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Availability of ICT Resources for the Research and Supervision Process: Perspectives from the Supervisors' and Supervisee Experiences of Public and Private Universities of Khyber Pakhtunkhwa, Pakistan

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Abstract
A study aimed to investigate the availability of ICT resources for the research and supervision process: perspectives from the supervisors' and supervisees' experiences of public and private universities of Pakistan. It investigates how public and private university supervisors and supervisees perceive the availability of ICT resources, particularly in terms of hardware, software, and Internet tools. A mixed-methods embedded design (quantitative and partially qualitative) was adopted. The researcher selected a survey design, and the population comprised all supervisors and supervisees enrolled in the academic year 2021-2023 at Khyber Pakhtunkhwa University. A sample of 396 participants was selected using a systematic sampling technique. Quantitative data were collected through structured questionnaires, while the researcher obtained qualitative insights through open-ended responses. Data were analysed using SPSS-26, applying descriptive and inferential statistical techniques, including Mean, Standard Deviation, and Cohen's d. Thematic analysis was applied to the qualitative data to gain deeper insights into ICT resource integration. Key findings indicated that ICT tools and resources were frequently available in the research process based on the experiences of supervisors and supervisees in both public and private universities. Thematic analysis further revealed that additional ICT tools beyond those listed in the structured instruments were also available, as highlighted by qualitative responses from both groups. Hypothesis testing showed no significant differences between public and private universities regarding ICT availability, except for hardware.

Keywords: ICT tools, ICT Resources, Availability, Research Processes, Supervisors, Supervisees, Public, Private, University.

Introduction
Information and communication technology (ICT) has emerged as a key component in contemporary academic environments, especially for improving research and supervision procedures. In general, ICT consists of various

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technologies, including sophisticated digital tools like computers, smartphones, and the Internet, as well as more conventional media like radio and television. In higher education, ICT tools facilitate various educational and research tasks, such as data collection, analysis, communication, and collaboration, which enhance educational interactions and research productivity. For both supervisees and supervisors to manage and carry out research tasks efficiently, the availability of ICT resources is necessary (Pratt, 2019; Alkamel & Chouthaiwale, 2018; Peña-López, 2009).

ICT in higher education has become crucial for enhancing knowledge sharing, data management, research activities, and communication (Sarkar, 2012; Suleiman, Yahya, & Turker, 2020). Higher education relies heavily on ICT to improve communication, research activities, data management, and knowledge sharing (Sarkar, 2012; Suleiman, Yahya, & Turker, 2020). Digital applications, software, or platforms that support data collection, statistical analysis, and research communication are known as ICT tools. Conversely, ICT resources support academic content and research, including databases, repositories, e-books, and e-journals. These resources and tools improve research quality, effectiveness, and teamwork.

The availability of ICT tools and resources has become crucial in determining research experiences as the global academic community depends more and more on digital platforms. The ICT infrastructure in Pakistani universities varies, directly impacting their ability to facilitate scholarly research. Due to financial constraints, public universities usually struggle with antiquated infrastructure, which limits access to necessary ICT resources. Private universities, on the other hand, provide more sophisticated ICT facilities and a more favorable research environment because they are supported by larger financial resources (HEC, 2020; UNESCO, 2021).

Integrating tools such as data analysis software, academic databases, and collaborative platforms like Google Workspace and Research Gate has revolutionised research practices. Supervisors employ these technologies to manage academic progress, communicate effectively, share feedback, and mentor and advise graduate students (Boud & Lee, 2005). Conducting literature reviews, gathering and analyzing data, and interacting with supervisors and supervisees usually rely on ICT tools. By streamlining the research process, these tools reduce reliance on laborious and conventional techniques (Iqbal & Rahim, 2021; Malik, Sheikh, & Mahmood, 2023).

The Higher Education Commission (HEC) has emphasized the importance of ICT integration to enhance research quality and strengthen Pakistan's position in the global academic arena. However, significant disparities persist, particularly in underfunded rural universities that lack reliable ICT infrastructure (Jamil, 2021). The COVID-19 pandemic further exposed these digital divides by forcing educational institutions to transition to online instruction and virtual research environments rapidly. This transition underscored the critical need for accessible ICT resources to maintain scholarly collaboration and ensure research continuity in public and private universities.

The availability of ICT directly influences research efficiency and academic performance. Supervisors and supervisees benefit significantly from access to high-speed internet, statistical software, academic repositories, and collaborative platforms. However, a notable digital divide exists. Private universities, driven by

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competitive positioning and better funding, typically have superior access to modern ICT tools, encouraging innovation and productivity. Public universities, by contrast, often struggle with outdated equipment, unreliable internet connectivity, and underfunded ICT support systems (Johnson, 2023; Ahmed & Kurshid, 2015).

Understanding the availability of ICT resources is essential for identifying infrastructural and support gaps that hinder effective research practices. This understanding also sheds light on the broader systemic challenges faced by academic institutions in Pakistan and can inform targeted improvements to enhance research capabilities across different university sectors.

In this context, the present study investigates the availability of ICT resources for the research and supervision from the perspectives of supervisors and supervisees in public and private universities of Khyber Pakhtunkhwa, Pakistan. It critically examines perceived access to ICT tools and resources in both institutions, highlighting systemic disparities and institutional variations. By doing so, the study aims to inform future strategies to strengthen ICT support for research and supervision. Ultimately, this research contributes to a deeper understanding of how ICT availability shapes research practices, capacity, and outcomes within Pakistan's evolving higher education landscape.

Statement of the Problem

Information and Communication Technology (ICT) has become essential in enhancing research activities within higher education. Several studies have explored the availability of ICT tools (Ghavifekr & Rosdy, 2015; Tariq, 2016; Kanwal & Ahmed, 2023; Afridi and Chaudhry, 2019). However, despite its increasing importance, limited research has specifically examined the availability of ICT resources for the research and supervision process from the perspectives of supervisors and supervisees in public and private universities of Khyber Pakhtunkhwa, Pakistan. Therefore, investigating these experiences is crucial for identifying gaps and promoting more equitable availability of ICT resources across universities in the Khyber Pakhtunkhwa.

Objectives of the Study

1. To ascertain the experiences of supervisors and supervisees regarding the availability of ICT tools and resources in the research process within public universities of Khyber Pakhtunkhwa, Pakistan.
2. To examine the experiences of supervisors and supervisees regarding the availability of ICT tools and resources in the research process within private universities of Khyber Pakhtunkhwa, Pakistan.
3. To compare the experiences of public and private universities' supervisors and supervisees regarding the availability of ICT tools and resources in the research process.

Research Questions

1. What are the experiences of the public university regarding the availability of ICT tools and resources in their supervisors' and supervisees' research processes?

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2. What are the experiences of the public university regarding the availability of ICT tools and resources in their supervisors' and supervisees' research processes?

Hypotheses

(Ho1). There is no significant difference between the experiences of public and private university supervisors and supervisees regarding the availability of ICT tools and resources in the research process.

Sub Hypotheses

Ho1(i) There is no significant difference between the public and private universities' supervisors' and supervisees' experiences regarding the **availability** of the **hardware devices** of CT tools/resources in the research processes.

Ho1(ii) There are no significant differences between the public and private universities' supervisors' and supervisees' experiences regarding the integration aspects of the **availability** of the **software devices** of CT tools/resources in the research processes in the universities of Khyber Pakhtunkhwa.

Ho1(iii) There are no significant differences between the public and private universities' supervisors' and supervisees' experiences regarding the integration aspects of the **availability** of the **internet** of CT tools/resources in the research processes.

Methodology

Research Design

This study employed a partially embedded mixed-methods design, combining quantitative and qualitative approaches to provide a comprehensive understanding. A survey design was selected for this study in light of the study's objectives. Quantitative data were collected through structured questionnaires, while qualitative insights were obtained through open-ended responses. The data were analysed using SPSS-26, applying descriptive and inferential statistical techniques to address the research objectives and test the hypotheses. Mean, Standard Deviation, and Cohen's d were used to examine patterns and group differences. For the qualitative section, the open-ended responses focused on themes related to ICT availability. These responses were coded and thematically analysed to identify recurring patterns and unique insights, offering a deeper understanding of ICT integration in the research and supervision process.

Population

The population of this study comprised all Higher Education Commission (HEC) PhD approved supervisors and their MPhil and PhD supervisees enrolled whose at least synopsis was approved during the academic years 2021-2023 in public and private sector universities of Khyber Pakhtunkhwa, Pakistan. The total population consists of 546 participants (233 Supervisors from public universities, 40 supervisors from private universities, and an equal number of 233 supervisees from public universities and 40 from private universities). This population included supervisors and supervisees actively involved in research.

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Table 1: Population of the study

Respondents	Public	Private	Total
Supervisors	233	40	273
Supervisees	233	40	273
Total	466	80	546

Sampling

The sample size for this study was determined using a randomizer calculator to ensure the appropriate number of participants. 396 participants were included in this study, with 320 participants from public universities (160 supervisors and 160 supervisees) and 76 from private universities (38 supervisors and 38 supervisees) in Khyber Pakhtunkhwa, Pakistan

Table 2: Sample of the study

	Supervisors	Supervisees	Total
Public	160	160	320
Private	38	38	76
Total	181	181	396

Research Instrument

The researcher developed one tool on the same theme to collect the data from selected supervisors and supervisees. The tool consisted of two parts. The first part included demographic information. The second part of the tool was the same for both the supervisors and the supervisees. This part comprises dimensions of availability. These dimensions were measured on the five-point Likert scale. The five points were Never, Rarely, Occasionally, Frequently, and Always, having values of 1, 2, 3, 4, and 5, respectively. Moreover, the tool also included open-ended questions at the end of each dimension.

Reliability of the Instruments

To evaluate the reliability of the modified questionnaire, Cronbach's alpha coefficient was used in SPSS version 26 (Statistical Package for the Social Sciences). The calculated value of Cronbach's alpha (α) was 0.95, falling in the excellent category (George & Mallery,2019).

Table 3: Range of reliability and its coefficient of Cronbach's alpha

S. No	Coefficient of Cronbach's Alpha	Reliability Level
1	More than 0.90	Excellent
2	0.80-0.89	Good
3	0.70-0.79	Acceptable
4	0.6-.69	Questionable
5	0.5-0.59	Poor
6	Less than 0.59	Unacceptable

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Table 4: Calculated Values of reliability and its coefficient of Cronbach's Alpha

		Number of Items		Cronbach's Alpha (α)	
Availability of ICT	Hardware	4		0.88	
	Software	4	18	0.83	0.95
	Internet	10		0.95	

Data Collection Process

Data were collected from a representative sample of supervisors and supervisees from both public and private universities in Khyber Pakhtunkhwa. For the collection of data, a structured questionnaire was used. The questionnaire was distributed through a combination of in-person visits to selected universities and digital platforms, including Google Forms, LinkedIn, WhatsApp, and Email.

Data Analysis

This study was partially embedded in a mixed-methods design (quantitative and qualitative) to provide a comprehensive understanding of availability of ICT resources for the research and supervision process: perspectives from the supervisors' and supervisee experiences of public and private universities of Pakistan A descriptive survey design was selected for this study based on the objectives. All the supervisors and supervisees in the universities of Khyber Pakhtunkhwa enrolled in the academic year (2021-23) constituted the population of the study.396 supervisors and supervisees were selected as a sample for the study. The study collected quantitative data through structured questionnaires and qualitative insights from open-ended responses to comprehensively understand ICT integration. The collected data were entered in SPSS-26 and analysed by applying descriptive and inferential statistical techniques to examine designs and differences according to the objectives and hypotheses of the study. Mean, Standard Deviations, and Cohen's d statistic tools were applied to obtain the results in light of the objectives and hypotheses of the study. For the qualitative component, open-ended responses focus on themes related to the availability of ICT tools and resources in the research process. These responses were coded and thematically analysed to capture recurring patterns and unique insights, offering a deeper understanding of ICT tools and resources in the research and supervision process.

Research Questions and Hypothesis: Wise Analysis and Interpretation of Data

Research questions and hypothesis-wise analysis and interpretation are given as follows:

A: Quantitative

1. What are the experiences of the public university supervisors and supervisees regarding the availability of ICT tools and resources in their research processes?

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Table 5: Availability of ICT tools/resources of Hardware Devices to supervisors and supervisees, in public universities

S.N		M	SD
1	Desktop computer/Laptop	4.27	1.19
2	Mobile(Android)/portable device(smart phone/iPad/e-tab)	4.03	1.37
3	Multimedia/projector	3.67	1.19
4	Printer/Photocopier	3.59	1.26

Table 5 illustrates, the respondents (supervisors and supervisees) reported the highest availability for desktop computers/laptops (M=4.27, SD=1.19) and mobile or portable devices (M=4.03, SD=1.37), indicating these tools were perceived as "always available". Multimedia projectors (M=3.67, SD1.19) and printers/photocopiers (M=3.59, SD1.26) were seen as "frequently available" to supervisors and supervisees in their research process in the public universities.

Table 6: Availability of ICT tools/resources of Software to supervisors and supervisees in public universities for the research process.

S.N		M	SD
5	**Thesis writing templates:** MS Office (Microsoft Word/ Excel/PowerPoint)/LaTeX/voice typing.	3.82	1.23
6	For **analysing** the Quantitative data, SPSS /STATA/ SAS /MATLAB	3.47	1.28
7	**Reference** managing and data storage Software Zotero/ EndNote/ Mendeley/Evernote/Refseek/Refwork/Refman.	3.23	1.33
8	For **analysing** the Qualitative data, NVivo/ MAXQDA/ ATLAS/Qurikos/Qualtrics.	2.57	1.37

Table 6 shows, most available software tools were thesis writing applications (M=3.82, SD =1.23), followed by quantitative data analysis software (M=3.47, SD=1.28), both rated as "frequently available". Reference management tools (M=3.23, SD=1.33) were "occasionally available", while qualitative data analysis software was rarely available (M=2.57, SD=1.37) to supervisors and supervisees in their research process at public universities.

Table 7: Availability of ICT tools/resources of the internet to supervisors and supervisees in public universities for the research process for the research process.

S.N		M	SD
9	**Internet Browser** (Internet Explorer/Mozilla/ Google Chrome/ Firefox/Opera).	4.28	1.07
10	Search Engines(Google/Yahoo/Bing/Ask/MSN)for different databases and research material	4.22	1.14
11	ICT **Communication resources,** (Email/WhatsApp/Twitter/ Messenger/CMS (Campus Management system) Chat GPT)	3.99	1.18

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12	E. Sources (ERIC/Google Scholar/World Cat/ JSTOR/Psych INFO for searching	3.99	1.22
13	Software for checking plagiarism, like Urkund /Scirbbr /Turnitin/Ithenticate.	3.82	1.27
14	Online data collection tools such as Google Forms /Survey Monkey/ Smart Proxy/Content Snare/Suma/Magpi.	3.77	1.31
15	For proceeding conferences, workshops, and research seminars (Zoom /Google Meet/Google Teams).	3.73	1.20
16	HEC(electronicbooks/ journal databases/research repository)	3.66	1.27
17	Universities' library websites/Questia/reference services.	3.56	1.27
18	For grammar check, (Grammarly/Ginger/Scribens/Writer/ Jetpack/Zoho Writer/Language Tool/Virtual Writing/Tutor /Quill Bot)	3.50	1.38

Table shows, internet browsers (M=4.28, SD=1.07) and search engines (M=4.22, SD=1.14) were "always available," emphasizing strong basic internet access. Other resources, such as communication tools (M = 3.99, SD=1.18), academic e-sources (M = 3.99, SD=1.22), plagiarism checkers (M = 3.82, SD=1.27), and online data collection tools (M = 3.77, SD=1.31) were "frequently available." Platforms for virtual seminars (M = 3.73, SD=1.20), HEC digital repositories (M = 3.66, SD=1.27), university library websites (M = 3.56, SD=1.27), and grammar checkers (M = 3.50, SD=1.38) were also rated as "frequently to occasionally available", **to supervisors and supervisees in their research process in the public universities.**

A. Qualitative

To enrich the quantitative data, open-ended responses were analyzed to explore additional ICT resources available to supervisors and supervisees in public universities in Khyber Pakhtunkhwa, supporting their research and supervision processes. The qualitative responses revealed a diverse and extensive range of tools beyond those in the structured survey. Commonly used resources included digital libraries (e.g., Sic-Hub, ProQuest, institutional e-libraries), research platforms (e.g., Research Gate), and statistical software (e.g., R, EVIEWS, Smarts, Graph Pad Prism). Technical and domain-specific tools such as COMSOL, Origin Lab, Mathematica, Python, GIS tools, and machine learning libraries were also noted. Collaborative platforms (e.g., Overleaf, Google Drive, Dropbox) and communication tools were frequently available for writing, storage, and the research supervision process. Infrastructure such as high-speed internet, computer labs, and scanning facilities were generally reported as available. Some participants highlighted university support in accessing necessary software, while others supplemented resources through personal efforts.

2. What are the experiences of the private university supervisors and supervisees regarding the availability of ICT tools and resources in their research processes?

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Table 8. Availability of ICT tools/resources of hardware devices to supervisors and supervisees in private universities.

S.N		M	SD
1	Desktop computer/Laptop	4.49	0.96
2	Multimedia/projector	4.12	1.17
3	Mobile(Android)/portable device (smartphone/iPad/e-tab)	4.07	1.34
4	Printer/Photocopier	4.06	1.15

The table shows that the availability of desktop computers and laptops received the highest mean score of 4.49 (SD = 0.96), indicating that supervisors and supervisees in private universities experienced these tools as they always had in their research process. The availability of multimedia projectors (M = 4.12, SD=1.17), mobile and portable devices (M = 4.07, SD = 1.34), and printers and photocopiers (M = 4.06, SD = 1.15), indicating these tools were "frequently available" to supervisors and supervisees in private universities in their research process.

Table 9: Availability of ICT tools/resources of Software for the research process.

S.N		M	SD
5	**Thesis writing templates:** MS Office (Microsoft Word/ Excel/PowerPoint)/LaTeX/voice typing.	4.04	0.89
6	For **analysing** the Quantitative data, SPSS /STATA/ SAS / MATLAB	3.61	1.10
7	**Reference** managing and data storage Software Zotero/End Note/Mendeley/Evernote/Refseek/Refwork/Refman.	3.19	1.28
8	For **analysing** the Qualitative data, NVivo/ MAXQDA/ ATLAS /Qurikos/Qualtrics.	2.82	1.26

Table 9 shows that the available software tools for supervisors and supervisees in private universities were thesis writing applications (M=4.04, SD=0.89) and quantitative data analysis tools(M=3.61, SD=1.10), both rated as "frequently available." Reference management tools (M=3.19, SD=1.28) and qualitative data analysis software (M=2.82, SD=1.26) were rated as "occasionally available."

Table 11: Availability of ICT tools/resources of the internet for the research process.

S.N		M	SD
9	**Internet Browser** (Internet Explorer/Mozilla/ Google Chrome/ Firefox/Opera).	4.41	.97
10	**Search Engines** (Google/Yahoo/Bing, Ask/ MSN)for different databases and research material	4.31	.99
11	ICT **Communication resources,** (Email /WhatsApp/ Messenger /Twitter/ CMS (Campus Management system) Chat GPT)	4.27	1.01

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12	E. Sources (ERIC/Google Scholar/World Cat/JSTOR /Psych INFO for searching	4.19	1.06
13	Online data **collection tools** such as Google Forms /Survey Monkey/ Smart Proxy/Content Snare/Suma/Magpi.	4.04	1.05
14	Software for checking **plagiarism,** like Urkund/Scirbbr / Turnitin /Ithenticate.	3.94	1.22
15	For proceeding conferences, workshops, and research seminars (Zoom /Google Meet/Google Teams).	3.94	1.21
16	Universities' **library** websites/Questia/reference services	3.92	1.19
17	HEC (electronic books/journal databases/ research repository)	3.61	1.34
18	For **grammar check,** (Grammarly/Ginger/Scribens /Writer /Jetpack/ Zoho Writer/Language Tool/ /Virtual Writing / Tutor /Quill Bot)	3.46	1.425

The table indicates that the available ICT tools for supervisors and supervisees in private universities were internet browsers (M = 4.41, SD = 0.97), search engines (M = 4.31, SD = 0.99), and communication platforms (M = 4.27, SD = 1.01), all rated as always available. Other tools that were frequently available included electronic sources (M = 4.19, SD = 1.06), online data collection tools (M = 4.04, SD = 1.05), plagiarism detection software (M = 3.96, SD = 1.22), virtual conferencing platforms (M = 3.92, SD = 1.19), university library websites and reference services(M = 3.61, SD = 1.34) , HEC-provided resources (M = 3.46, SD = 1.43) , and grammar-checking tools (M = 3.61, SD = 1.34). These tools were generally rated as frequently available in the research process.

b: Qualitative

Respondents from private universities in Khyber Pakhtunkhwa reported the availability of diverse ICT tools and platforms to support their research activities. Key resources included digital libraries, online databases (IEEE), and statistical software such as Smarts, STATA, and EVIEWS. Programming tools and libraries, especially Python with Tensor Flow and PyTorch, were also commonly mentioned for data analysis and model development. Other available tools included reference managers (e.g., Overleaf, DBLP), geospatial tools, cloud storage services (e.g., Google Drive, Dropbox), and communication platforms like Skype. Specialised resources such as Lime Survey, Typeform for data collection, and OCR software (e.g., Nano nets, Urdu OCR) were used for specific research needs. Some participants also noted access to websites and tools for paraphrasing and data visualisation.

Research Hypothesis

(Ho1). There is no significant difference between the experiences of public and private university supervisors and supervisees regarding the availability of ICT tools and resources in the research process.

Table 10: Comparison between the experiences of the public and private universities' supervisors and supervisees regarding the

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availability of ICT tools/resources in the research process.

Integration of ICT	**Type of university**	**M**	**SD**	**t**	**P**	**Cohen D**
Overall availability of ICT tools/ resources	public	3.73	0.87	-1.91	0.05	-.218
	private	3.91	0.77			

$p < 0.05$

The table shows a significant difference ($p = 0.05$) in ICT tool availability between public **(M = 3.73, SD = 0.87)** and private universities **(M = 3.91, SD = 0.77)**. Cohen's d value of 0.218 suggests a small but meaningful effect, indicating that private university supervisors and supervisees had better access to ICT resources.

Ho1(i) There is no significant difference between the public and private universities' supervisors' and supervisees' experiences regarding the **availability** of the **hardware devices** of CT tools/resources in the research processes.

Table 11: Comparison between the experiences of the public and private universities' supervisors and supervisees regarding the availability of hardware devices of ICT tools/resources

S. N	Integration of ICT	**Type of university**	**M**	**SD**	**t**	**P**	**Cohen D**
3	Availability of ICT tools/ resources of hardware Devices	Public	3.88	0.98	-2.61	0.01	-.307
		Private	4.19	0.91			

P>0.05

The results reveal a significant difference between public and private universities' supervisors and supervisees regarding the availability of hardware devices. Supervisors and supervisees in private universities reported higher availability (M = 4.19, SD = 0.91) than those in public universities (M = 3.88, SD = 0.98). The t-value of -2.61 and p-value of 0.01 indicate significance at the 0.05 level. Cohen's d value of -0.307 suggests a moderate effect size, highlighting a meaningful difference between the two groups.

Ho1(ii) There are no significant differences between the public and private universities' supervisors' and supervisees' experiences regarding the integration aspects of the **availability** of the **software devices** of CT tools/resources in the research processes in the universities of Khyber Pakhtunkhwa.

Table 12: Comparison between the experiences of the public and private universities' supervisors and supervisees regarding the availability of the software aspect of the integration of ICT tools/resources

S. N	Integration of ICT	**Type of university**	**M**	**SD**	**T**	**P**	**Cohen D**
2	Availability of ICT tools/ resources of software	Public	3.27	1.04	-1.29	0.19	-.144
		Private	3.41	0.88			

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p<0.05
The table shows that public universities (M = 3.27, SD = 1.04) reported slightly lower software availability than private universities (M = 3.41, SD = 0.88). However, with a t-value of -1.29 and p-value of 0.19, there is no significant difference, and Cohen's d-value of -0.144 suggests a negligible effect size. Therefore, there is no significant difference between the two groups.
Ho1(iii) There are no significant differences between the public and private universities' supervisors' and supervisees' experiences regarding the integration aspects of the **availability** of the **internet** of CT tools/resources in the research processes.

Table 13: Comparison between the experiences of the public and private universities' supervisors and supervisees regarding the availability of the Internet of ICT tools/resources

S. N	Integration of ICT	Type of university	M	SD	t	P	Cohen D
3	Availability of ICT tools/ resources on the Internet	Public	3.85	.96	-1.41	0.16	-.165
		Private	3.41	.88			

The table shows that Public universities **(M = 3.85, SD = 0.96)** reported slightly higher availability than private universities **(M = 3.41, SD = 0.88)**, but with a t-value of -1.41 and p-value of 0.16, the difference is not statistically significant. Cohen's d value of -0.165 indicates a small effect size, suggesting no significant difference between the two groups.

Discussions

Supervisors and supervisees in public and private universities reported general availability of essential hardware and ICT tools, with private universities showing slightly better access. Hardware like laptops and desktops was consistently "always available" in both sectors, though private institutions had an edge, confirming earlier findings (Cutshall et al., 2006; Carder et al., 2012). Software for thesis writing and quantitative analysis (e.g., MS Office, SPSS) was frequently available across both sectors, aligning with Sitinjak (2024) and Nai-shenga (2012). However, private universities reported better availability of reference management and qualitative data analysis tools, supporting Jahangeer's (2023) observation of richer digital resources in private institutions. Internet access and basic online tools were commonly available in both sectors. However, private university respondents had greater access to modern communication and data collection platforms like Chat GPT and Google Forms (Dei, 2024). Statistical results confirmed a significant difference in hardware availability, favoring private universities. However, no significant differences were found between software and internet tools. These findings support prior research (Ishaq et al., 2020; Jahangeer, 2023), indicating stronger ICT infrastructure in private institutions, enhancing research engagement and supervision quality.

Conclusions

Supervisors and supervisees in public universities experienced moderate ICT availability, with hardware more available than software and internet tools.

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Private universities showed higher ICT availability across all areas, particularly hardware resources. A significant difference was found in overall ICT availability between public and private universities, favouring the private sector. No significant differences were observed in software and internet-based tools, though private institutions had slightly higher scores.
In a qualitative public university, participants available various ICT tools, often through personal means, due to limited institutional support. Private university participants reported broader, structured access to modern tools, including AI-based platforms, statistical software, and cloud services.
Qualitative data confirmed that private universities provided a more supportive and resource-rich ICT environment than public institutions.

Recommendations

1. Through greater financing and collaborations with technology suppliers, public universities may improve available to specialized research software and hardware (desktops and laptops) to improve their ICT infrastructure.
2. Public universities may implement policies to ensure equal access to hardware and software through collaborations with private universities.
3. Public and private universities may offer regular ICT training for supervisees and supervisors to ensure effective utilization of research tools.
4. Increasing the availability of the Internet and funding for collaborative platforms will promote a more integrated academic environment, improving research and communication.

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