockdown restrictions eased. Blended learning required universities to take precautionary safety measures to mitigate the spread of COVID- 19 pandemic while having face-to-face classes. All participants said they were not prepared for the pandemic such as COVID-19 and the changes of blended teaching and learning that started thereafter but they had to adapt.

> ***Participant S 008:*** *We were not prepared, we were scared, wondering if I will die. I think only if someone prepared us and only if we knew that it was coming, we would have made means to deal with the pandemic. The hardest part about COVID-19 was travelling, the university gave us permits when we started blending, then we started travelling between residence and campus, sometimes to the shops to buy groceries. We had to wear masks all the time and it was difficult breathing under masks for long hours. We washed hands now and again; it was tiring and at some point, the skin was peeling. COVID-19 took us from comfort zone to a stressful season, we had to be brave.*

It affected us psychologically, people we know were dying, this was a constant reminder that COVID-19 is real, and it kills.

Participant S 007: *It was a bit hectic because we had to stay far apart from each other. We had to familiarize ourselves with new things like sanitizers and stuff, which we were not used to. We had to sanitize now and then and wear mask.*

All participants were not prepared for the changes brought by the COVID-19 pandemic. For some participants' houses were not conducive to their study or work environment. Findings revealed that studying online has many disturbances, whether at home or residence, such as noise and sometimes people coming in and out of the room asking questions. It needed commitment and discipline from both students and staff.

Participant S 002: *I like physical, as online has lots of disturbances like when we are attending, I may be sitting at home and doing my chores and not listening or focusing on the class which can affect marks. Physical is better because you can focus and understand the content.*

Participant L 004: *When COVID-19 started we shifted to online classes. We ended up getting a permit, we could come to campus for contact classes with our gear, you know personal protective equipment (PPE), obviously, so that we don't pick up any disease. Blended learning wasn't too bad, students coming for contact classes were divided into small, manageable groups.*

4.4 Theme 2: ICT Infrastructure Access and Availability

Findings on ICT infrastructure access and availability indicated inequality, which resulted in different experiences among students. Students and staff needed devices like computers and smartphones with internet connections and electricity to attend online classes. When blended learning started during COVID-19, six students out of ten that were interviewed did not have laptops, they were using smartphones while four students had laptops. From the six students that did not have laptops, three bought

laptops during COVID-19 pandemic.

4.4.1 Subtheme 1: Students' Access to Devices

South African universities are still experiencing inequalities in terms of digital resources. The Department of Higher Education and Training (DHET) tried to bridge the gap by providing laptops for those students who had NSFAS, but staff and students felt that it would have been better if universities provided laptops for first-year students who cannot afford to purchase laptops, whether they are funded by NSFAS or not. Findings reveal that COVID-19 increased computer ownership, access, and availability, as most students personally bought laptops, as no one knew how long the COVID-19 pandemic was going to last.

Devices were mostly needed for online classes than for contact classes when blending. Some students had laptops and smartphones; for those, the transition was manageable.

> **Participant S 002:** *I used a computer, a laptop, and a cell phone.*

> **Participant S 003:** *I used my laptop to attend online classes and a phone to communicate with the other students.*

Device access and availability experience was a bit challenging for some students at the beginning of blended learning, as students did not have laptops and survived solely on smartphones for attending online classes.

> **Participant S 006:** *2020 was my first year, so when COVID-19 struck, it was kind of like a whole new experience. I was so used to learning in class, and it was the only way I knew, having a teacher standing in front of the class and teaching. So, when we had to switch to gadgets, I had the phone and I didn't have a laptop at the time, so it was tough. I struggled at first, but eventually I got the hang of it.*

Participant S 001: *COVID-19 was new; I didn't have a laptop during that time. I was only using my phone. No one expected COVID-19 and the only available tool at the time was my phone. And there was a lot to learn, switching from contact classes to online classes. It was difficult, there were times when we had to project presentations online on the platform, and you cannot really see clearly on the phone. The screen is small, so it wasn't easy. I have a laptop now and it is much better.*

Participant S 005: *I used a smartphone, I come from a rural area, so it was hard for me to use computers. I had challenges and I used textbooks a lot. When I went to the library, I didn't even use computers because I didn't like them, I didn't know how to use them. I bought a laptop because my friends bought them, but it is at home, I am comfortable with my phone.*

4.4.2 Subtheme 2: Staff Access to Devices

When it comes to device access and availability, the staff had computers as the university provides laptops or desktops to staff, and they were given data to be able to work from home during the COVID-19 pandemic. Staff had SIM cards with data from the university, some were given routers, which made their experience of device and internet access comfortable.

Participant L 001: *At the university, we are supplied with laptops, so I was using a laptop during blended learning. And I was also using my cell phone for WhatsApp, to communicate with students. The university gave us data because most of our modules were online, we were working from home due to lockdown restrictions of social distancing.*

Participant L 002: *Laptops and data were provided for staff.*

4.4.3 Subtheme 3: Access to Internet – Wi-Fi and/or Mobile Data

Findings revealed inequalities when it comes to internet connections due to geographic location, electricity supply and/or loadshedding. Out of ten students interviewed, seven reported that they are from rural areas, the internet connection was very poor and loadshedding hindered the from attending online lessons and they survived on recordings.

4.4.3.1 Geographic Location

Students from rural areas experienced more challenges with internet connections than students in urban areas. Some had no connections at all due to poor or the absence of infrastructure that supports internet connections. Some students had to move around the village to find better connections, which made it difficult to attend online classes and/or submit tasks on time. Other students said that when they were given permits, they moved back to their residence as they did not have network coverage in their homes, and it was much better at university residences, as they had Wi-Fi. Students reported that they missed classes due to poor connections, and they survived on recordings as lecturers recorded lessons. Listening to a 2-to-3-hour recording was tiring, and one could not ask questions like those who participated in class.

> **Participant S 004:** *I didn't have Wi-Fi, they gave us data but since I reside in rural areas, the network connection was bad. I had a problem connecting to online classes, I missed some of them. Luckily lecturers recorded lessons, so we were able to listen to recordings whenever the connection was good. But the problem was listening to a 2-hour recording, it was too much, even if you have questions, unlike the online class, there was no one to ask, could not participate in class.*

> **Participant S006:** *I was in Ndwedwe, where I originally come from and it's a rural area so there's no network. At home, I used data that the university gave us which was 10 G during the day and 20 G, and it was enough when you use it for education only. I had to find a place that had good network connections to access certain classes, and it was much better when I*

came back to the university residence as we have Wi-Fi.

Most students did not have Wi-Fi at home, most relied on the mobile data that was provided by the university, 30 G monthly which was divided as 10 G anytime data and 20 G night data. Students said it was not enough, they felt that it would have been better if the night and anytime data were swapped to be 20 G anytime and 10 G night data. When it was finished, students bought data to top up so that they could attend online classes and submit assessments. Libraries also played a huge role in bridging the gaps with connections.

Participant S 001: *At first, we didn't have data for online classes, but then the university provided data for online classes. It was only 10 G of data during the day and 20 G at night for a month and it was small as using online platforms need lots of data. Connectivity was moderate in my area.*

Participant S 002: *For about two months, we didn't have data, so I used my own data when I had it or my sister's data, I didn't have Wi-Fi. Then the university provided us with data. The connectivity in my area was good.*

4.4.3.2 Electricity and Load Shedding

Electricity plays a huge role for both online and contact classes. Both lecturers and students need electricity for internet connections and to charge devices. For contact lessons, electricity was used for lighting lecture halls, charging laptops and projectors. Electricity also supplied power to laboratory equipment. All participants had power supply as infrastructure but suffered from loadshedding. Power outages affected blended learning since they result in poor or no internet connectivity. Students from rural areas said loadshedding was an everyday thing. To deal with loadshedding challenges, classes were rescheduled. Lecturers and students would use the Eskom schedule to find a slot where most people would be able to login and attend classes, which meant frequent rescheduling. Recording classes also played a huge role in cases where students could not attend.

Participant S 007: *Loadshedding was a pandemic on its own as without electricity there was no network which meant we missed classes as we could not join the classes. It was difficult, we would ask those who joined to send us the recorded lecture then listen to it when the electricity was back on. We survived on recording.*

Participant S 008: *It was hard, when it comes to electricity, from where I come from, loadshedding is part of life, we live with it, it is our food.*

Participant S 005: *When there is load shedding there is nothing you can do, lecturers also understand that it is a technical problem. It is either the class is postponed as about 50% of the class would have the same problem or listening to recording. When it was raining or the weather was bad, we had poor connections in my area.*

Participant L 001: *Electricity and the load shedding was a challenge; it was quite bad. It was hard to keep up, I conducted my classes during the time when I knew that we're not going to be disturbed by load shedding as Eskom released a schedule, but I had no control where students were, because you'll find that I don't have the load shedding at home, yet a student in the residence may have the load shedding.*

Participant L 003: *When we were on stage five lockdown, we didn't have loadshedding. As lockdown restrictions eased, power outages started, which was a huge challenge. When students had face-to-face classes, the power would go off then we could not project notes, since I'm old school I taught them using the white board and marker. Even for online, when there is loadshedding, there is no internet connection, phones do not work which means there is no communication. It was very difficult.*

4.5 Theme 3: Digital Literacy

Staff were computer literate though some of them had challenges using the LMSs and

educational platforms introduced during COVID-19. Training provided by the university was not adequate at the time. Six out of ten students reported that they did not have computer experience when blended teaching and learning started while four students had basic knowledge of computers.

> **Participant L 001:** *When it comes to digital skills preparedness, I don't want to lie, I had to learn it on my feet while conducting classes. Yes, we received training but since it was an emergency, we did not have time to practice and be comfortable with the system. We were thrown at the deep end, you know, and the training was not adequate at the time. However, the university continued with training, and each lecturer had to use tools and skills that they had at the time.*

> **Participant L 002:** *Using learning management platforms was challenging, training was provided but it was not adequate due to shortage of time.*

Students with minimal digital skills were not comfortable with online classes in the beginning but got the hang of it with time.

> **Participant S 001:** *No, I didn't know anything about computers at the time, I learned everything during COVID-19 difficult times.*

> **Participant S 007:** *My computer skills were not good, I didn’t have any knowledge at all because it was my first time to have a laptop, I was striving to use it, it wasn't that easy for me.*

Students with knowledge of computers found it easy to transition online. Some were lucky to be trained by siblings while others were self-taught. The siblings that were computer literate assisted their siblings during the pandemic.

> **Participant S 002:** *My computer skills were basic; my brother had a computer, and he taught me a thing or two during my high school years. So, moving to online classes was not hard for me.*

Participant S 004: *I had basics computer skills, so I was okay.*

4.6 Theme 4: Learning Platforms

Participants reported that the LMSs that were used at MUT for blended learning during COVID-19 were Moodle, Blackboard and Google Classroom though all participants said they were not familiar with LMSs when blended learning started. MUT learning management platform of choice is Blackboard, however, students and staff preferred Google Classroom as it was easier to use. Students and staff said that it is user-friendly, easy to download, and they could access files anytime. One can access Google Classroom information from any gadget, even with a new phone, one needs to just enter one's Google email address, and everything linked to the email address including Google Classroom will appear.

The staff and students reported that LMSs had a lack of interaction with each other compared to traditional classroom. Students could ask questions online, but it was not like face-to-face. Biomedical Science students and staff used Microsoft Teams for content delivery which gave online classes a face-to-face experience, then harder topics could be explained further in classroom for clarity. Students' experience on Microsoft Teams differed, with some saying it was user-friendly and clicking the link to join the class made it easy for them to join classes.

Participant L 001: *The university uses Blackboard and Moodle as learning management system, but it was not user-friendly. It was complicated for both students and lecturers, remember some of us grew up without computers and we learnt the navigation at the workplace, in most cases we need time to learn and adapt the system. Someone introduced me to Google Classroom, and I tried it. It was user-friendly, even students liked it, so we have been using it since COVID-19. We use Google Classroom to upload notes, slides, and videos then for teaching we use Microsoft Teams. But considering the work that we do that deals with human life, I prefer face-to-face. On top of the learning management system, I use WhatsApp for*

communication. If there's a place where you are most likely to find the student, quickly and easily, it's WhatsApp. I communicate with class the representative then their representative will share on their group.

Participant L 004: *When I first joined MUT, they taught us the old version of Blackboard, it seemed simple but since teaching and learning was in classroom, we never used it. The students were not familiar with Blackboard, and they said it was a little bit difficult for them, so we ended up using what was convenient, I used Google Classroom and Microsoft Teams. We tried Zoom for a short while, but it gave us limited time, we had to be done with teaching in 40 minutes or logout, create another session then login which was time consuming. The university settled for Microsoft Teams which is timeless. Also, during COVID I know I used a lot of WhatsApp for communication, it is very convenient for students.*

Both students and staff learned the navigation of educational platforms while classes were running. Students initially experienced difficulties with Microsoft Teams, they didn't know where to press to mute and unmute, as well as how to comment on Chat. Students did not know where to share screens during presentations. Others had network coverage barriers. There were problems with students' email addresses, one needed to remember the login details for the student portal email to get links. Forgetting those credentials meant they had to reset the password and by the time they joined the class, time had already passed, and they would miss important information but eventually got used to it.

Zoom was used for a short while but both students and staff did not like Zoom. The biggest challenge was that Zoom only gives 40 minutes free, and classes run more than an hour. Participants said it was not easy to connect with Zoom, as it needed the username and password to login, and you waited in the lobby for the host to accept.

On top of the LMS and educational platforms that the university used, students and staff used the social media platform WhatsApp to communicate, saying it was easier

to access, and WhatsApp messages were always accessible. They updated each other via WhatsApp, whenever they had an online class or assessment that needed to be attended or submitted, they would remind each other. They also used WhatsApp to assist each other whenever they had questions. If none of their peers could assist, class representatives would send those questions to the lecturer via WhatsApp and then send feedback to students. With some lecturers they could ask directly via WhatsApp and professionalism had to be maintained.

Participant S 002: *We used Google Classroom and Microsoft Teams. The platforms were easy to use, and we had basic training though even without training, you can just use YouTube. University gave us training on how to access the app and how the app looks like, how to download it and how to join the class. We used WhatsApp as well; we had the class group where the lecturer tells the class representative about work and the class representatives will share the messages in the group. WhatsApp is much better to use because we frequently use it and then you can be updated, but for Microsoft Teams and Google Classroom you need to open the applications so that you can see the messages. Some of students do not have access to the student email that informs them about assignments or meetings. So, WhatsApp was the quickest way to communicate right then.*

Participant S 009: *We used Google Classroom, Microsoft Teams for most modules, and Blackboard for information technology (IT). Most lecturers uploaded notes and videos in Google Classroom, and it was user-friendly. We used Zoom briefly and we had a lot of connection issues then we ended up using Microsoft Teams. But I prefer contact classes, when we have questions, lecturers can answer and demonstrate on the board. We used WhatsApp for communication, as a class representative it was lot of admin work passing the communication between lecturers to students, but it was the easiest, cheapest, and quickest form of communication.*

Participant S 005: *We used Blackboard for IT skills, Moodle for Anatomy. Then we ended up using Google Classroom for all modules and Microsoft Teams. Moodle is not easy to use but the rest are straight forward. I didn't like Zoom; connection is not as easy as Teams where you just get a link and connect. We used WhatsApp for updates and notes as some lecturers sent slides via WhatsApp.*

Participant S 008: *We used Google Classroom and Microsoft Teams. To be honest, I loved Google Classroom, it was easy to access information, and I could access it at any time I wanted to. I can access information since 2019. Even if I buy a new phone, if I just put my email address, it will keep the information, I could access everything. Then come to Microsoft Teams, at some point I struggled, didn't know where to press to mute myself. You had to make sure that you are in a space where the network coverage is good. And where I come from, the network coverage is better in town not at home in rural areas. So, you need a plan to be in class. It was a bit difficult. But now I understand Teams better. We didn't have training; it was way easy to learn Google Classroom. But for Microsoft Teams, you needed to log into your Internet, go to student Portal to join class. You had to remember your credentials to log in. If you forget them, you go back to the portal again and then you just recreate another password and then login. We had to write down your password or just save it over the phone. When you enter at some point you would have network errors. At some point you just enter the class, and you realize that they started an hour ago. Then you will listen to the recording after.*

4.7 Theme 5: Laboratory Practical Experiments

When COVID-19 lockdown restrictions started, there were no practical experiments. Classes started online first when movement was not allowed, and lecturers uploaded YouTube videos on Google Classroom to assist students to understand concepts.

Students also used YouTube videos whenever they could not understand notes or needed more clarity. When COVID-19 lockdown level decreased, students and staff received permits to be able to attend face-to-face classes and they could do practical sessions.

COVID-19 brought big shifts in practical session and new trends where both students and staff had to adapt to survive the disease and continue with teaching and learning. To follow COVID-19 social distancing protocol, students were separated into small groups (platoon system) as limited numbers were allowed on campus, in classes and in laboratories and they took turns to attend. Students experienced difficulties adjusting from working in groups or with partners to working alone but they said it taught them independence. Lecturers could do practical tests but there were no practical exams.

> **Participant S 006:** *That was kind of a shift because we all used to go into the lab for practical. Initially COVID-19 lockdown didn't allow us to go on campus then we were separated into groups, it was difficult doing an experiment on our own, not having a lab partner and we adjusted. COVID-19 taught us to be independent. Lecturers uploaded YouTube videos; they attached videos in Google Classroom related to the topic we were studying which helped a lot. I feel like it depends on your learning style, COVID-19 was just mainly independent. If you are a person who's visual like me, the videos helped a lot, but for someone who listens more, they would have struggled as sitting and watching videos is irritating for them. I think the university did not compromise us of our practical, we did every practical that we were supposed to do. Since we have been in the lab, there was nothing new that I saw at the lab.*

> **Participant S 002:** *When we were on lockdown, we were away from campus, and we did not do practical experiments. Then when we were allowed to come, we continued with the laboratory experiments. A new structure was implemented on how we can access the school, we came in small groups. We had to push, and the government helped*

with a new academic calendar which gave us time to finish the syllabus.

Participant L 003*: I used to do the practical and they will watch online but I stopped doing that as there are lot of YouTube videos, then I would send the YouTube link for them to watch where people were doing their experiments on the topic that I'll be talking about. For instance, for Histology the microtome cutting, the floating, the staining and everything. I would post videos on each process; they watched videos of people doing the experiments then when they came face-to- face, we would do the practical.*

Participants L 002: *The blended learning can work in Biomedical Science when theory is conducted online, and practical is face-to-face. During COVID-19 when movement was limited, we gave students videos to watch, then we would ask practical related questions to test their understanding. It was better when we were given permits and students could come to campus for practical. We had a practical test, and I asked laboratory technicians to assist me with invigilation as students were doing the tests at the same time in different laboratories. There is software for practical like virtual reality that can be used to explain concepts and demonstrate processes but that needs investment, and it does not equip students with laboratory skill, it's just knowledge. Biomedical science is a hands-on course, laboratory based, students need the skills.*

Participant L 001: *I was able to do a practical test, but we could not do practical exam. Since the laboratory capacity was limited, if others are writing a test, others will wait outside. That's how we handled the practical test at that time. And while students did well, I remember, when one person finishes first, we had to monitor them as they walk out and see that they don't mix with the other group. We didn't want them to tell their fellow students about the test questions as it*

compromises the quality of education, but I think we handled it quite well because we were able to accommodate two groups to write those practical tests.

COVID-19 affected the 4th year students as they could not be in the laboratories full time. They did online work integrated learning (WIL). They were supposed to do only certain hours in laboratories to limit the number of staff and movement. Two students from the participants were doing their second year when COVID-19 teaching and learning started, their fourth year WIL was also affected. Both the lecturers and the two students reported that the shortfall was identified, and both the industry and the university worked together to bridge the gaps before graduation.

Participant L 002: *For the 4th year students there was a shortfall. Because during COVID-19 we embarked on online work integrated learning (WIL). On the week when they were supposed to be physical, they were only expected to spend 40 hours. As a result, the industry knows that these students are not well trained. It was discussed in meetings with the Advisory Board. There were huge gaps, even though there was no time or space for correction, but the students learnt quicky. The gaps were easily identified, and they were trained on the gaps that were identified by the time they graduated.*

Participant L 004: *It was very difficult for 4th year students as they could not do WIL full time, it was online, but they managed to catch on. There were no failures, just one student that did not make it during examinations but passed supplementary exam.*

4.8 Theme 6: Assessments

The findings reveal that both students and staff prefer tests and examinations to be done in contact classes. During lockdown level five, all assessments were conducted online. The university used continuous assessment during the COVID-19 pandemic, which meant progress marks were obtained from tests, assignments, tutorials, and presentations as they could not sit for examinations. As COVID-19 lockdown restrictions

eased, students and staff mixed online and classroom assessments. Online assessment presented challenges, which included unsuitable study areas, loss of internet connection, loadshedding and minimum digital skills. Students reported that residences or homes were noisy with people coming in and out of their rooms which made it difficult to concentrate during assessments.

Students said that during the assessments their computer would freeze, or they would lose connections because of poor internet connectivity or loadshedding which meant they could not submit tests on time. Internet connection was a major challenge, and lecturers said they had no choice but to extend submission time as one would never know if the students were telling the truth or not. Both students and staff preferred that assignments and tutorials be done and submitted online as there was enough time to write and submit. The challenges with loadshedding and/or poor connections can be mitigated in assignments/tutorials by submitting earlier than the submission date.

> **Participant S 006:** *It was online sometimes, and some lecturers just really prefer that we go to class, and we just space ourselves. I prefer to write in class as well as in a controlled environment, with no distractions. At my residence, there's a lot of noise, people coming in or other distractions. I feel like the assignments didn't change much because we used to email the assignment even before COVID-19 in the university as lecturers wanted soft copy. Challenges came with uploading in the apps we were not familiar with. Meeting deadlines was also a challenge as we had poor network connections and loadshedding, then submission dates had to be extended.*

> **Participant S 008:** *Submitting online was difficult, with poor connections, the computer would just freeze. The lecturer will tell you that since you are writing a one-hour paper, then you must submit the answer sheet within 10 minutes, then you lose connections. You will be panicking. Then you must apologize to the lecturer and submit it later than expected. Assignments are better as we have the whole day to submit, so when you do your work in time, you could submit whenever you*

had connections, yet with tests it was hard to submit at a certain time due to technical errors. Traditional classroom assessments were much better as you can hand in your script when you finish.

Participant S 007: *Submitting assignments was a bit challenging because you must upload it. Maybe you don't know how to upload or maybe you have a poor gadget like mine, you do not have the Cam Scanner. You struggle or ask someone to scan for you and make a document PDF. Sometimes you will struggle to search for that document on your PC or gadget while you want to upload. It was time consuming.*

Participant L 001: *When it comes to online assessments, I am not too happy about those. I am not too happy because I have heard stories, especially with load shedding. Students would say in my area, we don't have electricity, and they were sharing gadgets and all those things. Others had electricity. You don't know the truthfulness of such things. When it comes to assessments, I'm sorry. I prefer face-to-face, especially for summative assessment – tests and exams. Some will say there is no internet connection, I have been trying to send the test, but it is not going through. I was very lenient with the submission date, sometimes I'll extend it to accommodate everyone. I mean, we must accept that others come from a rural area. Even if they have data, but electricity or connectivity can still be a problem. There isn't much you can do in such cases but to understand and work around it.*

4.8.1 Subtheme 1: Compromised Quality of Education

Lecturers commented that students cheated, they copied notes or got answers from Google which compromised the quality of education. Some lecturers gave students critical thinking questions, for them to work around the problem and apply knowledge which could not be copied. Other lecturers booked several venues so students could come write on campus.

Students admitted that when writing online, they used to help themselves as everything is around. Students said they did not study a lot as they knew they would be able to copy. While others admitted that they cheated, others were loyal and studied for their assessments. Some of the students interviewed were doing 1st year in 2020 when COVID-19 pandemic lockdown started in 2020, and they only experienced their first university face-to-face examinations in third year, 2022.

They said writing exams on campus was scary, with invigilators walking up and down the hall, it was a whole new experience for them, and they said they gained more knowledge when they were writing on campus as they had to study and memorize. As much as students and staff managed teaching and learning given the COVID-19 lockdown restrictions but the first preference from students and staff was face-to-face examinations.

> **Participant L 002:** *Assessment during COVID-19 was poor. We started with the online assessments, and we had problems with students copying. We don't have the system to monitor students when writing assessments online like UNISA* [University of South Africa]*. The quality of education was compromised, the only way I used to address the problem was to give them complicated question where they had to integrate information. Luckily, I am teaching higher levels so at that stage they are expected to integrate but that cannot work on first years. We ended up booking several venues for assessments, like two classes to practice social distancing and monitor students while writing. Tutorials and assignments were posted online, and they would upload their scripts online and it worked well. I would mark it online then send it back to them.*

> **Participant L 004:** *I structured questions that involved critical thinking, they needed to apply their knowledge by supporting their answer. Copying was going to waste their time.*

> **Participant L 003:** *They came to write the test manually, I mean, physically*

writing. We wrote minimum of three tests. There were two tests, and then big test, and they didn't write the exam. I didn't trust them, so, I made sure they come in and we used two classes to accommodate students while observing COVID-19 social distancing protocol, and I asked a colleague to invigilate the second class for me.

Participant S 001: *Most of the assessments were online. We didn't have exams it was just continuous assessments. It worked as it was the best possible option at that time and we only experienced university exams in 2022, this was my last semester, so it came as a surprise because it was my first time on the examination environment. It was very challenging. For online everything is around you, so you could help yourself. And with face-to-face everything must be in your head which made it difficult, but we made it.*

Participant S 007: *Both of methods are quite comfortable because writing online you can write even if you are not here in school. Yet with writing on campus, you must be here on campus. So, I think they are both quite fair. Lot of schools are using the traditional classroom assessments; it helps not to panic during final exams. It is scary having invigilators walking up and down, you will panic if you are only used to online. Online, sometimes you may copy and sometimes you may not. But what I know is when you write online, the answer is similar because we have been taught one and the same thing. So why would the answers not be the same? Even writing in class, the answer could be the same.*

Participant S 008: *We hate online assessments. At some point, I could just open my book and just write answers but as years went by, I realized I was not gaining any knowledge by copying. As good and easier online was but on the other side, it was killing me. There were benefits, but there were also disadvantages of it. Studying and memorizing everything helped with gaining knowledge.*

Participant S 009: *I didn't have problems with online assessments, even though I prefer face-to-face assessments. While others were cheating for online assessment and scoring higher than they used to when we were writing face- to-face, I studied and wrote as per my understanding. That helped me to gain knowledge and see where my shortfalls were. I just told myself this is my future, and I need to be professional.*

To answer research question number two of identifying and suggesting skills and resources needed by Biomedical Science students and staff in blended learning, the study findings revealed three themes: infrastructural support, ICT training and support and instructional design.

4.9 Theme 7: Infrastructural support

Students and staff suggested that renovation of lecture halls to smart classrooms and offices with increased internet connectivity could assist in making campuses conducive places for blended learning.

4.9.1 Subtheme 1: Renovation of Lecture Halls and Offices

Lecturers suggest that the university needs to invest in renovating lecture halls. Smart classrooms can assist in smooth blended learning. A smart classroom is a digital classroom which uses digital equipment like laptops, teaching screens and projectors to help make teaching and learning better. Improving internet connectivity everywhere around campus can help improve blended learning. Alternate power supplies like generators can assist in teaching and learning as loadshedding disturbs both traditional and online classes.

Lecturers felt there was a lack of privacy and noise distractions in their offices which made it difficult to conduct online classes from their offices. Currently Biomedical Sciences staff offices are in a building where there is no ceiling which means that the person next to your office can hear everything.

Participant L 001: *University must invest in alternative power supply. We cannot suspend learning for two hours because of loadshedding, I believe that the university must do something like persuade the government to add universities under category of facilities that cannot run without electricity like hospitals. Internet connection, Wi-Fi, or data for both students and staff should be continuous for ongoing blended learning. Upgrade or renovation of facilities like laboratories, we are happy that now Biomedical Science laboratories are being renovated, the university must renovate offices as well. There are open spaces in the ceiling, there is no privacy, conducting online classes during blended learning means that the person with the office close to your office can hear everything.*

Participant L 002: *We lack proper infrastructure to conduct blended learning smoothly, for instance our lecture room does not have Wi-Fi, we need the university to invest in infrastructure. Yes, we can move to technology direction provided the infrastructure is adequate. Because we are even packed in the class, the intake of students increased yet the venues are still the same, we need bigger lecture halls. We have air conditioning problems. We have been asking for smart classrooms, yet nothing has been done. With smart classrooms, we can even teach in an empty class while students are watching wherever they are, or the few that do not have access to internet at home can attend face-to-face classes. Then our blended learning will be complete. Smart classroom is a very nice tool. It's a very good thing.*

Participant L 004: *Blended learning is a way to go, we need university to upgrade internet connectivity, in Natural Science campus there is poor connection in some areas. The university must provide continuous data to lecturers and students, so we can work from home, the campuses are so busy, there's so much of noise, we can be more productive at home then come to university for certain classes and practical sessions.*

4.9.2 Subtheme 2: Laptops Access

For blended learning to be smooth going forward, both students and staff suggest that institutions should give laptops to the first-year students that cannot afford to buy laptops upon registration. Laptops are expensive and some students cannot afford to buy them. Owning proper gadgets and access to data or Wi-Fi may give students confidence in studying online.

> **Participant S 007:** *Yeah, I think the university should provide laptops because they're expensive. We can't buy a laptop with the monthly R1 500 from NSFAS. I had NSFAS and we were promised laptops, but I bought mine, they never provided. Some of us or most of us are not from privileged homes, we do not have enough money to buy proper gadgets.*

> **Participant S 001:** *Provision of computers at first-year level may help blended teaching and learning. Students should be given enough data as well as proper training on learning platforms used at the university as that would help students work faster and confidently.*

> **Participant L 002:** *Students do not have laptops, the university needs to provide laptops to students, smartphones are not conducive for educational purposes. The phone is small. If the university can buy laptops, we'll move easier to blended learning.*

4.10 Theme 8: ICT Training and Support

Students said it can help if the computer module is moved to the first-year level, as students who come from rural areas have no computer background. Students feel that doing computer lessons in the first year rather than second year in Biomedical Science may give students confidence when studying online and minimize delays in submission or any other digital literacy difficulties.

> **Participants S 002:** *We do have a module for computers, but it is in the second year. I think it can be shifted to the 1st year so that computer*

skills can be improved. I think first-years need to be exposed to using laptops and during internship you are also required to know how to operate the computer.

Participant S 007: *The university needs to train students in computer skills, because at high school level we are not taught. High schools in rural areas are not highly equipped with this infrastructure, so they need to teach us. I think the university should use blended learning because it is international. The modern technology is increasing, so we need to familiarize ourselves with these things.*

Continuous training of students and staff will improve digital transformation readiness. Students feel that computer lessons should also cover training in the specific LMS used in the university, important sites that they can use to download academic information from the internet, citations, and Microsoft Excel as they need to be competent when doing referencing and data analysis during their 4th year. They could be taught and assisted on downloading apps, how to upload scripts etc. Students said that early training in computers and consistent use of computers and typing will improve their speed thus they can finish and submit the online tests on time.

Students and staff believe that the world is under transformation with the4IR, in as much as they need specific skills for careers, computer skills are just as important in industries and for research. They believe that computer skills will also make adapting to modern technology simpler, easier, and quicker.

Participants S 003: *For computer skills students need additional training on Excel, yes, because during the research methodology, we needed to interpret results, and we had challenges.*

Participant S 006: *University need to choose one platform to be used when students are online, then train students on that app, just like we have training of how to use the library during orientation week in first year, the same could be done for online platforms to familiarize students.*

Lecturers say the university provides training for staff; however, it is usually during lessons which makes it difficult for them to attend. They feel that the university should have a strong information technology department for continuous support.

> **Participant L 002:** *We need the university to invest in infrastructure, training is available, but it is done during classes and most academics cannot attend. We lack proper infrastructure to conduct blended learning smoothly, for instance our lecture room does not have Wi-Fi.*

> **Participant L 003:** *University needs to have a strong information technology department for training and support. We need network systems that can work in the lab and in classroom and I've had some people are doing the research now because they want to implement robots. The robot that can do everything while students and staff are watching since students are not allowed to touch contaminated specimens. The university needs to invest in such studies and equipment. I do prefer blended learning, sometimes students can be sick, having blended learning and right equipment will help them attend while others are doing face-to-face. That way students can attend and ask questions. They won't miss a class.*

4.11 Theme 9: Instructional Design

Both students and staff agree on instructional design when adding online classes to the known traditional classes. Students need to be responsible when attending online classes. To improve attendance in online classes and make sure that students are attentive, students said that they need to login with camera on during lessons and assessments, that way people will not login and leave to do their chores or sleep. It may minimize cheating during assessments. Answering tutorial questions during classes and allocating marks that will contribute towards final mark may also improve attendance. Engaging the class may also improve attendance, lecturers should ask questions now and again to improve interaction thus the lecturer can see if students are listening and understand the concepts.

Participant S 005: *Blended learning can continue as online classes can be recorded and we are able to listen to those recordings repeatedly as well as rewind. Lecturers can tell students to open cameras so that they can see that everyone is attending and concentrating. If possible, for online assessment, students can write different papers so that they do not share notes. Online mixed with face-to-face is much better. The lecturer can also ask students to do presentations every week, it is easy to present something you studied. It is easier to see a person who knows what he is talking about, and the good part is that they will ask questions and test your knowledge.*

Participant S009: *I feel like blended learning works for certain modules and not for other modules especially in our field of study, we need contact classes for both content and experiments. I feel like we can use blended learning, it should be more hours in contact classes and occasionally do online classes. Our field needs a lot of application, it's a health field, hands-on application.*

Participant L 001: *But, you know, sometimes, you've got to adhere with where life is taking you. Blended learning is going to be our life now. So, we all need to teach our students to be responsible now, to know that if we're having an online class, they've got to be there, you know, sometimes you ask a question, you call someone's name, and that person cannot answer because probably the device is on, and they are not there. But they must be responsible. This is university level; we cannot chase around students. We can't babysit them. And we know that Biomedical Sciences is laboratory-based, and they need to be hands-on. Theory is there for them to understand the concepts, we need to design teaching and learning accordingly and adapt to modern technology.*

Long lectures can be reduced as when the lessons are long online, students lose interest and end up doing other things like chores or sleep as watching the screen can

be tiring. Having breaks in between can help students concentrate, students understand that during COVID-19 they had to push as hard as possible in the short space of time. Now going forward, shorter lessons with short breaks can help improve attendance and concentration thus providing quality education.

> **Participant S 002:** *We have very long lectures and then we get tired. Lectures can take three hours, three straight hours without a break. I'm not sure if they did that because they wanted to cover the work because we lost two months, but being in the lecture hall, listening to the lecturer for extended hours you lose focus and miss some of the important content as well. So, I think maybe we can have breaks in between, maybe small breaks.*

CHAPTER FIVE: DISCUSSION

5.1 Introduction

The aim of this study was to explore and describe the blended learning experience of Biomedical Science students and staff during COVID-19 in a university of technology with the objective of identifying and suggesting skills and resources needed by Biomedical Science students and staff for blended learning in a historical disadvantaged university. Students and staff answered the questions through semi-structured interviews and descriptive content analysis was used by the researcher to analyze and interpret the data.

Nine themes were identified, of which the first six answered Research Question 1 (Biomedical Sciences students and staff experience in blended learning) while the last three answered Research Question 2 (what are the resources and skills that are needed by Biomedical science students and staff for blended learning in a historical disadvantaged university of technology). The themes were unpreparedness, ICT infrastructure access and availability, digital literacy, learning platforms, laboratory practical experiments, assessments, infrastructural support, ICT training and support, lastly instructional design.

5.2 Discussion on Research Question 1

Exploring and Describing the Experiences of Biomedical Science Students and Staff in Blended Learning During COVID-19 Pandemic Lockdown Restrictions in a University of Technology

The study found that the university was not prepared for pandemics like COVID-19 and lockdown restrictions as it was the first of its kind. COVID-19 pandemic was a highly contagious disease add citation, hence when it started countries went on full lockdown with limited movement and only essential businesses were allowed to stay open add citation. To limit transmission of the virus, countries went on full lockdown, borders were closed, mass gatherings were suspended, and non-essential businesses were closed

including schools and universities (World Health Organization, 2020). Issues on blended learning came to the fore because of the pandemic which caused a sudden switch to remote education add citation. The Occupational Health and Safety department (from where) had to prepare and purchase necessary equipment and consumables for the campus facilities to mitigate the spread of COVID-19 for blended learning to take place (Appendix L to S).

Blended learning requires a device to access online learning such as a tablet, smartphone, laptop, or desktop computer (Sharma, 2022). Universities were forced to adapt to the new era (blended learning), unlike traditional classroom, blended learning required devices. Findings in this study indicate that some students had laptops when COVID-19 pandemic lockdown started, while others did not have laptops and some bought laptops during COVID-19. Findings agree with Bordoloi, Das, and Das (2021) that many countries suffered from disruptions in education, countries like India were more vulnerable because of the digital divide which is still one of the greatest threats to the implementation of successful online/blended modes of education.

Pather et al. (2020) reported that when universities shut down their physical campuses because of the COVID-19 pandemic but continued to offer teaching and learning through digital channels, the reality of the prevailing South African digital divide could not be ignored by university managers. Not all students could afford to buy laptops and survived on smartphones. They needed financial assistance to purchase laptops. Even though many universities had begun to procure affordable laptops for students, and subsidized data, this was not sustainable in the medium to long term (Pather et al., 2020). The reality of the students' digital resources was that one could not simply switch into an online mode of teaching and expect that all students were going to participate (Pather et al., 2020).

Smartphones worked in blended learning during COVID-19, but students had challenges of small screens, limited space, and were unable to share screens during presentations. Students stated that buying laptops during COVID-19 made their experience of online classes better than when they were using smartphones. One may

contend that not all mobile devices are equipped with the bare minimum capacity needed to carry and access online education systems (Majola and Mudau, 2022).

Students preferred laptops than smartphones, hence some of the students who did not have laptops when COVID-19 started, bought laptops during the pandemic. Students suggested that they should not have used a mobile device at all, this is not necessarily ideal for those who do not have access to another tool or face other limitations (Milheim et al., 2021). Websites, documents, and additional resources must also be designed in a mobile-friendly way to increase the accessibility and user experience of self-initiated mobile device learners (Milheim et al., 2021). The use of smartphones in higher education come with interruptions like social media, emails, and instant messaging that easily steal the students' attention from what is happening during class (Pattermann, Pammer, Schlögl, and Gstrein, 2022).

In contrast Nikolopoulou (2022), states that as the capabilities of smartphones are increasing, mobile technology-supported educational opportunities are evolving. Therefore, student mobile phone-mediated educational practices can be encouraged in blended learning education, in universities with limited infrastructure, or with socially disadvantaged students as mobile phones are usually cheaper than PCs or laptops (Nikolopoulou, 2022). Educators need to be aware of students' mobile phone practices when they design pedagogical interventions in mobile environments; it is important to plan and organize appropriate activities and create good quality digital resources (Nikolopoulou, 2022).

The current study found that apart from limited access to devices, electricity loadshedding also affected blended learning. Both students and staff could not attend classes as power outages affected internet connections and devices needed to be charged, and students could not submit assignments or tests on time. Lecturers had to extend the submission time to accommodate power outages. All university students were faced with load shedding, which had a negative impact on their performance, grades, competencies, self-study, and ability to complete assignments or tests on time (Malik et al., 2022).

Students in rural areas suffered more than those in urban areas as there was poor infrastructure. Load shedding lasted longer in rural areas. Students who reside in rural areas suffered more compared to urban areas (Kakepoto and Jalbani, 2021). The current study findings support Hlatshwayo (2022) who reported that online learning during the lockdown revealed a huge mismatch between the academic discourse on 4IR and concrete developments on the ground. Promoting 4IR in the context of load shedding, blackouts, and the very poor ICT infrastructure amounts to chasing a mirage. If the post-apartheid state had built ICT infrastructure and delivered electricity equitably, the pain suffered by many students could have been avoided, as was the case in countries that invested in power supplies and ICT infrastructure (Hlatshwayo, 2022).

Contact classes were also affected by load shedding as lecture halls were dark and poorly ventilated without electricity. Even laboratory practical experiments could not be done as instruments needed electricity. Online classes go for longer hours, so students found it difficult to charge mobile phones and laptop batteries during these times (Kakepoto and Jalbani, 2021). Classes could either be cancelled or postponed. Lecturers recorded online classes and students could listen to the recording at any time. This helped students when studying as it could be repeated, stopped and they could rewind.

Recording helped students who missed lessons due to technical glitches. Synchronous classes, where the instructor and the students in the course engage with the course content and each other at the same time but from different locations could be recorded and uploaded to Blackboard. Asynchronous classes offered learners the flexibility to study in a self-paced manner, giving students who are having trouble connecting to the internet and other students the chance to watch and assess lectures at their own pace (Dahmash, 2020).

Mulyadi et al. (2020) confirms that flexibility to access and engage in academics tasks which allow learners to use the material at their own pace and learning creatively from several sources was perceived to be the most effective aspects of blended learning. Warren et al. (2021) state that student forums suggest that the ability to work on

practice examples and receive instant feedback provides students with a flexible opportunity for multiple mastery experiences, and the interactivity of the platform facilitates the repetition of examples until such a point that the student is confident in a particular area.

The existence and quality of internet connections had a huge impact on blended classes, with students from rural areas having difficulties connecting to online classes due to poor ICT infrastructure. Similarly, Zitha et al. (2023) confirmed that in Venda, many science students in rural settings had inadequate knowledge or exposure to computer-based learning and lacked basic internet skills. University gave students and staff data to study while they were blending during COVID-19 lockdown. During the COVID-19 pandemic shutdown universities supplied 30 G of data per month to students, made up of 10 G anytime data and 20 G nighttime data (Motala and Menon, 2020).

As students faced challenges of devices and internet connection while blending during COVID-19, the university allowed students back in residences. Cook et al. (2021) said that until digital access is available to all students, online and blended learning may be more a case of "survival of the richest" than of the fittest. During the COVID-19 lockdown, lecturers and students stepped into the breach between ideal working circumstances and realities, but student resilience and staff dedication should not have to keep on bridging systemic gaps (Cook et al., 2021). Tackling these inequalities with a united front will help everyone to better manage contextual challenges beyond the COVID-19 lockdowns (Cook et al., 2021). All stakeholders need to work together in bridging the gaps of the digital divide.

Students suggested computer lessons be shifted from second year to first year to bridge the gap in digital literacy. This study's findings supported those reported by Faloye and Ajayi (2021) that academic institutions should introduce IT training and awareness programmes for students at the beginning of their first year. Although LMSs have a place in the solution, it is crucial to keep in mind that students still need to build capacity in using LMSs and other recently implemented online learning tools

(Mpungose, 2020). This will equip students with the necessary skills to perform their learning tasks effectively (Faloye and Ajayi, 2021).

Both students and staff had basic digital skills when blended learning started, however, the training on the learning platforms that were used would have helped them with confidence in using the LMSs. Mhlanga (2021), Muhuro and Kangethe (2021), and Paschal and Mkulu (2020) revealed that most students and instructors felt that online learning was ineffective and disliked by them due to a lack of resources, a lack of electricity, a lack of facilities, a poor network, a shortage of skills, and a lack of policies that encourage the use of online learning in African universities. Both students and staff learnt the navigation of LMSs while blending; it was challenging at first, but they all gained skills and managed.

Biomedical science students and staff said their skills improved while blending during the COVID-19 pandemic, which means more exposure to the digital world increases digital skills. Blended learning improved lecturers' technological literacy (Mulyadi et al., 2020). Dangwal (2017) confirms that with blended learning, students improved their digital fluency and became more tech-savvy. Irum et al. (2020) revealed that students gained confidence and became self-dependent when they completed their academic tasks through a blended mode. Blended learning improves digital literacy which is a skill that is beneficial in industry.

Findings agree with other researchers that the students can develop the skills necessary for the 4IR while also benefiting from an improved learning environment (Muhuro and Kangethe, 2021). Students must build their digital competencies to use various learning platforms and be aware of their opportunities for material delivery, learner engagement, and student interaction (Kovačević et al., 2021). Students that possess digital literacy will be more inclined to utilize mixed teaching and learning with ease (Kovačević et al., 2021).

Lecturers and students could not use the university LMS platform Blackboard due to lack of training, hence continuous training and support is required. Students and staff chose Google Classroom which was user-friendly. Google Classroom assisted both

students and teachers to connect, work together, create assignments, grade students and post lecture notes. Students could ask questions about the areas they did not understand. Okmawati (2020) confirms that the use of Google Classroom during the pandemic was very effective and useful to improve students' skill abilities, discipline, and to fulfil the demand of the government to continue teaching and learning.

The material uploaded can be in the form of articles or text, images, audio, videos, and several other teaching materials (Okmawati, 2020). Teachers can conduct tests, monitor, systematize, evaluate activities, review the results of exercises, apply various forms of assessment, comment and organize effective communication with the students in real time (Boychuk et al., 2022). Google Classroom helped with uploading notes and videos but lacked teaching and explaining to students. Hence, Biomedical Science students and staff used Microsoft Teams as an additional tool.

Students struggled a bit with Microsoft Teams, they had to learn where to mute and unmute, how to share screens and comment on Chat as the experience was new to them. Initially the experience was difficult, but they soon learnt the platform and managed. Sobaih et al. (2021) agree with this study's findings that students who used Microsoft Teams contended they did not have enough support or training in Microsoft Teams. Lecturers could teach online using Microsoft Teams, share the screen of their notes, providing the same atmosphere as the classroom setting. Students could raise their hands online and ask questions while others asked in the chat box. Even though there was interaction on Microsoft Teams, students and staff felt that the interaction was much better in traditional face-to-face classrooms.

Students and staff felt that traditional classrooms were better as biomedical science concepts are difficult, and face-to-face teaching helps lecturers see students' faces and see when they do not understand concepts. Lecturers said they could not read facial expressions online, whereas in the classroom, it is easy to see when students do not understand. Off-line classes are preferred over online classes since student- teacher-peer interactions are better (Sharma et al., 2022). Online classes are preferred when off-line classes cannot be conducted; during situations like the pandemic online class is

the best alternative to off-line classes since they help students to follow safety protocols (Sharma et al., 2022). Blending helps extract benefits from both traditional face-to-face and online though at this stage participants from this study prefer face-to- face lessons.

In addition, WhatsApp social media played a huge role in communication, students shared slides and updates on tasks that had to be done or submitted. They helped each other with questions as it is the easiest and quickest mode of communication. Both lecturers and students used WhatsApp as a communication tool as well as an educational tool during COVID-19 pandemic lockdown. WhatsApp acted as a conduit to enhance academic performance, which may have lessened some of the digital gaps in higher education that were previously present (Madge et al., 2019). Students could transfer and translate information in ways that were previously unattainable, thanks to the social media network WhatsApp (Madge et al. 2019). A study by Simbolon (2021) found that students experienced some benefits from blended learning using social media like WhatsApp and from the feedback via WhatsApp on the work they received from the lecturer.

The study found that there were no practical experiments when the COVID-19 lockdown started. Lecturers and students used YouTube videos to explain concepts and understand theory. Innovative methods can aid in closing the gap, such as online simulations or recorded practical experiments (Motala and Menon, 2020). During laboratory practical training, students were able to understand procedures and report using video-based demonstrations (Khan et al., 2021). The video-based demonstrations were useful in helping students understand concepts they learnt in theory but could not give students necessary laboratory skills. These skills include touch, smell, safety precautions, laboratory techniques and time management.

Current study findings support those of Ray and Srivastava (2020) who reported that regular online learning alone cannot provide adequate skills or knowledge regarding laboratory experiments or analysis of scientific data. Virtual labs have been criticized for not offering students health and safety education and for lacking multisensory, or smell, sound, and a real-life feel (Lynch and Ghergulescu, 2017). When COVID-19

lockdown restrictions eased, students and staff were given permits to allow them to travel from residence to campus.

Students were divided into smaller groups and limited numbers were allowed in lecture rooms and in laboratories to keep social distancing. COVID-19 risk communication and community engagement strategies included physical distancing to reduce transmission (World Health Organization, 2020). Less people were permitted on campus at a given time to adhere to the social distancing protocol although this impeded physical learning activities (Mhlanga, 2021).

Students and staff appreciated blended teaching and learning of the theoretical material as the face-to-face lessons gave them time to do practical experiments and attend to difficult concepts. Elhaty et al. (2020) revealed that most science teachers and students were worried about missing the practical skills during the COVID-19 pandemic because these skills could not be taught through e-learning techniques. Biomedical science is a laboratory-based course, and the laboratory skills are part of the curriculum.

Laboratory exercises are a vital part of science learning and allow students to develop practical skills, connect content to real world applications, and serve as the foundation for further knowledge beyond the classroom (Lahr, 2023). Blended learning is much better for science students and staff as it allows experimentation in both online and contact classes unlike pure online which is only virtual. The most effective teaching method depends on what provides the optimum balance between the interaction and integration of technology-based models in education (Megahed and Hassan, 2022).

The students who were doing WIL during COVID-19 experienced a shortfall in laboratory training as they trained online to limit the spread of the COVID-19 virus. The universities and industries identified and corrected the gap before students graduated. COVID-19 has granted the opportunity for the university to look at virtual laboratories and invest in those that will increase students' practical skills and knowledge. There is high probability that both types of laboratories (virtual and real) will coexist in the post-COVID-19 hybrid educational models, which combines face-to-face and online

teaching and learning (Vergara, Fernández-Arias, Extremera, Dávila and Rubio, 2022).

Social distancing during COVID-19 also affected the assessment processes used in universities, especially summative assessments. Students did not have examinations during COVID-19 pandemic lockdown restrictions year 2020 to 2021, the final pass mark was generated through continuous assessments. Students were assessed using tests, assignments, and tutorials, mostly done online with some during contact classes. Assessments became a major challenge during the COVID-19 pandemic and academic regulations were changed to emphasize continuous formative assessment (Motala and Menon, 2020). Students who were doing first year in 2020 experienced their first in-contact university examinations in 2022 which was a scary new experience.

For contact assessments, lecturers used several venues to observe social distancing protocols, with colleagues assisting with invigilation. For the practical assessment, staff said they had to monitor students as they left the assessment venue so that they did not speak to their peers that were waiting outside. Other lecturers used different laboratories and asked technicians to assist with monitoring so that each level could do the practical assessment at the same time.

Both students and staff experienced difficulties during online assessments due to a lack of proper devices, poor internet connection, electricity load shedding and limited knowledge of learning platforms. The facilitating factor to conducting online assessment was access to the internet and a computer at home (Montenegro-Rueda et al., 2021). The digital assessments were quite problematic for some students as they were expected to respond to the questions on the online space while they were unable to retrieve certain symbols and icons required in their responses to the assessments (Zitha et al., 2023).

Online assessment had challenges as there was poor monitoring which compromised the quality of education and students were cheating and the university had not yet invested in an electronic-proctoring system. The lecturers reported that they created critical thinking questions that required students to apply knowledge to prevent students from copying. Real-time invigilation is required to maintain and demonstrate

integrity of the online examination. Organizations need to use invigilator apps, or remote proctoring software, to supervise and ensure the integrity of online tests (Majola and Mudau, 2022; Montenegro-Rueda et al., 2021). The technology has advanced, and online assessments can be monitored, the university just needs to invest and implement the right tools.

The affordable and straightforward countermeasures for cheating practices among students in low resource settings during online examination include the identification of candidates, scanning the examination room and using video conferencing tools and close observation of the candidate's computer screen or monitor (Tuah and Naing, 2021). Biometrics is a very important method to identify people and therefore the university needs to ensure that every student passes a screening process before writing the examination (Majola and Mudau, 2022). Online assessments with proper monitoring tools are possible and the quality of education can be maintained. Students need to be reminded about the academic integrity policy and compelled to agree to it. Quality assurance in teaching and learning were among the reasons for universities to return to traditional classrooms when COVID-19 restrictions were lifted.

The findings above indicate that the initial stage of blended learning experience was unpleasant due to unpreparedness, lack of technological tools and the absence of training in LMSs. Paschal and Mkulu (2020), Mhlanga (2021) and Muhuro and Kangethe (2021) support the findings that the majority of students and lecturers indicated that online education is not effective and is not liked by many students and lecturers because of the lack of computers, lack of funds, insufficient facilities, shortage of electricity, poor network, inadequate skills, and the policies that were not supportive enough to implement online education in African universities. Since blended learning is a mixture of both online and face-to-face, the online challenges faced by both students and staff need to be addressed to improve acceptance and behavior towards blended teaching and learning.

Despite all difficulties students and staff agreed that blended learning was manageable. They finished the academic programmes and achieved their learning

outcomes.

5.3 Discussion on Research Question 2

What are the Resources and Skills that are Required by Biomedical Science Students and Staff for Blended Teaching and Learning in a Historically Disadvantaged University of Technology?

The findings of the current study suggest that the government and the university must provide proper infrastructure and digital resources to bridge the inequalities for blended learning to be sustainable. Funding for laptops was only given to students who had NSFAS, and the students who were not funded by NSFAS did not get assistance. Students and staff feel that the university can purchase laptops in bulk then give them to students in need at cost price and be added to the student fees. Offering laptops through NSFAS to students that cannot afford to buy laptops can bridge the digital divide. Motala and Menon (2020) indicated that NSFAS was utilized as a stand-in for the underprivileged by supplying laptop devices. Maintaining equity in the delivery of curricula is vital, and all electronic learning programmes ought to be accessible to all students (Mahaye, 2020).

Government should work towards ending electricity load shedding as blended learning is affected by this national crisis or exclude universities from load shedding. Load shedding had a negative impact on students' performance, grades, competencies, self-study, and ability to complete assignments or tests on time (Malik et al., 2022). The university must invest in alternative power supplies because load shedding is an ongoing problem, and it affects both online and face-to-face classes. Generators or solar panels may help supply power to all gadgets needed for academics, i.e., lighting, charging laptops, projectors, and laboratory equipment. If HEIs focus on the optimization of ICT infrastructure and software and promote ICT knowledge and sustainable values among users, the institutions can successfully implement blended education (Suleri and Zwaal, 2022).

The university and government have started addressing these issues in South Africa,

with some universities installing generators on campus which solves the electricity problems on campus but leaves a gap off campus which needs to be attended too. Pather et al. (2020) reported that prior to the COVID-19 pandemic, universities expanded the availability of on-campus learning resources, and students could utilize resources inside the campus environment to achieve effective academic outcomes. The focus is still more on campuses and COVID-19 taught everybody that the world can change in a minute, and that requires investing in infrastructure throughout the country to prepare for similar pandemics.

Staff would appreciate it if the university could invest in renovating classrooms. Smart classrooms will make blending much easier, with all gadgets being connected to Wi-Fi and communicating with each other (Figure 5.1). Lecturers can teach in smart classrooms while students are in residence, this may help correct the problem of small lecture halls. Staff would like renovation of offices; their offices do not have a ceiling and teaching online is difficult due to lack of privacy and noise disturbances. Teaching and learning environments are important. The challenges of blended learning were inadequacy, academic integrity, learning environment, and family burden (Bdair, 2021). Infrastructure problems, resource constraints, and curriculum deficiencies have negative effects on the blended learning model and pedagogy (Muhuro and Kangethe, 2021).

Mulyadi et al. (2020) confirms that flexibility to access and engage in academics tasks which allow learners to use the material at their own pace and learning creatively from several sources are perceived to be the most effective aspects of blended learning. Blended learning enables access of multiple and extensive reading materials which help students understand complex concepts associated with any subject (Irum et al., 2020).

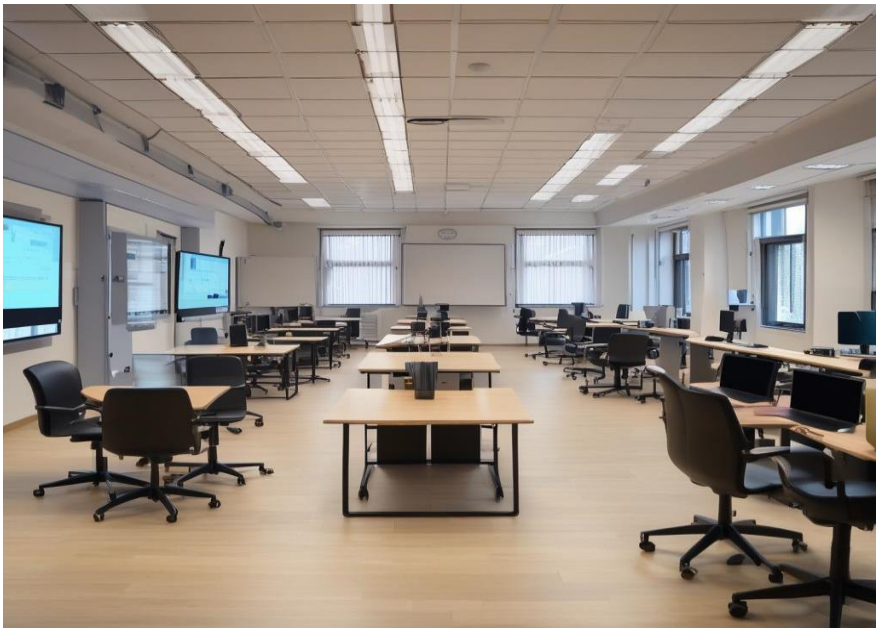

Figure 5.1 Smart classroom (DaVinci AI)

Equipping students and staff with digital skills may help improve blended learning and bridge digital disparities. Continuous training and support on various learning platforms may help students and staff work confidently. Findings support Gumede and Badriparsad's (2022) assessment that both lecturers and students require continual support and skills development during the transition from contact to online teaching and learning to deal with incidences such as the COVID-19 pandemic. Staff said there is ongoing training on Blackboard LMS facilitated by the Teaching, Learning and Development Community (TLDC) unit at MUT and there was continuous support, unfortunately, most training is done during timetabled time which limited academic staff from attending.

Training could be done during student registration or when students are on study leave so that academic staff can attend, preferably face-to-face where staff can have computers to practice onsite instead of online. An ICT support unit should be established to assist educators and students in acclimatizing to the new online learning environment (Sobaih et al., 2021). Teachers will embrace the change more readily if

they are trained and given the necessary support (Harris, 2017).

Instructional design training may help lecturers with identifying the specific blended teaching mode for each faculty, maximize benefits on best practices, tools, and resources to ensure trail-blazing blended teaching and learning. Students felt that lectures were long, sometimes they would fall asleep or do chores while attending online. In blended mobile learning, instructors should pay particular attention to instructional design, which includes objective identification, learner analysis, learning material design and development, and instructional evaluation (Sophonhiranrak, 2021).

Choosing a suitable instructional strategy depends on what will provide the right amount of balance between the interaction and integration of technology-based models in education (Megahed and Hassan, 2022). The educational approach towards a blended learning environment requires the learners to be actively involved, hence science educators within blended learning environments should accommodate instructional strategies and materials and assess students' science practical skills (Hinampas et al., 2018).

As students indicated that the online lessons were too long, hence they ended up doing chores or sleeping while online, instructional design could help with appropriate design shorten lesson, grasp students' attention, and achieve learning outcomes. Sophonhiranrak (2021) agrees with findings, that mobile learning does not only involve using mobile devices for transmitting information to learners, but instructors should also consider learners' learning styles, attitudes, or readiness for acceptance of mobile learning. Hence, analyzing the content, tools, objectives, and learners should be central for identifying how to deliver content, arrange activities, and conduct assessment (Sophonhiranrak, 2021). The scope and kind of content should determine appropriate types of media for transferring information to learners, as well as the length of each module or lesson (Sophonhiranrak, 2021).

COVID-19 and blended learning have provided opportunities for curriculum redesign and experimenting with new ways of teaching and learning in universities. The

instructional mix chosen by lecturers must achieve the module objectives. The findings of this study support those of Mahaye (2020) that this is the time for significant curriculum development and redesign. To provide the next generation with a planned course and direction, blended learning pedagogy is being phased in as a means of transitioning from the traditional classroom, which follows orthodox methods, to the digital classroom, which uses digital technology (Mahaye, 2020). Dahmash (2020) proposes that training workshops by people with expertise in blended learning approaches and strategies could address the issues related to instructors' performance.

Findings of Castro-Rodríguez et al. (2021) indicate that there is potential for improving online platforms and resources to allow for much more personalized learning, but better training in digital skills is necessary. Teachers and students must possess expert knowledge of navigating technology platforms used for implementing blended learning for effective online teaching (Angwaomaodoko, 2023). If HEIs focus on the optimization of ICT infrastructure and software and promote ICT knowledge and sustainable values among users, the institutions can successfully implement blended education (Suleri and Zwaal, 2022).

5.4 Conclusion

The findings revealed that both staff and students' digital skills improved during COVID-19, students bought laptops during COVID-19 blended learning, and they learnt the navigation of learning platforms. The blended learning achieved learning objectives during COVID-19. This study is providing information that may help the university to reflect and recalibrate blended learning to accommodate educational systems post COVID-19.

The stakeholders need to invest in proper resources and skills to fully maximize technology and enjoy the benefits of both forms of learning – traditional classroom and online. The resources needed are laptops for students who cannot afford to buy their own, alternative power supply that will supply electricity during load shedding for both online and traditional classes, renovation of lecture classrooms to smart classrooms

with improved internet connections, and investment in electronic-proctoring systems for online assessments monitoring. Staff and students need continuous training and skill on learning platforms to maximize the use of technology. Lecturers need training on instructional design to develop and redesign curricula that can utilize various digital technologies and enhance students' overall learning experience.

Planning and organizing blended learning within the biomedical science context with appropriate course structures and proper resources and skills may lead to different experiences, perceptions, and results. I hope the findings give insight into the experiences of blended learning in a university of technology and that these insights contribute evidence-based information that can help management with making decisions and policies needed by science students and staff in a university of technology.

5.5 Recommendations

- A study on virtual laboratories to identify those that are suitable for biomedical science.
- Management to invest and direct skills and resources to appropriate departments for improved blended learning.
- None of the staff or students knew about policies regarding blended learning. Management should ensure that there are policies in place that clearly state the responsibilities of both staff and students for smooth educational practice and improved quality assurance. Conduct research on educational policies in blended learning from a South African perspective.

5.6 Limitations

The limitations identified for this study are:

Narrow scope: the focus was only on biomedical science students and staff who studied online during COVID-19 at MUT. Results and solutions may differ with other

departments or faculties. The study was exploratory and targeted specific groups. Other researchers can conduct a study using a large quantitative design for generalizability.

Response rate: one of the limitations was the low response rate from students and staff. This could be due to invitations that were sent online via email, and some people may not have read the email. However, the sample was adequate to give robust information and valid results.

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APPENDICES

Appendix A: Letter of Information

LETTER OF INFORMATION

Title of the Research Study: The experiences of Biomedical Sciences students and staff in blended learning during the COVID-19 pandemic lockdown in a University of Technology, Durban, KwaZulu- Natal

Principal Investigator/s/researcher: Nonkululeko Ntimbane

Co-Investigator/s/supervisor/s: Dr P. Orton (supervisor) and Dr J. Mbatha (Co-supervisor)

Greetings to the participant,

My name is Nonkululeko Ntimbane, laboratory technician in Biochemistry laboratory, Faculty of Natural Science. I am a currently doing my Master of Health Sciences in Medical Laboratory Science with Durban University of Technology. The research study will explore and describe the experiences of Biomedical Science students and staff in blended learning during COVID-19 pandemic lockdown in a university of technology, in Durban Township,

KwaZulu-Natal. I would like to invite you to participate in the research, please read the information below, initial every page and sign where demarcated if you would like to participate.

Brief Introduction and Purpose of the Study:

Coronavirus disease (COVID-19) is an infectious disease that was first identified in China, Wuhan in December 2019 and started spreading to other countries across the world, hence it was declared a pandemic. The COVID-19 pandemic led to a dramatic loss of human life and many governments across the globe went into lockdown to mitigate the spread of the coronavirus. Border gates closed, domestic and international trade was disrupted, non-essential business including Higher Education Institutions were closed and where possible people worked from home.

South African universities have been forced by COVID-19 pandemic lockdown restrictions and protocols to transit from face-to-face to online learning (electronic learning), in a bid to save the 2020 academic year. Mangosuthu University of Technology decided to use blended learning along with the platoon system. The research aims to explore and describe the experiences of the students and staff in blended learning based on device availability, internet access, digital literacy and learning management system that was/ is being used during the COVID-19 pandemic lockdown, laboratory practical, assessments and academic performance.

This research primary question is “What is the experience of Biomedical Sciences students and staff in blended learning during Covid-19 pandemic?” Universities were not prepared for the emergent transition to online teaching and learning, all stakeholders are learning the online learning method while the academics programme is in progress. South African universities include a more diverse student population that come with challenges of extreme socio-economic inequality in terms of schooling, race, and language of communication as well as shortage of infrastructure.

The study will be done at Mangosuthu University of Technology (MUT), one of the historically disadvantaged universities of technology situated in Umlazi Township in Durban, KwaZulu-Natal. MUT services students from all 9 provinces of South Africa and beyond South African borders. Blended learning and platoon system have been used from year 2020 to date, it is not yet known when things will go back to normal, however number of students attending face-to-face varies with levels of lockdown, the lower the lockdown level, the higher the number of students permitted on campus for face-to-face teaching and learning. Students and staff were not assessed for their digital literacy before online classes, they did not have time to prepare for change.

The study aims to describe the experiences that Biomedical Sciences students and staff are facing with the new normal (blended learning and platoon system), identify challenges and areas of improvement that can form part of strategic plan (short-, medium- or long-term goals) and policy development. It may help increase and improve the use of technology at Mangosuthu University of Technology.

Research Methodology:

The research intends to interview minimum of 10 participants 7 students and 3 staff from Biomedical Sciences for about 6 – 8 months. The recruitment process will start in July where the researcher will explain the purpose of the research to the participant, read this informed consent form and the interviews will start once the participants have signed the consent form. The researcher will schedule the interview meetings with participants when the timetables are out, to ensure that the research does not interfere with academic processes. The researcher will have one - on – one in depth interview meeting with each participant for 1-hour session once a week. Interviews will be held in the researcher's office for confidentiality or in the participant's office where participant is staff and owns private office. The researcher will ask questions and write short-hand field notes of participant answers, follow-up questions may also arise from discussion. The interview will be recorded, then transcribed after the session.

Risks or Discomforts to the Participant:

The risk that may arise from the interview is emotional stress on students and staff that were affected negatively by blended learning system due to COVID-19 pandemic lockdown. Should you feel any emotional stress due to research study, please report to the researcher and you will receive assistance to organize counselling sessions with the institution

counselling services at 031 907 7186 or studentcounselling@mut.ac.za. You may decline to answer any or all questions and you may terminate your involvement at any time if you choose.

Withdrawal from the Study:

If you decide to take part in this study, you will be asked to sign a consent form. Your participation in this study is voluntary. Once the consent form is signed, the interviews will start, and you are free to withdraw at any time without giving a reason. Withdrawing from this study will not affect the relationship with the researcher, if any. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

Benefits:

The proposed research intends to improve the university education teaching and learning in Durban Township through description of Biomedical Science students and staff experience in blended learning. The results are expected to describe the benefits and risks of blended learning systems, possibly identifying areas that need improvement for the institution to produce students that are ready for industries and well equipped for the 4th industrial revolution.

Current and future students and staff may benefit directly or indirectly from the research study since the information will indicate issues that directly affect or affected participants, this may help the institution to:

1. Strategically plan teaching and learning tools that accommodates the University of Technology in a township, which works using the resources and expertise that the students and staff have.

2. identify areas where training is needed.

3. And the study may indicate areas that need investment of new resources in order for the institution to offer quality education to you as the participants, your peers and community.

Remuneration:

A token of appreciation will be given to you when we have concluded your interviews.

Costs of the Study:

You are not expected to incur any financial cost; the interview will take up approximately one of your time a session.

Confidentiality:

For the purposes of this research study, your comments will not be anonymous. Every effort will be made by the researcher to preserve your confidentiality including the following:

1. Assign code numbers for all who participate, that will be used on all research notes and documents.

2. Keeping notes, audio recordings, transcripts and any other document or file identifying participant information in a locked file cabinet in the researcher's office.

3. Adding password to open laptop or desktop computer, USB or file that identifies participants' information.

4. Documents and computer files will be stored for 5 years after finishing the research. Thereafter, the paper documents will be shredded and discarded through general waste, computer files will be deleted permanently by the researcher.

5. When the research protocol has been approved by Durban University of Technology Research and Ethics Committee, results will be shared with the participants and Mangosuthu University of Technology for feedback.

Results:

The researcher will give feedback on the results obtained via presentation to the participants and Biomedical Sciences Department management.

Research-related Injury:

The research study data collection method is not invasive; therefore, it does not pose any danger to the participants, except that they may be emotional stress that may arise especially to those participants that were negatively affected by blended learning during COVID-19 pandemic lockdown. Student counselling will assist in such cases, should there be any medical related problems, and the university clinic will be contacted for medical attention and treatment. There is no compensation for any injuries that might have been incurred during the research study.

Storage of all electronic and hard copies including tape recordings:

Hard copies and electronics will be stored under locked cabinets in the researcher's office. Computer / laptop and computer files will be encrypted.

Persons to contact in the Event of Any Problems or Queries:

If you have questions at any time about this study, or you experience adverse effects as the result of participating in this study, you may contact the researcher at 031 819 9458 or ntimbane.nonkululeko@mut.ac.za. If you have questions regarding your rights as a research participant, or if problems arise which you do not feel you can discuss with the Primary Investigator, please contact the supervisor at pennyo@dut.ac.za or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support Dr L Linganiso on 031 373 2577 or researchdirector@dut.ac.za.

Appendix B: Informed consent form

Informed Consent

Full Title of the Study: The experiences of Biomedical Sciences students and staff in Blended Learning during the COVID-19 pandemic lockdown in a University of Technology, Durban, KwaZulu- Natal.

Names of Researcher/s: Nonkululeko Ntimbane

Statement of Agreement to Participate in the Research Study:

 I hereby confirm that I have been informed by the researcher, Nonkululeko Ntimbane, about the nature, conduct, benefits, and risks of this study - Research Ethics Clearance.

 I have also received, read, and understood the above written information (Participant Letter of Information) regarding the study.

 I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

 In view of the requirements of research, I agree that the data collected during this study can be processed in a computerized system by the researcher.

- I may, at any stage, without prejudice, withdraw my consent and participation in the study.

- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

Full Name of Participant	**Date**	**Time**	**Signature/ Right Thumbprint**

I, Nonkululeko herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Full Name of Researcher	**Date**	**Signature**

Full Name of Witness (If applicable)	**Date**	**Signature**

Full Name of Legal Guardian (If applicable)	**Date**	**Signature**

Appendix C: Training certificate – Introduction to research ethics

Zertifikat
Certificado
Certificat
Certificate

TRREE

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Nonkululeko Ntimbane

a complété avec succès - has successfully completed

Introduction to Research Ethics

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Clinical Trials Centre
The University of Hong Kong

Release Date: 2023/08/28

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

APPROVED BY SIWF ISFM

FPH

Ce programme est soutenu par - This program is supported by :

Appendix D: Training certificate – Research ethics evaluation

TRREE

Zertifikat
Certificat
Certificado
Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Clinical Trials Centre
The University of Hong Kong

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Nonkululeko Ntimbane

a complété avec succès - has successfully completed

Research Ethics Evaluation

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Release Date: 2021/09/29
CID : QA8stTNJRY

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

FMH Continuing Education Program (5 Credits)
Programme de Formation Continue (5 Crédits)

Foederatio Pharmaceutica Helvetiae FPH Programmes de formation continue
Continuing Education Programme
Programmes de formation continue

Ce programme est soutenu par - This program is supported by :
European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (http://www.cihr-irsc.gc.ca/e/2891.html) - Swiss Academy of Medical Science (SAMS/ASSM/SAMW) (www.samw.ch) - Commission for Research Partnerships with Developing Countries (www.kfpe.ch)

[REV : 20170310]

Appendix E: Training certificate – Informed consent

Zertifikat
Certificado
Certificat
Certificate

TRREE

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Clinical Trials Centre
The University of Hong Kong

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Nonkululeko Ntimbane

a complété avec succès - has successfully completed

Informed Consent

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Release Date: 2021/10/29

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

FMH Continuing Education Program (5 Credits)
Programme de Formation continue (5 Crédits)

Foederatio Pharmaceutica Helvetiae FPH Programmes de formation continue
Continuing Education Programme
Programmes de formation continue

Ce programme est soutenu par - This program is supported by :
European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (http://www.cihr-irsc.gc.ca/e/2891.html) - Swiss Academy of Medical Science (SAMS/ASSM/SAMW) (www.samw.ch) - Commission for Research Partnerships with Developing Countries (www.kfpe.ch)

[REV : 20170310]

Appendix F: Certificate of attendance – Research integrity workshop

Appendix G: Letter of request MUT

UMLAZI KWAZULU-NATAL

P.O. Box 12363 Jacobs 4026 Durban

Tel: 031 907 7111

Department of Biomedical Sciences Management

Mangosuthu University of Technology

To Whom It May Be Concerned

RE: Request Permission to Conduct Research in Biomedical Sciences Department

I hereby request permission to conduct research methodology in the department of Biomedical Sciences for my master's degree in medical laboratory medicine. The topic is "The Experiences of Biomedical Sciences Students and Staff on Blended Learning during Covid-19 Pandemic lockdown in a university of Technology, Durban, KwaZulu-Natal. The research aims to describe and explore experiences of students and staff on blended learning based on device availability, internet access, and digital literacy, learning management system that was / is used during Covid-19 pandemic lockdown, laboratory practical, assessments and academic performance.

The research intends to interview a minimum of 10 participants 7 students and 3 staff members from Biomedical Sciences for about 6 – 8 months, the number may increase until the study reaches data saturation. The recruitment process in July then once informed consent has been signed by participants, the interviews will start. I will schedule meetings with participants when the timetables are out to ensure that the research does not interfere with academic processes.

The proposed research intends to benefit the University of Technology Stakeholders through describing and increasing knowledge on the phenomena thus improving the quality of teaching and learning.

Please let me know if you needed more information, I would also like to arrange a meeting with the head of the Biomedical Sciences department at ones earliest

convenient time.

Regards,

Nonkululeko NtimbaneLaboratory Technicians (FNS Labs- Office of the Dean) ext. 9458

Appendix H: Ethical clearance DUT

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

16 October 2023

Ms N P Ntimbane
24 Mpingizane Road
Bufferstrip
Pietermaritzburg
3201

Dear Ms Ntimbane

The experiences of Biomedical Sciences students and staff in blended learning during the COVID-19 pandemic lockdown in a University of Technology in Durban, KwaZulu-Natal
Ethical Clearance number IREC 016/23

The DUT-Institutional Research Ethics Committee acknowledges receipt of your gatekeeper permission letter.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the DUT-IREC according to the DUT-IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the DUT-IREC as outlined in the DUT-IREC SOP's.

It is compulsory for a student or researcher to apply for recertification on an annual basis. The failure to do so will result in withdrawal of ethics clearance. It is the responsibility of the researcher and the supervisor to apply for recertification.

Please note that you are required to submit a Notification of Completion of Study form together with an abstract to the DUT-IREC office on completion of your study.

Yours Sincerely

Prof J K Adam
Chairperson: DUT-IREC

Appendix I: Ethical clearance MUT

MUT
MANGOSUTHU
UNIVERSITY OF TECHNOLOGY

Research Directorate

UMLAZI KWAZULU-NATAL
PO Box 12363 Jacobs 4026 Durban
Tel: 031 907 7450

10 October 2023

REF: RD1/16/2023

Mrs Nonkululeko Ntimbane
Mangosuthu University of Technology

Dear Mrs Ntimbane

PROTOCOL: 'The experiences of biomedical sciences students and staff in blended learning during COVID-19 pandemic lockdown in a University of Technology in Durban, KwaZulu-Natal.'

The MUT Research Ethics Committee considered your application at their meeting held on 18 September 2023. It is my pleasure to inform you that permission to conduct the research project above was granted.

The approval is valid for two years from 18 September 2023. Any changes to the project must immediately be brought to the attention of the MUT Research Ethics Committee.

Your acceptance of this approval denotes your compliance with South African National Research Ethics guidelines (2004) and the MUT Research Ethics Policy, Procedures and Guidelines.

Good luck with your research.

Yours sincerely

Dr A Mienie
Director: Research

1

Appendix J: Students interview schedule

Students Interview Schedule

1. Please tell me about your experience of blended learning during COVID-19. How was your experience based on the following?

   1.1 Infrastructure: gadget i.e., laptop, computer, smartphone (accessibility and cost), electricity, load shedding

   1.2 Internet: accessibility (WI-FI and/or data), cost, connectivity

   1.3 Digital skills: how is your knowledge in computers?

2. Please take me to your experience on learning management system (LMS)?

   2.1 Learning platform used for content delivery and lecturing? Moodle, Blackboard, Google Classroom, Zoom, Microsoft Teams, YouTube videos?

   2.2 Training and support provided.

   2.3 Any social media platforms for educational purposes (WhatsApp, Facebook)?

3. Please share your experience on laboratory practical experiments conducted during COVID- 19 lockdown?

   3.1 Practical tests or exam?

4. How was your experience in online assessment?

   4.1 Online activities: group activities, tutorials, assignments, tests and exams?

5. Do you have any suggestions/ comments on skills and resources needed for blended learning?

Appendix K: Staff interview schedule.

Staff Interview Schedule

1. Please tell me about your experience on infrastructure during blended teaching and learning

   1.1 Internet connection

   1.2 Electricity load shedding

   1.3 Platoon system

2. Please share your experience on Content Delivery and Learning management systems

   2.1 Moodle, Blackboard, Google classroom, Zoom, Microsoft Teams?

   2.2 Any training or support experience provided on LMS?

3. Please share your experience on laboratory practical experiments

   3.1 How did you conduct experiments? Videos, YouTube, Virtual – assimilations?

   3.2 How would you describe the acquired laboratory skills – techniques during lockdown?

   3.3 Laboratory practical tests and exams?

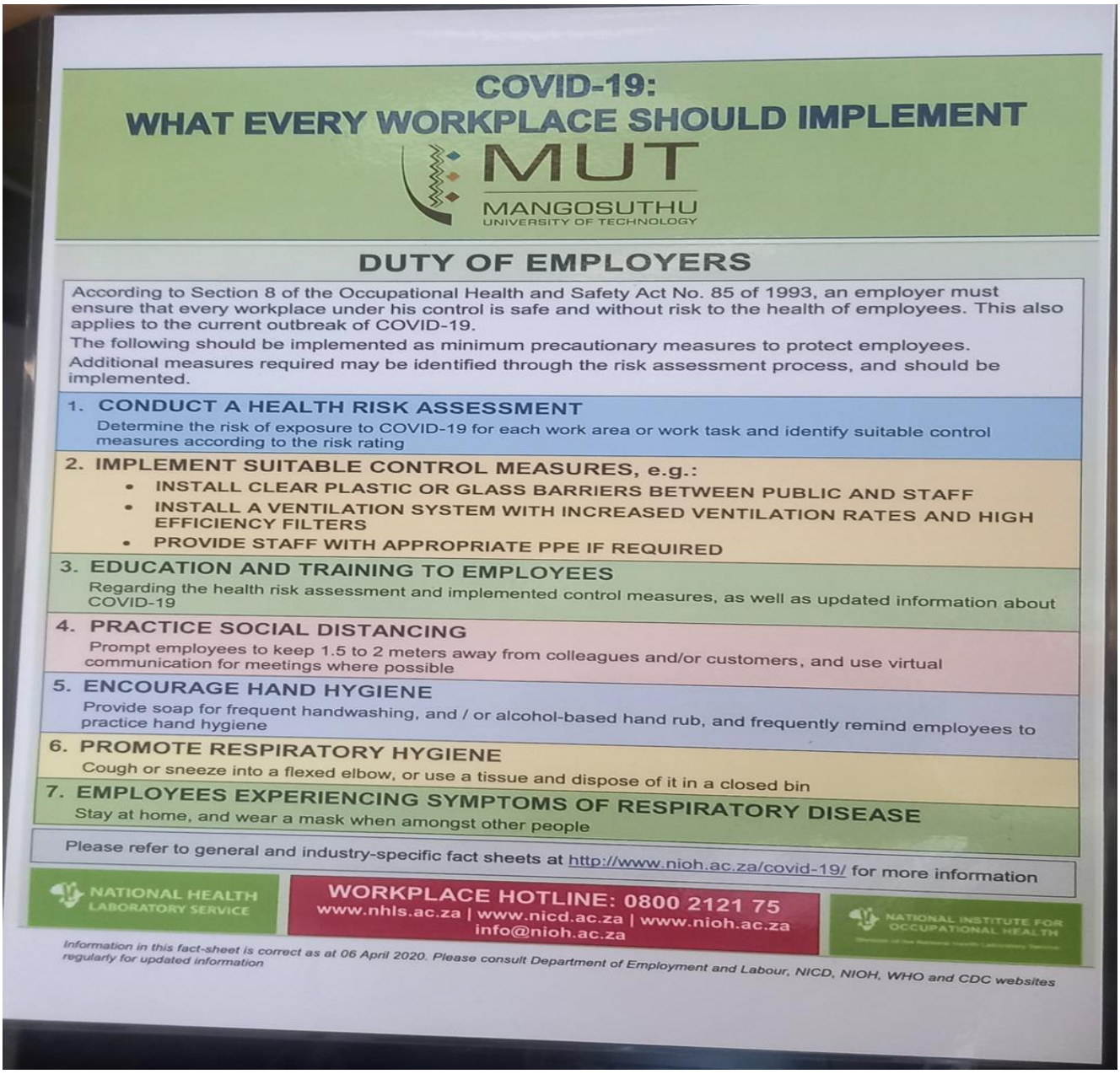
4. Assessment

   4.1 How did you conduct assessments during COViD-19 lockdown? Group activities, tutorials, assignments, tests, and exams?

5. Are there policies in place guiding the staff and students of blended learning and do those policies accommodate Biomedical Sciences?

6. Do you have any suggestions or comments on skills and resources required for blended learning?

Appendix L: COVID-19 safety – Duty of employers



COVID-19:
WHAT EVERY WORKPLACE SHOULD IMPLEMENT

MUT
MANGOSUTHU
UNIVERSITY OF TECHNOLOGY

DUTY OF EMPLOYERS

According to Section 8 of the Occupational Health and Safety Act No. 85 of 1993, an employer must ensure that every workplace under his control is safe and without risk to the health of employees. This also applies to the current outbreak of COVID-19.

The following should be implemented as minimum precautionary measures to protect employees.

Additional measures required may be identified through the risk assessment process, and should be implemented.

1. CONDUCT A HEALTH RISK ASSESSMENT
   Determine the risk of exposure to COVID-19 for each work area or work task and identify suitable control measures according to the risk rating
2. IMPLEMENT SUITABLE CONTROL MEASURES, e.g.:
   - INSTALL CLEAR PLASTIC OR GLASS BARRIERS BETWEEN PUBLIC AND STAFF
   - INSTALL A VENTILATION SYSTEM WITH INCREASED VENTILATION RATES AND HIGH EFFICIENCY FILTERS
   - PROVIDE STAFF WITH APPROPRIATE PPE IF REQUIRED
3. EDUCATION AND TRAINING TO EMPLOYEES
   Regarding the health risk assessment and implemented control measures, as well as updated information about COVID-19
4. PRACTICE SOCIAL DISTANCING
   Prompt employees to keep 1.5 to 2 meters away from colleagues and/or customers, and use virtual communication for meetings where possible
5. ENCOURAGE HAND HYGIENE
   Provide soap for frequent handwashing, and / or alcohol-based hand rub, and frequently remind employees to practice hand hygiene
6. PROMOTE RESPIRATORY HYGIENE
   Cough or sneeze into a flexed elbow, or use a tissue and dispose of it in a closed bin
7. EMPLOYEES EXPERIENCING SYMPTOMS OF RESPIRATORY DISEASE
   Stay at home, and wear a mask when amongst other people

Please refer to general and industry-specific fact sheets at http://www.nioh.ac.za/covid-19/ for more information

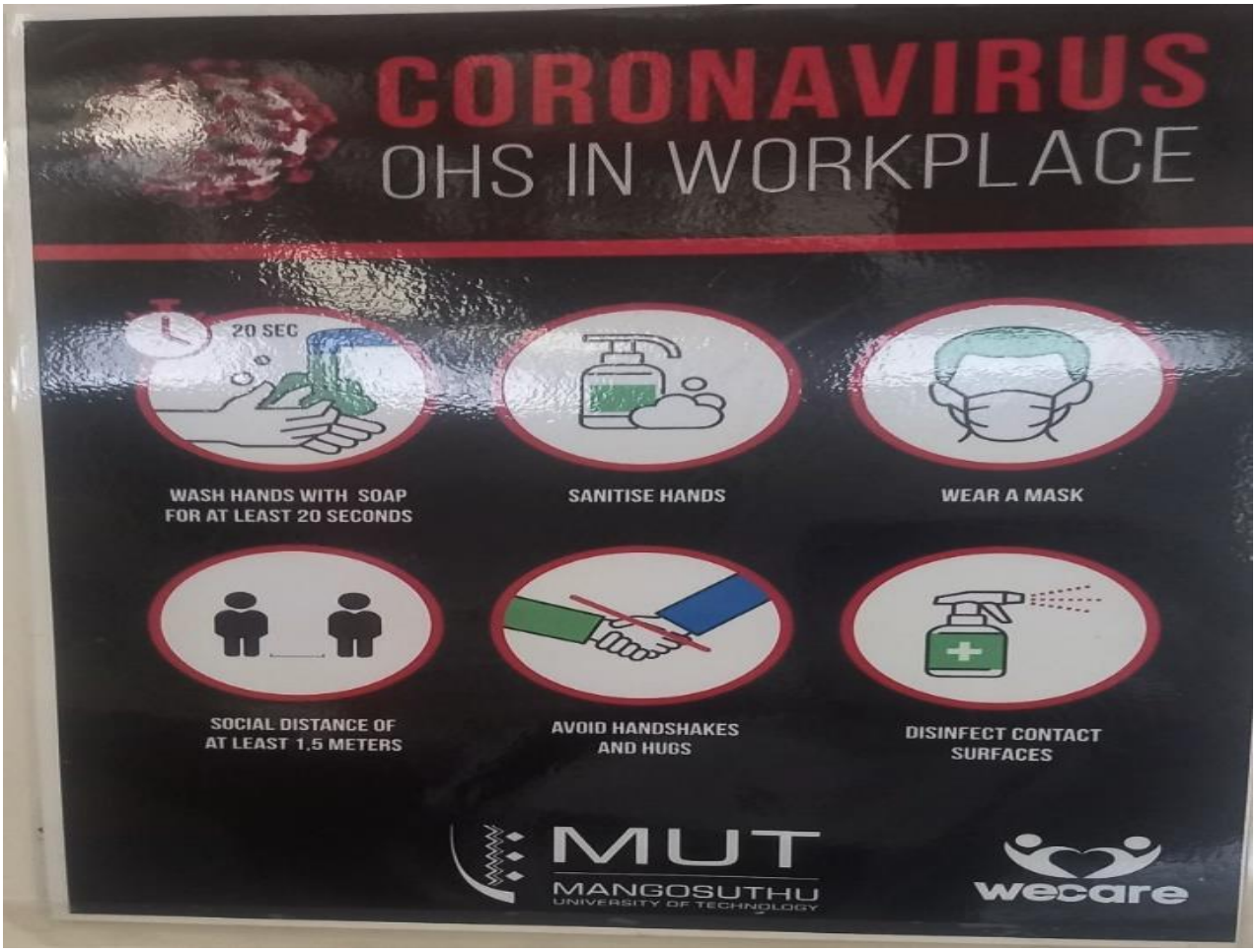
NATIONAL HEALTH LABORATORY SERVICE

WORKPLACE HOTLINE: 0800 2121 75
www.nhls.ac.za | www.nicd.ac.za | www.nioh.ac.za
info@nioh.ac.za

NATIONAL INSTITUTE FOR OCCUPATIONAL HEALTH

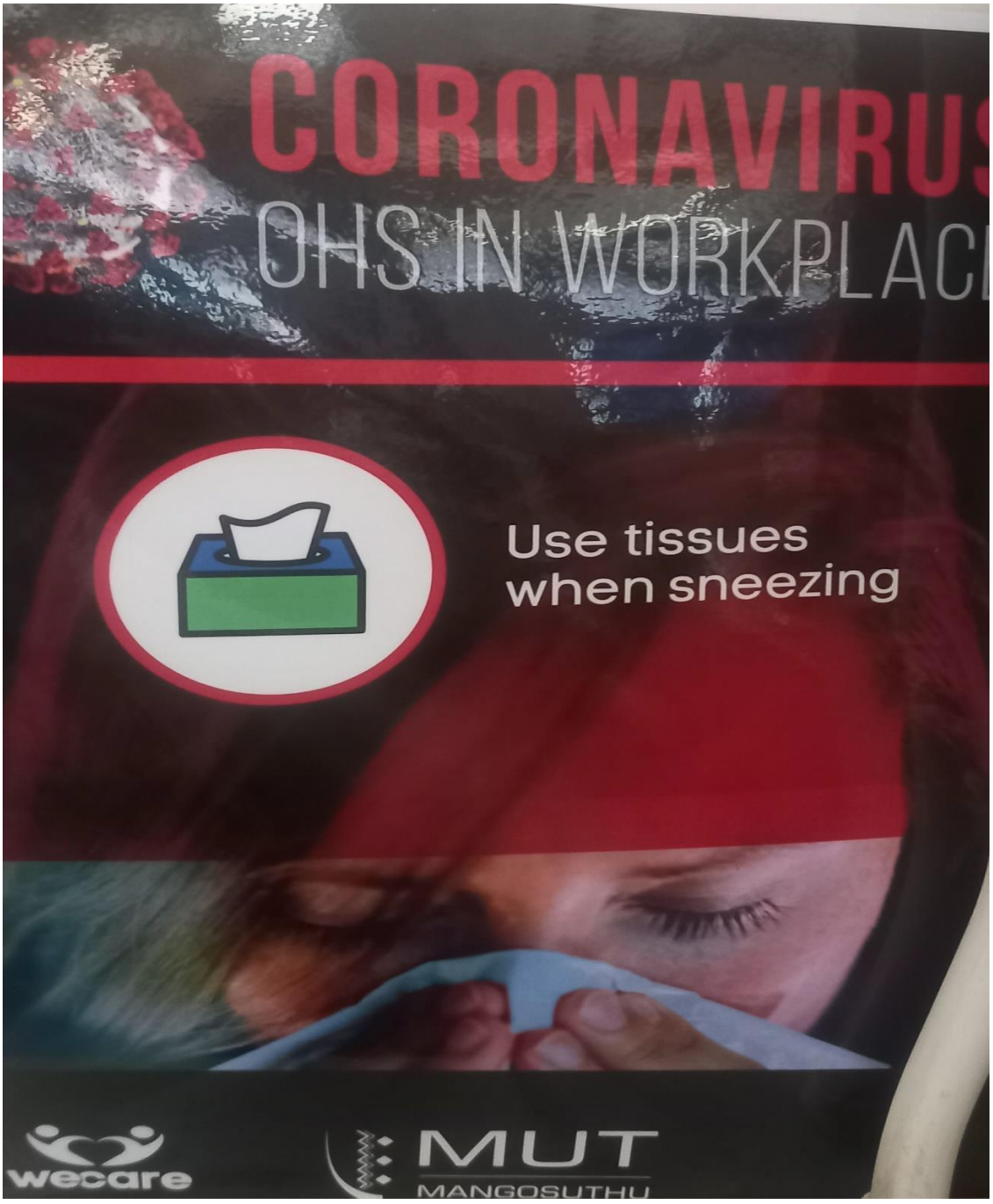
Information in this fact-sheet is correct as at 06 April 2020. Please consult Department of Employment and Labour, NICD, NIOH, WHO and CDC websites regularly for updated information

Appendix M: Coronavirus OHS in workplace (1)



Appendix N: Coronavirus OHS in workplace (2)

Appendix O: Coronavirus OHS in workplace (3)



Appendix P: Social distancing

Appendix Q: Foot operated sanitizing stand

Appendix R: Foot operated sanitizer hallway

Appendix S: Clear plastic installed on desks

Appendix T: Editing Certificate

DR RICHARD STEELE
BA HDE MTech(Hom)
HOMEOPATH
Registration No. A07309 HM
Practice No. 0807524
Freelance academic editor
Associate member: Professional Editors' Guild, South Africa

154 Magenta Place
Gxarha [Morgan Bay]
5292
Eastern Cape

082-928-6208
rsteele@vodamail.co.za
rsteele201@outlook.com

EDITING CERTIFICATE

Re: **Nonkululeko Protasia Ntimbane**
DUT master's dissertation: **The Experiences of Biomedical Sciences Students and Staff in Blended Learning During the COVID-19 Pandemic Lockdown in a University of Technology in Umlazi Township, Durban, KwaZulu-Natal**

I confirm that I have edited this dissertation and the references for clarity and language. I returned the document to the author with track changes so correct implementation of the changes and clarifications requested in the text and references is the responsibility of the author. I am a freelance editor specialising in proofreading and editing academic documents. My original tertiary degree which I obtained at the University of Cape Town was a B.A. with English as a major and I went on to complete an H.D.E. (P.G.) Sec. with English as my teaching subject. I was a part-time lecturer in the Department of Homoeopathy at the Durban University of Technology for 13 years and supervised many master's degree dissertations during that period.

Dr Richard Steele
22November 2024
per email