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Anees Muhammad[1], Asif Ali Jamali[2], Shahmurad Chandio[3], Arifa Bhuto[4], Khali Ur Rehman Khoumbhati[5], Altaf Hussain Abro[6]
[1]University of Sufism and Modern Sciences, Bhitshah, Pakistan
[2,4,5] IICT University of Sindh, Jamshoro, Pakistan
[3,6] IMCS, University of Sindh, Jamshoro, Pakistan
Correspondence:

Anees Muhammad: dr.aneesjamali@gmail.com

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Anees Muhammad[*1], Asif Ali Jamali[2], Shahmurad Chandio[3], Arifa Bhutto[4], Khali Ur Rehman Khoumbhati[5], Altaf Hussain Abro[6]

[1]University of Sufism and Modern Sciences, Bhitshah, Pakistan
[2,4,5] Dr. A.H.S Bukhari, IICT University of Sindh, Jamshoro, Pakistan
[3,6]IMCS, University of Sindh, Jamshoro, Pakistan

Abstract

ICT is key factor for cultivating higher education quality, fairness, and access. This study assesses ICT infrastructure and student ICT acceptance in universities in Sindh, Pakistan. An investigation of 445 randomly selected students transversely five universities was led, and descriptive statistics were applied to investigate the facts. The outcomes display that elementary ICT services are widely offered (78% report departmental internet access), but progressive resources are wanting. Only 54% of students have access to computer labs, 36% can find particular software, and just 23% have digital library access. Video-conferencing amenities are virtually nonexistent (13%). A majority of students (70%) are familiar with LMS and rate their ICT skills as usual or upstairs, signifying enthusiasm to adopt technology. However, about half of the departments lack campus-wide Wi-Fi, and 65% of students report wanting supplementary training to progress their ICT skills. Over half of students use ICT mainly for education. These results recommend that while universities of Sindh province have made early progress in ICT adoption, significant gaps in infrastructure and support remain. To make ICT's promise of inclusive, high-quality education a reality, we need to fill these gaps. This is in line with Sustainable Development Goal 4.

Keywords*:* ICT Infrastructure, Higher Education, Digital Divide, Public Universities, Sindh, SDG 4, ICT Utilization.

Introduction

Handwritten Adopting Information and Communication Technology (ICT) in higher education grow it informal for students to get more participation and learn more as ICT tools make learning more welcoming.

[1][2]. In resource-limited environment, the operational functions and academic operations are adjusted and so collaborative education system become more acceptable [3]. The ICT is still working toward the Sustainable Development Goals, which confirm the parity in education[4], [5]. Regardless of these benefits, a continuing digital divide stays to hamper ICT amalgamation in many emergent states. Barriers consist of internet issue, controlled access to digital resources, inadequate setup, and inadequate ICT literacy among university stockholders[6]. In particular, the digital gap is particularly pronounced in rural areas, where basic facilities such as reliable energy and campus-wide internet are still missing[7].

Higher Education Commission (HEC) in Pakistan display noteworthy difference in their readiness for ITC. Intra-city universities classically have greater reach to digital infrastructure, whereas rural institutes frequently deficiency important facilities. The Sindh province echoes this inequality inside the national context. Urban universities mostly equipped with education technology tools with basic ICT infrastructure, whereas public sector universities in rural face deficiency of such tools and technologies. There is a shortage of ICT tools, and inadequate experience to e-learning technologies [8] [9].

The pandemic of COVID-19 highlighted such issues, mainly for e-learning. During that period universities with scarcity of ICT infrastructure leaving most students lacking access to learning environments or support facilities. These happenstances underline the obligation for re-examination of technology readiness in education and acceptance of technology by student in public institutions in Sindh[10].

Paying a demanding data-based approach, this research inspects the adoption of ICT facilities and their acceptance by students to support learning. The results aim to provide actionable insights for policymakers and stakeholders to resolve this current digital divide, improve access to digital learning resources, and growth towards the objectives of comprehensive and reasonable education in Pakistan.

Objectives of the Study

Research objectives of this study are: RO1: To explore how simple it is for students to use ICT infrastructure and facilities in public sector HEIs of Sindh province. RO2: To study the actual involvement of student in adopting ICT in their academic activities.

Literature Review

ICT have reformed university education everywhere the world through amplified access and supplemented education openings. Technology-enhanced learning (TEL) takes benefit of digital technology to boost availability, fairness and excellence of schooling. TEL is evidently attentive on resolving questions of availability and fairness in teaching [11]. ICT incorporation can boost student contribution and enlarge entree to resources, principally in inferior atmosphere [12].

In practice, collaborative ICT tools like online forums, simulations, multimedia; have been publicized to rise student enthusiasm and partaking by producing more adapted and appealing education settings. A systematic review observed that ICT tools will rise students' inspiration and participation, which could avert dropout if students are well supported [13]. These transnational researches specify that ICT can make pedagogy lither and more student-centered when organized appropriately and can encompass educational openings beyond conventional limitations. In nastiness of this latent, the aptitude of ICT in education is well-adjusted by considerable blockades, often denoted to as the digital divide. Scholars note that scarce infrastructure, high

expenses, and irregular digital skills commonly bound the paybacks of ICT tools. Joshi review educations from South Asia and report that insufficient internet connectivity, unsatisfactory computer readiness, and curtailed digital literacy are testified as the most salient problems to actual e-learning in emerging nations [12]. Correspondingly, Eltaiba observed that Middle East and North Africa, dogged digital divides and cultural encounters impede ICT acceptance. During COVID-19[11], Meng identified in their research that strong ICT setting is serious area as they note that "infrastructure defects strongly undermine learning effectiveness" that is only gap between advance nations and developing nation [14].

Such results notice that lacking committed ICT tools, even rich advanced learning tools cannot grasp their complete impression a pattern evident in many lower income nations where institutes informed unjustified Wi-Fi, power issues, and few training plans. In instant, the literature shows that universal fairness in ICT use leftovers indefinable, with rural and deprived societies far behind inter-city in infrastructure and digital skills. Scholars have also calculated the reasons that impact ICT embracing in education. Literature recognized four key groups: performance expectancy, effort expectancy, social influence, and facilitating conditions [15] on the other side they also highlight insistent encounters such as digital disparity and institutional confrontation regardless of high student curiosity. In Pakistan, researcher Barra encompass this by investigative socio-cultural reasons: they observe that students' digital knowledge and personal usefulness muscularly mark their willingness to practice ICT, and that gender inequalities added confuse embracing [16]. These studies recommend that actual ICT practice not only hang on infrastructure, but also on training, inspiration, and strategy assistance. When these circumstances are pleased, student success progresses for example, ICT equipped education can bring collaborative and tailored training to upsurge assignation and accomplishment, the COVID-19 pandemic bids a theatrical actual test of these dynamics. The unforeseen shift to distant education exposed and amplified present divides. This is spotted that the swift shift emphasized discriminations in technology readiness, digital knowledge, and formal measurements, with more prosperous nations acting better than emerging countries [17].

Asher perceived that institutes of Pakistan experienced a digital divide during COVID-19 than U.S. counterparts, principally due to Pakistan's trivial investment in educational technology [5]. Studies in Pakistan noticed that students of rural areas required steadfast internet and tools for e-learning, imposing them to drop behind when institutes closed. For example, during the lockdown the majority of rural students had no suitable internet or gadgets to join in distant teaching, while intra-city, prosperous students were less affected [7]. These results reflect international reports: one review highlights that the switch to distance learning tended to deepen the "digital divide" for deprived students, making it a key hindrance to sustaining educational endurance. In short, the pandemic confirmed the status of talking ICT gaps: without reasonable access and training, many students are excellently left out from smart learning. In the definite context of Pakistan and Sindh province, recent empirical researches

acknowledged alike ICT restrictions. One of scholar found that while students commonly trust e-learning can make instruction more authentic, concrete operation agonized from administrative and resource limitations [18] [19]. In their words, teachers are not encouraged by management to implement ICT due to limited resources and lack of competencies echo this: surveying Sindh students through an extended Technology Acceptance Model, they report that students' ICT self-efficacy, interest, and perceived usefulness drive adoption, but that the "ramifications of ICT utilization on student performance remain ambiguous" due to inconsistent infrastructure [9]. Across Pakistan, Tamim found a striking rural–urban gap: urban universities managed the COVID pivot smoothly, whereas rural institutions lacked policies, equipment, and readiness [8].

Their survey of 170 Pakistani universities showed large disparities in infrastructure and support, with city campuses far outperforming rural ones on all measures of online-teaching preparedness. At the student level, Mumtaz studied Karachi undergraduates and found that while most students use smartphones and the internet for learning, they remain "dissatisfied with available ICT-based technologies" on campus [10]. Research shows that 68% of students in Pakistan from medical side partaking fundamental ICT skills but having operations issues with them [20]. The reason for that is due to majority of students using their personal gadgets for e-learning that spot deficiency of ICT services at HEI setting. Although the contemporary tools and technology that yield classrooms as smart or advance learning institutes like AI based Learning Management System (LMS), Virtual Reality/Augmented Reality (VR/AR based lecture halls or laboratories or simulation software are still required and government may need to pay attention on this scarcity.

While HEIs in Pakistan having basic computer labs yet advance computer labs and dedicated video conferencing for each faculty are still lacking. Based on literate results the scholars confirms that the transformative potential of ICT in HEIs is the way to align with SDG-4 for quality education whereas there is still ongoing gap to fulfill such requites in Pakistan. For these many scholars advise that policy maker may allocate more funding for educational technology to keep up with G7 nations [21]. This vision encourages the current study: to empirically evaluate closely how ICT setup and usage planes are demonstrating in HEIs of Sindh, and whether students' fervor for e-learning is supported or hindered by campus resources and training.

Research Methodology

Philosophy: The positivist research philosophy is applied to highlight the objective investigation and statistical analysis [22].

Approach: A deductive positivist research paradigm was applied as objectives were resulting from theories on educational technology [23].

Design: A cross-sectional random sampling survey method was applied for data collection from five public sector universities of province of Sindh, Pakistan [24].

Data Collection: The survey instrument was designed using 7-point Likert scale and shared both in-person and online from where 130 and 350 responses were received respectively, in this way a total 480 responses are developed. After applying screening test a total 445 valid responses flourished for this research while other were discarded from research.

Data Analysis: By using SPSS v22 descriptive statistics was applied to get respondent demographics, ICT access levels, and usage patterns results. This research paradigm showed a very fresh remarks into the readiness of resources and student behavior [25].

Results

Response Rate

For this study, 480 questionnaires were collected over the period of eight weeks. From that, 130 were taken out in person, while the remaining 350 were collected electronically. However, 35 surveys have been dropped from the analysis because 9 respondents provided the same answers to every item on the Likert scale, 17 responses were completed but contained missing information, 4 participants stated they had never used the internet, and 5 surveys had some sections left blank, such as demographic questions. Consequently, the data from 445 questions passed the screening procedure and were included for additional data analysis.

Demographic information of responses

Table 1 shows that there were 346 male respondents, accounting for 77.8% of the total participants, and 99 female respondents, accounting for 22.2% of the total participants.

Table 1: *Demographic Data*

Category	Frequency	Percent %	Cumulative Percent
Male	346	77.8	77.8
Female	99	22.2	100.0
Total	445	100.0	

Academic Background

As shown in Table 2, 134 respondents belonged to the Faculty of Social Sciences, 74 from Natural Sciences, 48 from Commerce and Business Administration, and 44 from Arts. Additionally, 33 participants were from the Faculty of Law, 30 from Education, 24 from Medicine and Allied Sciences, 22 each from Pharmacy and Engineering and Technology, and 14 from Islamic Studies.

Table 2: *Academic Background*

Category	Frequency	Percent	Cumulative Percent
Arts	44	9.9	9.9
Education	30	6.7	16.6
Commerce & Business Administration	48	10.8	27.4
Engineering & Technology	22	4.9	32.4
Islamic Studies	14	3.1	35.5
Law	33	7.4	42.9
Natural Science	74	16.6	59.6
Pharmacy	22	4.9	64.5
Social Science	134	30.1	94.6
Medicine and allied sciences	24	5.4	100.0
Total	445	100.0	

Institutional Affiliation of Participants

Table B illustrations the spread of respondents from six contributing universities. A total of 169 (38.0%) responses were received from the University of Karachi (UoK), 136 (30.6%) from the University of Sindh (UoS), and 55 (12.4%) from SALU. Moreover, 33 (7.4%) respondents were from MUET, while 29 (6.5%) and 23 (5.2%) responses were received from LUMHS Jamshoro, and the USMS, respectively. A total of 445 students took part in the survey.

Table 3: *Institutional Affiliation*

Category	Frequency	Percent	Cumulative Percent
UoK	169	38.0	38.0
UoS	136	30.6	68.5
SALU	55	12.4	80.9
USMS	23	5.2	86.1
MUET	33	7.4	93.5
LUMHS	29	6.5	100.0
Total	445	100.0	

Using of Internet

Table 14 shows the rate of survey respondent stated the use of internet (27) rate of (6.1%) Not used yet, (117) rate of (26.3%) from 1-year (239) rate of (53.7%) using from (2-3 years), (62) rate of (13.9%) using more than five years.

Table 4: *Internet Usage*

Category	Frequency	Percent	Cumulative Percent
Not using yet	27	6.1	6.1
1 year	117	26.3	32.4
2-3 years	239	53.7	86.1
>5 years	62	13.9	100.0
Total	445	100.0	

Availability of internet in department

Table 16 exhibits the total number of participations was 445. The lowest frequency is 97 (21.8%), and the highest frequency is 348 (78.2%) specified internet availability in department.

Table 5: *Avl of Internet in Dept*

Yes/No	Frequency	Percent	Cumulative Percent
No	97	21.8	21.8
Yes	348	78.2	100.0
Total	445	100.0	

Availability of computer laboratory

Table 17 demonstrates that the total number of participants were 445. 205 (46.1%) of the respondents indicated there was no active computer lab available; while 240 (53.9%) responses indicate there was available computer lab in departments.

Table 6: *Avl of Compt Lab*

Yes/No	Frequency	Percent	Cumulative Percent
No	205	46.1	46.1
Yes	240	53.9	100.0
Total	445	100.0	

Availability of related software

The information provided in table 24 indicates that of 445 questionnaires that formed part of this study, 285 (64%) of the respondents indicated no access to related software, whereas 160 (36%) of the respondents reported that they were able to access related software in the computer lab. Furthermore, the respondent ratio was grouped

under each University separately.

Table 7: *Avl of related Soft*

Name of University	Yes	Percent (%)	No	Percent (%)
UoK	59	34.9	110	65.1
UoS	51	37.5	85	63.5
SALU	22	40.0	33	60.0
USMS	9	39.1	14	60.9
MUET	10	30.3	23	69.7
LUHMS	9	31.0	20	69.0
Total	160	36.0	285	64.0

Digital library access

Table 19 depicts 445 participants involved in this study; out of 342 (76.9%) respondents reported their ware lack of digital library access while 103 (23.1%) responses depicted availability of digital library access in computer laboratory.

Table 8: *Digital Library*

Yes/No	Frequency	Percent	Cumulative Percent
No	342	76.9	76.9
Yes	103	23.1	100.0
Total	445	100.0	

Video conference room

Table 20 shown lack of video conference room facility in department out of total participant 445 among 387 (87%) and 58(13%) respectively indicated facility exist.

Table 9: *Video Confr Room*

Yes/No	Frequency	Percent	Cumulative Percent
No	387	87.0	87.0
Yes	58	13.0	100.0
Total	445	100.0	

Learning management system

Table 21 implies that 313 (70.3%) responses showed familiarity with learning management systems (LMS) and 132 (29.7%) responses showed inexperience about LMS.

Table 10: *LMS statistics*

Yes/No	Frequency	Percent	Cumulative Percent
No	313	70.3	70.3
Yes	132	29.7	100.0
Total	445	100.0	

Wi-Fi facility

Table 22 indicates that 227(51%) responses shown lack of Wi-Fi facility in department. While 218 (49%) responses showed availability of Wi-Fi in departments or institutes.

Table 11: *Wi-Fi facility*

Yes/No	Frequency	Percent	Cumulative Percent
No	227	51.0	51.0
Yes	218	49.0	100.0
Total	445	100.0	

Usability of Available ICT Resources

Table 23 indicates the quality of user experiences 39 (8.1%) showed familiar all resources are available, 183 (41.1%) showed few resources and 55 (12.4%) showed very low usage of ICT resources. While 168 (37.8%) showed most of resources available in department.

Table 12: *ICT Resources*

Category	Frequency	Percent	Cumulative Percent
Very few resources	55	12.4	12.4
Few resources	183	41.1	53.5
Most of resources	168	37.8	91.2
All are available	39	8.8	100.0

Total	445	100.0

Level of computer literacy

Table 24 indicates that literacy level of computer technology of responses out of 445, showed beginner 55(12.4%), 216(48.5%) showed in average class 15(3.4%) showed advance, while 159 (35.7%) showed expert.

Table 13: *Computer Literacy*

Category	Frequency	Percent	Cumulative Percent
Beginner/Novice	55	12.4	12.4
Average	216	48.5	60.9
Advance	15	3.4	64.3
Expert	159	35.7	100.0
Total	445	100.0	

ICT equipment availability

Table 25 exhibits that 308 (69.2%) responses out of 445 showed the challenges faced by Universities were due to a shortage of equipment; whereas, 137 (30.8%) were shown ICT equipment availability; as well as, presented ratio of selected Universities individually.

Table 14: *ICT equipment Availability*

Name of University	Yes	Percent (%)	No	Percent (%)
UoK	45	26.6	124	73.3
UoS	47	34.5	89	65.5
SALU	15	27.2	40	72.7
USMS	9	39.1	14	60.9
MUET	11	33.3	22	66.6
LUHMS	10	34.4	19	69.5
Total	137	30.8	308	69.2

Training and time for learning ICT skills

Result shown in Table 26 indicates that 290 (65.2%) responses revealed required additional time for training and learning ICT related tools to enhanced their abilities, whereas 155 (34.8%) responses showed satisfied with the given time allocated for enhancing their skills and training abilities.

Table 15: *ICT skills*

Yes/No	Frequency	Percent	Cumulative Percent
No	155	34.8	34.8
Yes	290	65.2	100.0
Total	445	100.0	

Common use of ICT

Table 27 indicates that specific use of ICT 252 (56.6%) in learning, 84 (18.9%) showed research and 109 (24.5%) uses for social media or gaming.

Table 16: *Common use of ICT*

Category	Frequency	Percent	Cumulative Percent
Learning	252	56.6	56.6
Research	84	18.9	75.5
Using social media/Gaming	109	24.5	100.0
Total	445	100.0	

Location uses of ICT

Table 28 indicates where ICT technology mostly accessed by students. This study result shown 221 (49.7%) at homes, 153 (34.3%) at departments, and 71 (16%) at libraries.

Table 17: *Location uses of ICT*

Location	Frequency	Percent	Cumulative Percent
At home	221	49.7	49.7
At Department	153	34.3	84.0
In library	71	16.0	100.0
Total	445	100.0	

Discussion

The results reveal a mixed picture of ICT infrastructure in public sector universities of Sindh. A large majority of participants (78.2%) reported that their departments have internet access, and about half (53.9%) indicated the presence of a computer laboratory. This suggests that basic connectivity and facilities exist at most campuses. However, significant gaps remain. Over half of students reported no access to related software (64.0%), and most had no digital library access (76.9%) or video conference rooms (87%). These shortfalls show that advanced ICT tools are wanting, that may overcome the potential of adopting for learning.

These results discourse that these universities have unreliable and inadequate resources. In fact, one of major issue in most of HEIs in Pakistan; particularly the rural areas institutes. There isn't ample accessible in digital libraries, and such unattainability may hinder students from fully employing the ICT-enhanced tools.

In terms of RQ2 (extent of student utilization), the survey indicates substantial student engagement with ICT. Most students (around 54%) have been using the internet for 2–3 years, and 70.3% are familiar with Learning management systems (LMS), suggesting comfortable digital proficiency among many respondents. Indeed, a plurality rated their computer skills as “average” (48.5%) or “expert” (35.7%), and only a small fraction (12.4%) were beginners. This high level of computer literacy likely contributes to the finding that 56.6% of students use ICT primarily for learning. In practice, students reported accessing ICT mostly at home (49.7%), with fewer using campus libraries (16%). This may reflect either a preference for home study or limitations in campus access (e.g. lab shortages or Wi-Fi coverage). Despite this enthusiasm, student utilization is constrained by remaining obstacles. For example, about half (51.0%) said their department lacks Wi-Fi, meaning they must rely on wired connections or personal networks. Moreover, 65.2% of students felt they needed additional time or training to improve their ICT skills. This suggests that while students are eager to use technology for education and research (18.9% used ICT for research), they still feel under-supported. Only about 49% reported that “most resources” are available for usage; 41.1% said few resources were available, and 12.4% indicated very low usage of ICT resources. In short, students are ready and willing to use ICT tools, but infrastructural and training limitations hinder their full utilization. Importantly, the demographic data hint at broader social factors. The sample was predominantly male (77.8%), which may reflect gender imbalances in enrollment or in survey response. This raises several questions as to whether female students have issues in accessing the ICT resources or are inadequately represented in some fields. Future ICT interventions should be inclusive, equitable, and sensitive to gender considerations. SDG-4 targets equity; hence, equitable measures in training and provision of safe access environments may be necessary to ensure that gender sensitivity is taken into consideration. This is based on reported digital gender disparities in education. General discussion highlights that Sindh’s public universities

have made initial progress in adopting ICT, but key resources like software, digital libraries, and advanced facilities are insufficient. These findings support the objectives of the study: whereas ICT services create ease of access to educational resources, their limitations hinder the same. Students use ICT tools to study, but they face difficulties due to a lack of infrastructure and user support. The study shows that ICT-driven education has great potential to bring better and inclusive learning, but it needs infrastructural deficiencies and user support gaps to be addressed to reach its full potential.

Future Work

For future aspects many pathways may be explored

Infrastructure Improvement Plans: As small education technology project may be provided to any single department and then results of students may be investigated to measure the level of impact before and after ict incorporation that will help policymakers on strategic planning institution ICT infrastructure development.

Training and Capacity Building: Since many students are average user thus hands-on workshops and skill development training may be developed to solve this deficiency that will help student to accept ICT.

Inclusive Access Studies: Moreover, ICT infrastructure for rural and urban areas should be balance to provide quality access for eLearning.

Comparative and Longitudinal Research: Private HEIs of Sindh province could be included to compare ICT infrastructure across Sindh Pakistan.

By trailing these guidelines, scholars and officials may work towards confirming that the potential of ICT for excellence, comprehensive education (SDG 4) is fully appreciated in Sindh's higher education.

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