



Students' Perceptions of Digital Technologies' Efficiency for Research During and Before the COVID-19 Era

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Abstract

The COVID-19 pandemic catalysed a rapid shift towards the use of digital technologies in higher education. This prompted the need to explore how digital technologies are used in academic research, propelling a critical examination of their efficiency for postgraduate research purposes. This mixed-methods study investigated students' perceptions of digital technologies' efficiency for research during and before the COVID-19 era in two universities in South Africa. A simple random sampling method was utilised to recruit fifty (50) postgraduate student respondents who completed a survey questionnaire designed to capture their perceptions. The survey instrument included items that assessed the ease of access, usability, and overall satisfaction with digital technologies both before and during the pandemic. The quantitative analysis revealed notable shifts in perceptions between the two time periods where participants generally reported an increase in reliance on digital technologies during the COVID-19 period. The increased use of digital technologies as indicated by participants improved access to online databases and other research environments. Nonetheless, challenges such as lack of user training, and technical issues were also highlighted. This study recommends that universities develop user-friendly guides to aid students in independently understanding the use of digital technologies, thus encouraging efficiency whilst promoting self-directed learning.

Keywords: Academic research, COVID-19 pandemic, Digital technologies, South Africa, Student perceptions

Introduction and background

The advent of the COVID-19 pandemic in Higher Education created more space for the use of digital technology. In South Africa, the effects were overwhelming, as face-to-face classes were cancelled, students were sent home and classes suddenly had to be conducted online (Munyanyo, & Simuja, 2024). As a result, students used digital technologies to engage in various academic activities, including postgraduate research projects. The emergency adoption of digital technologies in many South African universities was challenging as the full shift to online modes of instruction occurred hurriedly and unexpectedly. This is further emphasised by Nikou and Aavakare (2021) who assert that due to the COVID-19 epidemic in higher education contexts, conventional teaching and learning have become obsolete. When the pandemic struck, higher

education institutions, like many other sectors, were already grappling with digitalisation and trying to figure out the best ways to utilise and enjoy the benefits of digital technologies (Khoza, 2022). These benefits include connecting with students in different locations, and access to learning content online (Rabah 2015; Gupta et al. 2020; Biccard & Meeran, 2024). As a result of COVID-19, higher education has had to undergo considerable transformations (Skulmowski & Rey 2020; Ndlovu et al 2022). Many universities have already begun making changes in response to this advent challenges posed by COVID-19 (Ndebele & Mlambo, 2021). Efforts are being made to improve digital technologies and adjust academic courses to get the best possible outcomes in teaching, learning, and research practices.

Blackboard and Moodle, two popular Learning Management Systems (LMSs), have been adopted by many academic institutions.

Although many universities in South Africa have previously implemented these LMSs, they have only lately established a reputation as important instruments in the area of education (Rachmadtullah et al. 2020). When it comes to creating, deploying, and maintaining completely digital educational technologies, LMSs play a critical role. Interestingly, the use of established and widely known digital technologies did not always take recent research results into account (Mpungose, 2020; Mpungose & Khoza, 2022). Many questions remain unanswered, such as how academics and students choose to incorporate digital learning, what reasons influenced their decisions, and how they assess their usage of digital technologies. In light of the COVID-19 pandemic's potential impact on higher education in the long term, there is an urgent need for a study to explore and provide relevant recommendations for these ambiguities, particularly for postgraduate research students. This study aimed to answer the two following research questions:

1. What determined students' perceptions of digital technologies' efficiency for research during and before the COVID-19 era?
2. How did students perceive the efficiency of digital technologies for research during and before the COVID-19 era?

Literature review

Digitalising teaching, learning, and research practices in higher learning institutions

Diversity in the student population has emerged from increased access to higher education, which has resulted in a more diverse student body with a broad variety of learning styles and demands. Concerning globalisation and the information economy, higher education institutions have adapted their curricula and teaching processes to equip students with 21st-century skills and competencies for the workforce (Kpolovie & Lale, 2017). There also have been calls for more effectiveness, greater accountability, and improved research and teaching outcomes (Lai, 2011; van Loon et al., 2012). In higher education contexts, active learning and digital learning material need a clear framework otherwise, the students may feel overwhelmed by

it (Winkelmes et al., 2023). Over the last two decades, there has been minimal change in the way students learn in higher education. Universities have used digital technology in a wide variety of ways throughout this period. This is in part due to the inclination of employees to drive innovation rather than rely on strategic efforts by university leadership. Most educational institutions have responded by providing a basic degree of technology-enhanced learning to fulfil the expectations of teams and students (Tsui et al, 2024; Makumane, et al, 2022). Virtual learning environments, online material, plagiarism detection, and electronic assignment submission are some of the most common components of digitalised learning.

The use of digital technologies in higher education research practices

The use of digital technologies in higher education institutions has transformed the landscape of teaching, learning, and research. In the context of this study, digital technologies refer to the electronic systems, tools or platforms that postgraduate students use to generate, process, and store data for their research projects (Daramola et al., 2024; Mhlongo et al., 2023; Sokhulu, 2021). As such, digital technologies have revolutionised the way students conduct research, transforming the landscape of academic inquiry. Digital technologies have also proven to enhance student engagement, accessibility, and flexibility (Bates, 2015). Thus, higher education institutions have adopted various digital tools, including learning management systems (LMSs), massive open online courses (MOOCs), and multimedia resources to communicate with postgraduate students and upload research material online (Sokhulu, 2021; Khoza, 2017; Hew & Cheung, 2014). Such use of digital technologies can result in improved student outcomes, increased efficiency, and enhanced research practices (Katz, 2013).

However, challenges persist, including technical issues, digital divides, and concerns about academic integrity (Katz, 2013; Czerniewicz & Feldman, 2024). Further to this, Bates (2015), Dichev and Dicheva (2017) and Zawacki-Richter et al (2019) suggest that faculty training and

support are essential for effective digital technology integration so that postgraduate students use them innovatively and with integrity. Nevertheless, student characteristics, such as age, experience, and motivation, also impact digital technology adoption (Hew & Cheung, 2014). In postgraduate studies, there is often a diverse group of students ranging across different ages, socio-economic backgrounds and digital competencies (Sims et al., 2008). Likewise, Selwyn (2014) asserts that the use of digital technologies for research has varied widely based on users' level of study, delivery mode, age, and educational settings. The diversity in student backgrounds contributes to the perpetuation of the digital divide (Czerniewicz et al., 2020). Since students engage and perceive these digital technologies in different ways, their experiences become complex and multifaceted. Moreover, in this COVID-19 era university students were compelled to use digital technologies throughout their undergraduate and postgraduate studies, therefore necessitating the need to examine their perceptions more thoroughly (Makumane et al., 2022). This study is significant because it presents students' perceptions to understand how the use of digital technologies impacted their research during and before the COVID-19 era. Furthermore, the findings can guide educational institutions in developing policies and practices that are responsive to student needs and challenges regarding digital technologies.

Students' perceptions regarding the use of digital technologies in research

Integrating digital technologies into research has transformed how postgraduate students conduct academic studies. In this study's context, students' perceptions of digital technologies relate to the attitudes and beliefs that students hold regarding the use of digital tools. These perceptions encompass students' views on the effectiveness, ease of use, availability, affordability and overall value of digital technologies in facilitating their research. Before COVID-19, digital technologies were increasingly being adopted in research, enhancing productivity and collaboration (Sife et al., 2017). However, the pandemic accelerated this adoption, necessitating a shift to online research methods (Azubuike,

2020; Sokhulu, 2023). Studies have thus highlighted positive and negative perceptions among postgraduate students regarding digital technologies' efficiency.

On the one hand, positive perceptions of digital technologies include several key benefits and advantages. Students' reflections on the enhanced flexibility and accessibility are frequently highlighted, as noted by Azubuike (2020), allowing them to engage with research content at their convenience and from various locations. Improved collaboration and communication are also significant benefits, as emphasised by students in Ifijeh et al. (2020) study, fostering more interactive and cooperative learning environments. Additionally, there is increased access to academic resources, a benefit identified by Mutula and Van Brakel (2018) and Daramola et al (2024) which provides postgraduate students with a broader range of materials and tools to support their research endeavours. These aspects collectively contribute to a more effective research experience and increased self-efficiency in using digital technologies (Daramola et al., 2024; Steenkamp & Van Schalkwyk, 2023).

On the other hand, negative perceptions of digital practices often revolve around several challenges that impact the efficiency of digital technology adoption. Technical issues and digital distractions are notable concerns, as identified by Azubuike (2020), which can slow down the research process and report writing progress of postgraduate students. Another significant challenge is information overload and the difficulties associated with evaluating the credibility of online sources, a challenge highlighted in a study conducted by Nwachukwu and Eze (2020). Such challenges negatively impact postgraduate students' research and learning outcomes as they limit their digital competence and marginalise their educational experience (Daramola et al., 2024). This can further lead to frustrations and hinder the ability to determine the value of research information. Additionally, the digital divide and unequal access to digital technologies, as discussed by Akindele and Ojo (2020), Czerniewicz et al (2020), Mahlaba and Sekano (2023), and Faloye and Ajayi (2022),

magnify educational inequalities by limiting opportunities for those without adequate technological resources. These factors collectively present substantial barriers to the success of digitalised research practices in higher education.

Interestingly, some studies suggest that the pandemic has fostered some innovative uses of digital technologies for research, such as virtual experiments and simulations (Okeke & Ezeugwu, 2020). Despite these benefits, concerns persist regarding digital literacy skills, unequal access, and the need for training and support for students (Nwachukwu & Eze, 2020). Given these varied perceptions, further research is needed to fully understand the efficiency of digital technologies for postgraduate research, both during and before the COVID-19 pandemic.

Research design and Methodology

Research approach, design and sampling

This study employed a mixed-methods research approach to investigate students' perceptions of digital technologies' efficiency for research before and during the COVID-19 pandemic. The mixed-methods approach allowed for both quantitative and qualitative data collection and analysis, providing a comprehensive understanding of the research topic (Creswell, 2024). However, the results used for this study only reflect data obtained quantitatively using student responses from an online survey questionnaire. The participants recruited in this study were postgraduate students from two universities in KwaZulu-Natal, South Africa. A simple random sampling method was employed to ensure a diverse and equal representation of students and postgraduate academic levels (Honours, Masters, and Doctoral) from the two universities. This sampling method aided in capturing dynamic perceptions of 50 postgraduate students regarding the efficiency of digital technologies in research during and before the COVID-19 era.

Data collection method

Data collection was conducted through a structured online questionnaire administered to the participants. The survey instrument was designed

to gather quantitative data on postgraduate students' perceptions of digital technologies' efficiency in research, including measures such as *availability, accessibility, ease of use, user training, affordability, connectivity, and satisfaction* with various digital technologies. Closed-ended questions were included to produce quantitative results regarding students' perceptions. Before distribution, the questionnaire underwent pilot testing with a small group of students to refine wording, ensure relevance of questions and provide clear instructions. This process validated the survey questionnaire instrument and enhanced its reliability. Participants were invited to complete the questionnaire electronically via each university notice system. The survey period spanned from September 2022 to June 2023 allowing for sufficient data collection to get a sufficient number of responses to produce adequate quantitative results.

Data analysis

Quantitative data were analysed using descriptive statistics to summarise participants' responses and assess changes in perceptions over time. Ethical approval for this study was obtained from both University 1 and 2 Ethics Committees in the 2022 academic year, ensuring that all procedures adhered to ethical standards and protected participants' confidentiality and anonymity throughout the research process.

Results

Table 1 summarises the sample's demographic data and also highlights their digital skills. Participants were from 2 universities – University 1 – a historically white-only institution and University 2 a historically black-only university. The 50 participants were evenly split between male and female. Regarding age distribution, the majority of respondents fell within the 21-25 age group, comprising 42% of the sample, followed by those below 20 (22%), 26-30 (20%), and above 30 (16%). In terms of educational institutions, the participants were divided between two universities, with 48% from University 1 and 52% from University 2.

Sample's descriptive data

Table 1: Descriptive summary – sample characteristics

		Frequency	Valid Percent
Gender	Male	25	50
	Female	25	50
	Total	50	100
Age	Below 20	11	22
	21-25	21	42
	26-30	10	20
	Above 30	8	16
	Total	50	100
I study at the following university	University 1	24	48
	University 2	26	52
	Total	50	100
Which college/Faculty are you registered with?	Humanities	24	48
	Comm./Management	3	6
	Law/Pub. Admin	22	44
	Education	1	2
	Total	50	100
What is your highest attained educational level?	Bachelors and below	9	18
	Honours	18	36
	Masters	17	34
	PhD/Doctorate	6	12
	Total	50	100
How many years of work experience do you have in academics?	0-2 years	26	52
	3-5 years	14	28
	6 and + years	10	20
	Total	50	100
How would you rate your digital skills?	Beginner	3	6
	Intermediate	22	44
	Competent	22	44
	Very competent	3	6
	Total	50	100

Source: Authors own construction (2023)

In terms of college or faculty which they came from the largest proportion of respondents, at 48%, belong to the Humanities, followed by Law/Public Administration at 44%. A smaller percentage was distributed between Commerce/management (6%) and Education (2%). Regarding the highest attained educational level, the majority of respondents held an Honours degree (36%), followed by Masters (34%), Bachelor and below (18%), and PhD/Doctorate (12%). In terms of work experience in academics, the largest group, at 52% of the sample had 0-2 years of experience, followed by 3-5 years (28%), and 6 and more years (20%). Lastly, when it came

to digital skills, the majority of respondents rated themselves as either intermediate (44%) or competent (44%), with smaller percentages identifying as beginners (6%) or very competent (6%).

Satisfaction levels with current digital technologies - descriptive

Table 2 shows the mean scores for different digital technologies and how they differed (1) between University 1 and University 2 and between the pre (BC) and during (DC) Covid-19 periods. The mean scores were derived from a 5-scale Likert scale and can be interpreted as

follows: Very low satisfaction (1.00 – 1.79), low (1.80 – 2.59), neutral (2.60 – 3.39), high (3.40 – 4.19) and very high (4.20 – 5.00).

In terms of learning management systems (LMSs), University 1 demonstrated high satisfaction levels across both the pre-COVID (BC) and during COVID (DC) periods, with mean scores of 3.38 (SD=1.00) and 3.38 (SD=0.97) respectively. Conversely, University 2 exhibited low satisfaction levels with LMSs, with mean scores of 2.93 (SD=0.99) in the BC period and 2.98 (SD=0.94) in the DC period across both periods. These results concur with Azubuike

(2020) and Ifijeh et al. (2020) sentiments that there are positive perceptions of digital technologies that include several key benefits and advantages. Such as students’ reflections on the enhanced flexibility and accessibility are frequently highlighted, allowing them to engage with research content at their convenience and from various locations. Furthermore, Mutula and Van Brakel (2018) and Daramola et al. (2024) argue that increased access to academic resources provides postgraduate students with a broader range of materials and tools to support their research endeavours.

Table 2: Satisfaction levels with current digital technologies – descriptive

Digital technology	University	Before (BC)		During (DC)	
		Mean	SD	Mean	SD
Learning management systems	University 1	3,38	1,00	3,38	0,97
	University 2	2,93	0,99	2,98	0,94
Online classrooms/Teams	University 1	3,29	1,09	3,28	1,08
	University 2	3,01	0,96	3,08	0,90
Messaging/Communication systems	University 1	3,44	1,01	3,41	0,96
	University 2	3,28	0,93	3,32	0,91
Referencing systems	University 1	3,38	1,08	3,36	1,02
	University 2	3,15	1,02	3,15	0,99
Free online journal/article/thesis databases	University 1	3,39	1,03	3,37	1,00
	University 2	3,26	0,99	3,34	0,99
Paid online journal/article/thesis databases	University 1	2,74	1,19	2,81	1,16
	University 2	2,71	1,01	2,86	0,97
Plagiarism checking systems	University 1	3,04	1,16	3,08	1,11
	University 2	3,13	1,09	3,11	1,02
Grammar/language use systems	University 1	3,20	1,11	3,23	1,06
	University 2	3,15	1,01	3,18	0,96
General internet websites	University 1	3,44	1,07	3,44	1,05
	University 2	3,29	1,01	3,30	0,93
Statistical and data analysis systems	University 1	2,86	1,22	2,83	1,15
	University 2	2,99	1,00	3,08	1,02
Online data collection systems	University 1	3,04	1,17	3,09	1,10
	University 2	3,04	1,06	3,13	1,06
Journal/article submission systems	University 1	2,94	1,17	3,03	1,14
	University 2	2,87	1,00	2,96	0,94

Source: Authors own construction (2023)

Learning management systems

Online Classrooms/Teams

On online classrooms/teams, University 1's satisfaction perception was neutral, showing little change between BC and DC, with mean scores of 3.29 (SD=1.09) and 3.28 (SD=1.08) respectively. However, University 2's satisfaction

with these systems increased slightly during the DC period, moving from a low to a neutral level of satisfaction, with mean scores of 3.01 (SD=0.96) in the BC period and 3.08 (SD=0.90) in the DC period.

Messaging/Communication systems

In messaging/communication systems, University 1 consistently showed high satisfaction levels, with mean scores of 3.44 (SD=1.01) in the BC period and 3.41 (SD=0.96) in the DC period. In contrast, University 2 remained neutral, with marginal improvements in satisfaction observed in the DC period, with mean scores of 3.28 (SD=0.93) in the BC period and 3.32 (SD=0.91) in the DC period. Overall, this shows satisfaction with the use of digital technologies, which is in line with Katz, (2013) who concur that the use of digital technologies can result in improved student outcomes, increased efficiency, and enhanced research practices.

Referencing systems

For referencing systems, both University 1 and University 2 exhibited neutral satisfaction levels, with University 1 maintaining a slightly higher level of satisfaction than University 2, which remained relatively stable across both periods. University 1 had mean scores of 3.38 (SD=1.08) in the BC period and 3.36 (SD=1.02) in the DC period, while University 2 had mean scores of 3.15 (SD=1.02) in the BC period and 3.15 (SD=0.99) in the DC period.

Free online journal/article/thesis databases

Regarding free online journal/article/thesis databases, University 1 consistently demonstrated high satisfaction levels, with mean scores of 3.39 (SD=1.03) in the BC period and 3.37 (SD=1.00) in the DC period. University 2 showed an increase from high to very high satisfaction during the DC period, with mean scores of 3.26 (SD=0.99) in the BC period and 3.34 (SD=0.99) in the DC period.

Paid online journal/article/thesis databases

Paid online journal/article/thesis databases saw both universities rating them at a low to neutral satisfaction level across both periods. University 1 had mean scores of 2.74 (SD=1.19) in the BC period and 2.81 (SD=1.16) in the DC period, while University 2 had mean scores of 2.71 (SD=1.01) in the BC period and 2.86 (SD=0.97) in the DC period.

Plagiarism checking digital technologies

In plagiarism-checking digital technologies, University 1's satisfaction remained low, with slight improvement during the DC period, while University 2's satisfaction remained neutral across both periods. University 1 had mean scores of 3.04 (SD=1.16) in the BC period and 3.08 (SD=1.11) in the DC period, while University 2 had mean scores of 3.13 (SD=1.09) in the BC period and 3.11 (SD=1.02) in the DC period.

Grammar/language use technologies

Postgraduates from both universities rated grammar/language use systems at a neutral satisfaction level, with minor improvements observed during the DC period. University 1 had mean scores of 3.20 (SD=1.11) in the BC period and 3.23 (SD=1.06) in the DC period, while University 2 had mean scores of 3.15 (SD=1.01) in the BC period and 3.18 (SD=0.96) in the DC period.

General internet websites

General internet websites received high satisfaction ratings from University 1 across both periods, while University 2's satisfaction increased from neutral to high during the DC period. University 1 had mean scores of 3.44 (SD=1.07) in the BC period and 3.44 (SD=1.05) in the DC period, while University 2 had mean scores of 3.29 (SD=1.01) in the BC period and 3.30 (SD=0.93) in the DC period. The postgraduate increase satisfaction on the use of internet websites refute the findings. Azubuikwe (2020) identifies technical issues and digital distractions as notable concerns. Another significant challenge is information overload and the difficulties associated with evaluating the credibility of online sources (Nwachukwu and Eze, 2020 & Azubuikwe, 2020). This suggests that although there is some satisfaction regarding the use of internet websites, these factors collectively present substantial barriers to the success of digitalised research practices in higher education.

Statistical and data analysis digital technologies

For statistical and data analysis digital technologies, University 1's satisfaction remained low, with a slight decline during the DC period, while University 2's satisfaction improved from neutral to high during the DC period. University 1

had mean scores of 2.86 (SD=1.22) in the BC period and 2.83 (SD=1.15) in the DC period, while University 2 had mean scores of 2.99 (SD=1.00) in the BC period and 3.08 (SD=1.02) in the DC period.

Online data collection digital technologies

In terms of online data collection systems, both universities rated them at a low to neutral satisfaction level across both time periods. University 1 had mean scores of 3.04 (SD=1.17) in the BC period and 3.09 (SD=1.10) in the DC period, while University 2 had mean scores of 3.04 (SD=1.06) in the BC period and 3.13 (SD=1.06) in the DC period.

Journal/article submission digital technologies

Both universities expressed low to neutral satisfaction levels with journal/article submission systems across both periods. University 1 had

mean scores of 2.94 (SD=1.17) in the BC period and 3.03 (SD=1.14) in the DC period, while University 2 had mean scores of 2.87 (SD=1.00) in the BC period and 2.96 (SD=0.94) in the DC period.

Paired correlations and normality tests

Table 3 shows the Shapiro-Wilks test of normality for the before and during COVID-19 samples. The sample's paired correlations are shown in the same table.

For all the digital technology used, a Shapiro-Wilk above 0.05 indicated a normal distribution of responses from the respondents. This was an exception for Paid online journal/article/thesis databases ($p < 0.05$) and Online data collection systems ($p < 0.05$). The assumption of normality was therefore mostly met with. Paired sample correlations were all strong and statistically significant at $p < 0.00$.

Table 3: Paired correlations and normality tests

System	Before COVID-19			During COVID-19			Paired Correlation	
	Stat.	Df	Sig.	Stat.	df	Sig.	R	Sig.
Learning management systems	0,96	48	0,15	0,97	49	0,25	0,99	0,00
Online classrooms/Teams	0,97	48	0,25	0,97	49	0,29	0,99	0,00
Messaging/Communication systems	0,97	48	0,32	0,98	49	0,44	0,99	0,00
Referencing systems	0,96	48	0,10	0,96	49	0,08	0,99	0,00
Free online journal/article/thesis databases	0,96	48	0,12	0,97	49	0,21	0,99	0,00
Paid online journal/article/thesis databases	0,95	48	0,04	0,95	49	0,04	0,99	0,00
Plagiarism checking systems	0,96	48	0,06	0,95	49	0,05	1,00	0,00
Grammar/language use systems	0,97	48	0,34	0,97	49	0,27	1,00	0,00
General internet websites	0,95	48	0,06	0,96	49	0,09	0,90	0,00
Statistical and data analysis systems	0,96	48	0,07	0,95	49	0,06	0,97	0,00
Online data collection systems	0,95	48	0,03	0,95	49	0,04	0,99	0,00
Journal/article submission systems	0,96	48	0,12	0,96	49	0,09	0,98	0,00

Source: Authors' own construction (2023)

Digital Technologies' Efficiency for Research

For all variables under comparison across the two universities, Levene's test produced statistically insignificant values ($p > 0.05$) indicating that the assumption of equality of variances or homoscedasticity was met. For all variables under comparison between University 1 and University 2, the main t-tests produced statistically insignificant results ($p < 0.05$). This led to the conclusion that there were no statistically significant differences between University 1 and University 2 postgraduate students' satisfaction with the before COVID digital academic and research systems.

Secondly, there were no statistically significant differences between University 1 and University 2 postgraduate students' satisfaction with the COVID digital academic and research systems.

Paired t-test comparisons

Table 4 shows paired t-tests comparison for satisfaction before and during COVID-19 for University 1 and University 2 independently.

Table 4: T-tests between universities

	Levene's Test for Equality of Variances		t-test for Equality of Means			Mean Difference (Uni 1- Uni 2)	
	F	Sig.	T	Df	Sig. (2-t)	Mean Diff.	SE.D
BC Learning management systems	0,05	0,82	1,58	46,15	0,12	0,45	0,29
BC Online classrooms/Teams	0,53	0,47	0,97	45,94	0,34	0,28	0,29
BC Messaging/Communication systems	0,68	0,41	0,60	46,31	0,55	0,17	0,28
BC Referencing systems	0,14	0,71	0,77	47,11	0,45	0,23	0,30
BC Free online journal/thesis databases	0,10	0,75	0,45	46,64	0,66	0,13	0,29
BC Paid online journal/thesis databases	1,13	0,29	0,10	45,07	0,92	0,03	0,32
BC Plagiarism checking systems	0,03	0,86	(0,28)	46,99	0,78	(0,09)	0,32
BC Grammar/language use systems	0,03	0,86	0,14	46,58	0,89	0,04	0,30
BC General internet websites	0,00	0,97	0,52	47,11	0,61	0,15	0,30
BC Statistical and data analysis systems	1,32	0,26	(0,42)	44,48	0,68	(0,13)	0,32
BC Online data collection systems	0,07	0,79	0,02	44,57	0,98	0,01	0,32
BC Journal/article submission systems	0,04	0,84	0,23	45,32	0,82	0,07	0,31
DC Learning management systems	0,11	0,74	1,50	47,40	0,14	0,41	0,27
DC Online classrooms/Teams	1,40	0,24	0,71	45,00	0,48	0,20	0,28
DC Messaging/Communication systems	0,33	0,57	0,31	47,20	0,76	0,08	0,27
DC Referencing systems	0,06	0,80	0,75	47,49	0,46	0,21	0,28
DC Free online journal/thesis databases	0,09	0,77	0,11	47,61	0,92	0,03	0,28
DC Paid online journal/thesis databases	0,95	0,33	(0,18)	45,12	0,86	(0,05)	0,30

DC Plagiarism checking systems	0,11	0,75	(0,09)	46,25	0,93	(0,03)	0,31
DC Grammar/language use systems	0,07	0,79	0,17	46,43	0,87	0,05	0,29
DC General internet websites	0,24	0,63	0,49	46,05	0,63	0,14	0,28
DC Statistical and data analysis systems	0,19	0,67	(0,81)	46,25	0,43	(0,25)	0,31
DC Online data collection systems	0,00	0,97	(0,13)	47,27	0,90	(0,04)	0,31
DC Journal/article submission systems	0,62	0,44	0,25	44,66	0,80	0,07	0,30

SE.D=Standard error of the mean difference

Source: Authors own construction (2023)

In University 1, comparing the significance of the pre and post-COVID-19 differences within universities as subjects – only Paid online journal/article/thesis databases, Plagiarism checking systems and General internet websites exhibited significant BC versus DC differences in University 1 at $p < 0.05$. These differences however were very small, being changes ranging from -0.07 to 0.21. Other differences were statistically insignificant. In University 2, differences between BC and DC satisfaction were significant in Learning management systems, Online classrooms/Teams,

and Paid online journal/article/thesis databases also at $p < 0.05$.

Some studies indicate that the pandemic has catalysed the creative use of digital technology in research, including virtual experiments and simulations. Despite these benefits, concerns persist regarding digital literacy skills, unequal access, and the need for training and support for students (Nwachukwu & Eze, 2020). Given these varied perceptions, further research is needed to fully understand the efficiency of digital technologies for postgraduate research, both during and before the COVID-19 pandemic.

Table 5: Paired t-test comparisons

Pair	System (BC-DC)	University 1				University 2			
		MD	T	df	Sig. (2-tailed)	MD	t	Df	Sig. (2-tailed)
1	Learning management systems	0,02	0,95	22	0,35	-0,05	-2,05	25	0,05
2	Online classrooms/Teams	0,01	0,37	23	0,71	-0,07	-2,49	25	0,02
3	Messaging/Communication systems	0,04	1,36	23	0,19	-0,02	-0,73	24	0,47
4	Referencing systems	0,02	0,59	23	0,56	0	0,01	25	0,99
5	Free online journal/article/thesis databases	0,02	0,53	23	0,6	-0,02	-0,55	24	0,59
6	Paid online journal/article/thesis databases	-0,07	-2,6	23	0,02	-0,11	-2,91	24	0,01
7	Plagiarism checking systems	-0,04	-2,08	23	0,05	-0,01	-0,54	24	0,6

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8	Grammar/language use systems	-0,03	-1,34	23	0,19	-0,03	-1,18	25	0,25
9	General internet websites	0,21	2,17	23	0,04	0,11	1,32	25	0,2
10	Statistical and data analysis systems	0,02	0,36	23	0,72	-0,01	-0,53	24	0,6
11	Online data collection systems	-0,01	-0,38	22	0,71	-0,02	-0,86	24	0,4
12	Journal/article submission systems	-0,09	-1,75	23	0,09	-0,04	-1,6	24	0,12

Source: Authors own construction (2023)

Conclusion

In examining students' perceptions of digital technologies' efficiency among the two universities before and during the COVID-19 period, it was noted that students from University 2 provided dynamic responses to the challenges posed by the pandemic, particularly evident in the components of availability, accessibility, ease of use, and user training. While students from both universities initially perceived similar levels of efficiency in certain areas, such as availability and affordability, students from University 2 showcased a remarkable ability to adapt to digital technologies, resulting in substantial increases in efficiency levels across multiple dimensions during the COVID-19 period. This emphasises the essence of proactive measures and viable strategies in ensuring the resilience and efficiency of digital technologies, especially in times of crisis. However, it is important to acknowledge that challenges persisted, particularly in the areas of accessibility, affordability, and connectivity, where students from both universities experienced a decrease in efficiency levels during the pandemic. While University 2 demonstrated commendable progress, there remains room for improvement in addressing these persistent issues to ensure equitable access and usability of digital technologies for all university stakeholders. Moving forward, these findings stress the necessity for ongoing evaluation and enhancement of digital technologies, coupled with targeted interventions to address areas of concern and ensure a continuous and inclusive academic experience for all students and stakeholders involved.

Recommendations

Based on the conclusions drawn from investigating students' perceptions of digital technologies efficiency for research during and before the COVID-19 era among two universities, three research recommendations can be derived. Firstly, it is recommended that future research investigate how universities can enhance their available digital technologies. This research could involve in-depth interviews, and case studies to identify best practices and lessons learned that can be applied to other institutions facing challenges with the use of digital technologies for postgraduate research purposes. Secondly, universities can develop user-friendly guides to aid students in independently understanding the use of digital technologies and promote self-directed learning. Thirdly, universities can use this research to inform policy changes and enhance technical infrastructure to better support students' digital literacy. The practice element of the research also involves the ongoing adaptation of educational institutions to evolving technologies to ensure that students can fully benefit from digital tools in their research activities.

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