Assessing the IoT Acceptance at Public Sector Universities of Sindh, Pakistan

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Citation | Muhammad. A, Chandio. S, Jamali. A. A, Maree. M. U. R, "Assessing the IoT Acceptance at Public Sector Universities of Sindh, Pakistan", IJIST, Vol. 07 Issue. 02 pp 755-769, May 2025

Received | April 16, 2025 **Revised |** May 09, 2025 **Accepted |** May 12, 2025 **Published |** May 13, 2025.

The Internet of Things (IoT) technology blends the real world and digital life, ensuring seamless integration for accomplishing tasks to make life easier. Analysts often get lost in the deep technical details of IoT, but there is a lack of focus on student acceptance and willingness to adopt these technologies. Concentrating on the factors that drive the adoption of IoT technologies. This study employs a quantitative approach to investigate the deep interrelations and interactions in the process with the Unified Theory of Technology Acceptance (UTAUT2) and other factors like IoT Skills, Trust and Personal Innovativeness. Through an explanatory survey method, data was collected from 389 students across 5 public universities in Sindh, Pakistan, to assess the level of acceptance of IoT technologies in universities among the students. This study produces existing literature by expanding the UTAUT2 model to incorporate novel elements relevant to the acceptability and application of IoT in developing nations. It provides important recommendations for policymakers and university stakeholders. The results highlight the need for improving IoT infrastructure, incorporating central IoT courses in academic offerings and developing an enabling environment for successful technology adoption. The evidence presents inadequate proper IoT infrastructure and supporting environment in institutions. In addition, the adoption of IoT among students is evidenced by the study field instead of by the professional need for IoT.

Keywords. Internet of Things (IoT), UTAUT2, Smart University, Higher Education, Technology Acceptance.

Introduction.

The internet has become an integral part of everyday life, continually evolving and gaining importance as emerging technologies increasingly depend on it for their functionality [1]. The Internet began as the "Internet of Computers," an international network that connected computers and facilitated the development of services like the World Wide Web (WWW). In the past few years, this has turned into the internet of humans, as increasing numbers of humans who had accessed the internet began to produce and consume information, laying the ground for the building of the social web [2]. The edges of the internet are increasing day by day as technology keeps growing at an ever-increasing speed. High-speed internet access has become remarkably affordable, prompting numerous tech companies to compete in extending these services to even the most remote corners of the world. At the same time, devices are being equipped with sensors that enable them to go online and sense, calculate, and act. Additionally, everyday items are increasingly being equipped with tags that can be detected by smart devices. The convergence of these technologies has ushered in the era of the Internet of Things (IoT), where ordinary objects are interconnected through sensors and smart devices, enabling seamless communication and data exchange [3].

The term "Internet of Things" was originally developed in 1999 by Kevin Ashton[4], [5]. He describes the "Internet of Things" as a network whereby common objects link the physical world to the Internet. IoT is a group of things that are in communication with each other through the internet at any given time and from anywhere to exchange information and deliver services[6]. IoT is the latest era of internet services, and it enhances global internet connectivity among physical devices. IoT makes it possible for objects to communicate with each other, delivering greater control and performance. The IoT has had an influence on agriculture[7], healthcare[8], transportation, cities and businesses[9], [10].

IoT envisions a fully connected world where the physical and digital realms merge to enrich everyday human experiences. In the field of education, it acts as a disruptive force, revolutionizing teaching practices and significantly improving operational efficiency [11],[12]. The Internet of Things fosters immersive, data-driven learning spaces through real-time engagement with devices, sensors, and systems. Energy efficiency, environmental monitoring, student health surveillance, enhanced campus security, and adaptive instructional delivery are some of the contemporary educational uses. These groundbreaking use cases not only support the viability and sustainability of educational institutions but also represent a paradigm shift in how information is created, accessed, and communicated[13][14].

Smart cities are founded on innovation, and education becomes one of the cornerstones of their development. No society can become truly "smart" without investing heavily in information, learning, and technology innovation[15][16]. Thus, the idea of IoT-empowered Smart Campuses is slowly making its presence felt among universities in Sindh, Pakistan. Based on the larger Smart City plan, this strategy combines university infrastructure available today with IoT technology to improve teaching support and student interaction[17][18]. While Pakistan has achieved impressive progress via ICT programs like digital libraries, multimedia classrooms and the broad availability of the internet the incorporation of smart, IoT-enabled systems is still in its infancy[19][20]. In contrast, developed countries have already used IoT in higher learning, realizing tangible gains in efficiency and learning achievements[21][22][23][24]. Realizing this gap, the current study intends to assess the level of IoT adoption in universities of Sindh Pakistan and student preparedness.

Context of Study.

The acceptance of IoT in higher education is well in line with Pakistan's Vision 2025 and the Higher Education Commission's (HEC) strategic plans to upgrade academic infrastructure[20][25]. Initiatives like PERN Wi-Fi connectivity, Eduroam for uninterrupted connectivity, the Smart Classroom Project Sites, and the overall "Smart Education through Smart Universities" program are intended to digitally empower students, researchers, and teachers nationwide. These initiatives, as depicted in Figure 1, are indicative of a national resolve to make universities technology-based learning institutions. Yet, Pakistan's specific socio-cultural and infrastructural environment necessitates localized studies to comprehend how students perceive and embrace new technologies such as IoT. The study examines the status of IoT adoption in Sindh's universities. It recognizes critical factors determining students' readiness and analyses further general progress toward IoT adoption within Pakistan's higher education system.

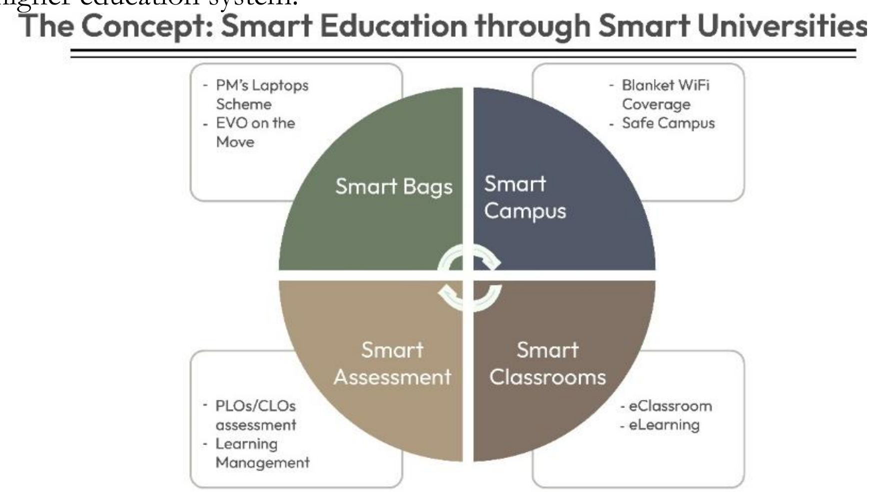


Figure 1. Smart Education by HEC [20].

Literature Review.

For comprehension of the acceptance of IoT in the context of higher education, especially student populations, this research uses a broad range of available literature, theories, and models. Researchers have examined the acceptance of technology from users over the years, using established frameworks like the TAM, TPB, IDT, and UTAUT, among other established frameworks. These models have extensively been employed to describe behavior intention and actual usage of technologies in diverse domains such as education, healthcare, and e-business. The increasing importance of IoT in the education sector has, over the last few years, drawn the attention of researchers and policymakers. This interest lies in analyzing students' preparedness, competency levels, and motivational aspects that affect the adoption of IoT. Among all models, UTAUT and its variant UTAUT2 have been particularly useful in describing the intricacies of IoT adoption by bringing in the most fundamental factors like Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions[26][27]. The current research advances on these platforms to offer a framework that can be appropriate in the context of education in Pakistan. To give an overall picture of the previous research in this field, a tabulated summary of the literature reviewed is given here. A study on Romanian economics students reveals that their intention to use IoT in their professional lives is strongly influenced by their willingness to adopt IoT in educational settings. This indicates that students not only embrace IoT innovations in academia but also anticipate integrating them into their future careers, underscoring the growing significance of IoT as a driver of both academic engagement and professional development[28]. The article [24] introduced an IoT-based adaptive learning system piloted at a British university. It combines RFID attendance, EEG headbands to track engagement, and real-time feedback to customize teaching. Further, it illustrates IoT's ability to improve campus security and smart environmental control, making IoT an essential facilitator of adaptive, green university learning. Another article[29] introduces an IoT-enhanced LMS that employs camera-enabled devices to track students' facial and eye movement when watching video lectures, processes attentiveness in real-time, and incorporates the scores within the LMS for topic level insights as well as peer interaction making eLearning an adaptive, engaging experience.

In the article [30], the author discovers significant advantages like enhanced student engagement through collaborative learning technologies, effective campus management (e.g., intelligent laboratories and libraries), and data-driven administrative decision-making. These benefits show that IoT can significantly enhance institutional effectiveness and learning attainment if appropriately employed. In the article [31], the study demonstrates IoT uptake in higher education is dependent upon TAM and UTAUT frameworks. The critical factors are usefulness, ease of use, and social influence. Privacy and security issues are significant adoption inhibitors. Although studies are increasing, most employ quantitative designs, requiring increased qualitative research. More targeted IoT uptake studies are needed in developing countries. Future research must consider mixed methods and regional variations.

This systematic literature review (2010-2021) examines the implications of IoT technology on education for disabled students, observing that the web of interconnected devices offers possible solutions for inclusive learning. Although the COVID-19 pandemic has accelerated ICT uptake in education, IoT rollout remains in the early stages of development. The research aligns with UN-SDGs, emphasizing inclusive and equitable quality education, which is particularly valuable given the fact that 15% of the world's population lives with impairments. The research points out that the Internet of Things can offer inclusive educational resources and improve lifetime learning opportunities while acknowledging the gaps in prevalent acceptance and infrastructure barriers in special education environments[32].

Framework for Study.

The UTAUT model was initially intended to determine how employees adopt technology in the workplace. Subsequently, the UTAUT2 model was conceptualized based on the initial and focused more on individual beliefs in the process of adopting new technology [27]. It was far more successful in describing why people have different intentions regarding the use of technology. As this research is all about observing whether university students choose to adopt IoT, we utilized the UTAUT2 framework as a research model. It's full of great insights that can guide us in understanding the different factors that drive students' acceptance of technology.

This theoretical model, recognized for its generalizing nature, stretches its breadth to cover heterogeneous critical determinants borrowed from developed models such as TAM, TRA, and TPB. In Venkatesh's seminal paper, UTAUT2 was devised, condensing these components into six core constructs and four moderators[33].

These carefully selected theories serve as the foundation for our objective of assessing students' behavioral intentions and their acceptance of IoT within university settings. The research attempts to investigate the embedded relationship between these aspects and outside variables, to measure the behavioral intentions and behaviors exhibited by students.

We aim to establish standards for understanding the IoT landscape within universities in Pakistan's Sindh province by effectively applying the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2). Accordingly, this research work follows the high standards of scholarly research, utilizing a systematic and quantitative approach to enhance our cognizance of this key area.

Research Objectives.

1. To investigate the present situation of IoT implementation in public universities.
2. To assess the extent of acceptance and usage of IoT among students in universities.

3. To identify the significant challenges to the successful implementation of IoT in universities.

Proposed research model is shown in Figure 2.

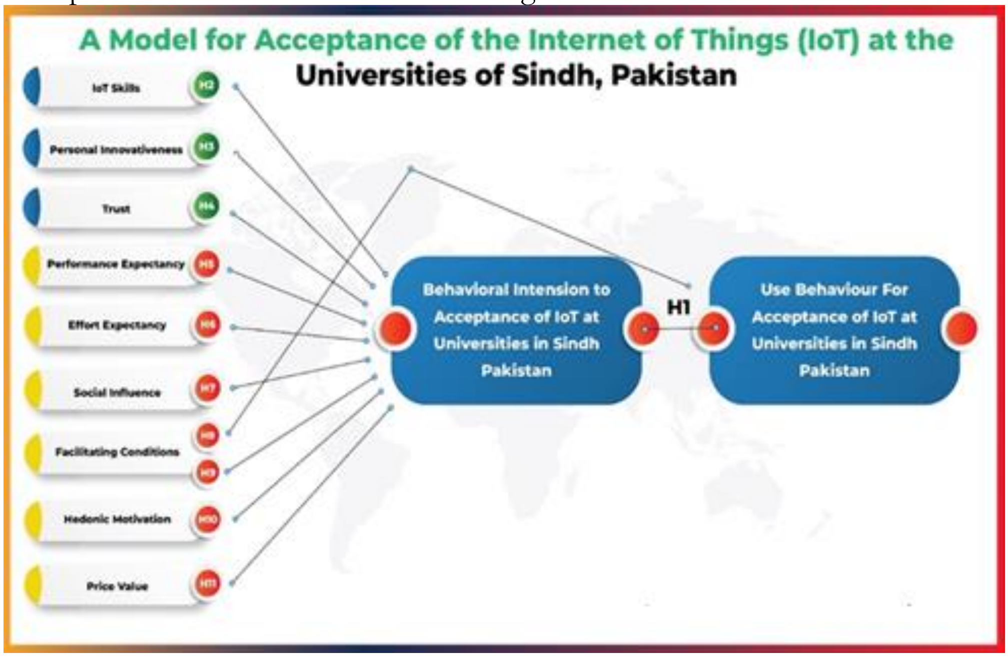


Figure 2. Proposed Research Framework.

Use Behavior (UB).

UB is clearly defined according to the research paradigm introduced by Venkatesh and his coauthors in their work of 2003. Within this study, UB is the observed outcome of a user's technological interactions. It is a quantifiable indicator according to a deep analysis of the user's frequency and regularity of interaction with technology. This extensive exploration of "use behavior" is one of the core components of the UTAUT2 entire framework[33].

Behavioral Intention (BI).

BI is a measure of the will and motivation to adopt and embrace IoT technology. In this research, BI is a critical predictor of actual IoT usage, quantifying to what extent an individual is ready to engage with intelligent solutions in terms of his/her attitude and readiness[33].

IoT Skills (IoTS).

IoTS refers to the key abilities required to engage with smart devices and efficiently handle IoT data. In our research, IoTS plays an important role in understanding how users, particularly students, interact with IoT, with improved skill levels resulting in increased confidence, easier uptake, and deeper integration in educational contexts[34].

Personal Innovativeness (PI).

PI refers to someone's willingness and interest in exploring and embracing new technology. PI, in the present research, aids in assessing students' interest in adopting IoT in education based on how curiosity and technological preparedness drive pioneering adoption[35].

Trust.

Trust is a very much sought-after construct that is essential for establishing a strong and dependable privacy and security framework, which is crucial for the positive implementation of IoT[36].

Performance Expectancy (PE). PE is an important variable that looks at the deepest aspects of a person's beliefs and how much introducing IoT technology into their daily routine will improve their work efficiency[27].

Effort Expectancy (EE).

EE refers to how easy individuals believe it is to make use of technology, which shows how easy and friendly it is to use. In this research, EE helps explain how usability affects the willingness of students to accept IoT applications[27].

Social Influence (SI).

SI is defined as the way that customers' views and recommendations affect whether or not they adopt a technology. SI is significant in the IoT context, especially within schools, because students often look to others, such as peers, instructors, or technology buzz, for a stamp of approval. Knowledge of social opinions and collective sentiment regarding IoT can significantly affect one's plan to use it, making SI a strong, popular force behind adoption[27].

Facilitating Conditions (FC).

FC are the support systems and resources that are accessible to enable users to adopt and use IoT technology efficiently. These encompass technological infrastructure in terms of stable internet connectivity, access to devices, organizational assistance, and training. When such conditions are present, students will be more inclined towards IoT adoption due to increased comfort and trust. This illustrates the way environmental readiness directly influences user acceptability and long-term engagement[27].

Hedonic Motivation (HM).

HM refers to the pleasure that a user gets from using a technology which determines their willingness to adopt it. In our research, HM is considered an underlying but important factor in IoT adoption, as consumers are driven not only by utility but also by pleasure and good experiences offered by smart technologies. This effective engagement enhances long-term usability and emphasizes the increasing importance of user-centered design in IoT devices[27].

Price Value (PV).

User behavior analysis applies Price Value, where users compare the advantages and disadvantages of a technology with its price. UTAUT2 method is based on PV since a rise in PV reflects a consistently stronger preference towards that technology. Since PV plays an important role in IoT acceptance, we incorporated it in our study[27].

Research Methodology.

Philosophical Perspectives.

This research employs a positivist paradigm to investigate IoT acceptance among Sindh HEI students. The positivist paradigm emphasizes objectivity, measurability, and neutrality[37]. It is conducive to systematic, quantitative analysis. Self-administered questionnaires were used to gather data, providing systematic assessment with little bias. The positivist approach was selected due to its rigor, cost-effectiveness, and capacity to yield reliable, comparable results. Therefore, it successfully tests the relationships in the IoT acceptance model[38][39].

Methods of Data Collection.

The research applied both online (Google Forms) and hard-copy questionnaires in data gathering. The tools applied validated scales from well-established technology acceptance studies. The questionnaire comprised two parts. First, closed-ended questions based on a 7-point Likert scale for accurate responses[40]. Second, open-ended questions collected demographic data such as institution, gender, and education level. A mixed approach harmonized response levels with research intensity. The use of both digital and paper methods provided exhaustive data collection.

Sampling Frame.

Random sampling was employed through university enrollment records. Both the bachelor's and graduate (MPhil/PhD) students participated. Krejcie and Morgan's (1970) table was used to calculate the sample size of 398[41]. It maintained consistency and broad participation. The random selection provided all the participating students with equal opportunities. The technique minimized bias and maximized result reliability in the universities that were surveyed.

Measurement Scale Used.

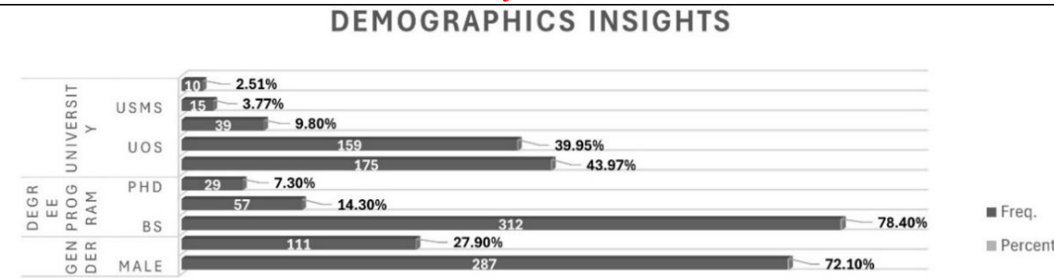
The research utilized a structured questionnaire with validated scales of measurement to evaluate the adoption of IoT by university students. The tool included a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree) for attitude items, chosen due to its established reliability for use in educational technology studies[40]. Demographic information was gathered through nominal scales to facilitate participant classification and subgroup analysis. All scales were drawn from vetted instruments of educational technology acceptance, and scale reliability was verified using Cronbach's alpha ($\alpha \geq 0.70$)[42]. This measuring strategy conforms to the quantitative, positivist paradigm guiding the study and to traditional methods of technology adoption research, thereby ensuring data validity and methodological rigor. The use of a 7-point scale was intentionally selected for its capacity to elicit subtle responses without compromising analytical accuracy[43].

Quantitative Data Analysis.

This study employed a rigorous quantitative analysis method on IBM SPSS Statistics (Version 22) as the primary computational environment, where the research instrument went through an intensive development procedure involving systematic question format creation, pretesting procedures, and a pilot study to validate construct validity and measurement reliability before deployment at large scale. The analysis process proceeded in three landmark steps. Initially, data preparation involved meticulous variable coding and stringent cleansing processes for the data to detect and repair missing values, outliers, and outliers. The analytical method revolved around descriptive statistical analysis, focusing particularly on frequency distributions and percentage calculations to examine response patterns against demographic factors and overall research topics. Finally, scale reliability was probed rigorously through Cronbach's alpha coefficient analysis whereby all multi-item scales indicated internal consistency at or greater than the conventional cutoff value of $\alpha \geq 0.70$, thereby meeting accepted psychometric standards. Through this rigorous analytical process, methodological precision was achieved while allowing for the valid interpretation of the dataset.

Results.

The study gathered demographic information on participants, focusing on factors such as gender, university enrollment, and the specific degree programs they were pursuing. In total, 398 individuals responded, as presented in Figure 3. Nearly, 287 responders were men, making up 72.1% of the total number of participants. On the other hand, 111 responders were female, making up 27.9% of the entire participant pool. A total of 312 participants, or 78.4% of the total were enrolled in bachelor's degree programs. Furthermore, 57 respondents, or 14.3% of the sample, were enrolled in M.Phil. programs. Additionally, 29 respondents, or 7.3% of the total population, were enrolled in Ph.D. degree programs. Additional sample size information from every university. Interestingly, 159 (39.95%) of the participants were from the University of Sindh, 39 (9.8%) from Shah Abdul Latif University, 15 (3.77%) from USMS Bhitshah, and 175 (43.97%) from the University of Karachi and 10 (2.51%) from GC Hyderabad.

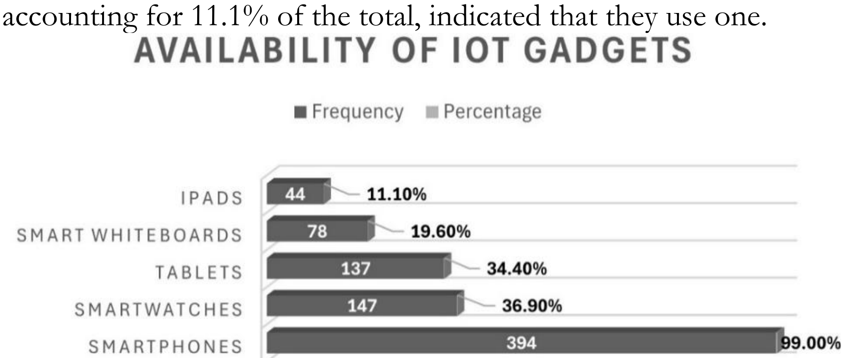


	Gender		Degree Program			University				
	Male	Female	BS	M.Phil.	PhD	KU	UoS	SALU	USMS	GCU
Freq.	287	111	312	57	29	175	159	39	15	10
Percent	72.10%	27.90%	78.40%	14.30%	7.30%	43.97%	39.95%	9.80%	3.77%	2.51%

Figure 3. Demographics insights of participants

To Learn About IoT Implementation in Public Sector Universities.

Understanding the statistics on IoT availability in universities is essential to achieving this objective. This section focused on discussions surrounding IoT deployment and the extent to which IoT technologies are accessible within university settings. The scope of IoT infrastructure implementation at different public institutions was investigated in this section. The specifics of IoT deployment at public universities are displayed in Figure 4. This indicates a lack of IoT infrastructure, as seen by the data in Figure 4, which also shows how common smartphone use is among respondents, indicating a broad uptake of this IoT device. Out of the 398 students surveyed, only four reported not owning a smartphone, representing less than 1% of the total respondents. Conversely, 394 of the respondents; an overwhelming majority reported owning smartphones, reflecting an impressive 99.0% ownership rate among students. As far as smartwatches are concerned, it was found that 63.1% of the total population, i.e., most of the 251 respondents, did not own them. Contrary to this, 36.9% of the total population, i.e., 147 respondents, use smartwatches in their daily lives, while respondents' use of tablets is pointed out, depicting their technology preference. Most of the 261 respondents (65.6% of the population) did not possess tablets. However, 137 individuals (34.4% of the sample) were in support of using tablets. The use of smart whiteboards from the data presented, the majority of 261 participants, which is 65.6% of the overall population, had no prior use of Smart Whiteboards. 137 participants, or 34.4% of the overall population, indicate that they use Smart Whiteboards in their studies. This usage gap highlights the diverse levels of experience and exposure among participants regarding this emerging learning technology, providing valuable insights into the prevalence and implementation of Smart Whiteboards in academic settings. Notably, 354 respondents (88.9%) reported not owning an iPad, while only 44 students, accounting for 11.1% of the total, indicated that they use one.

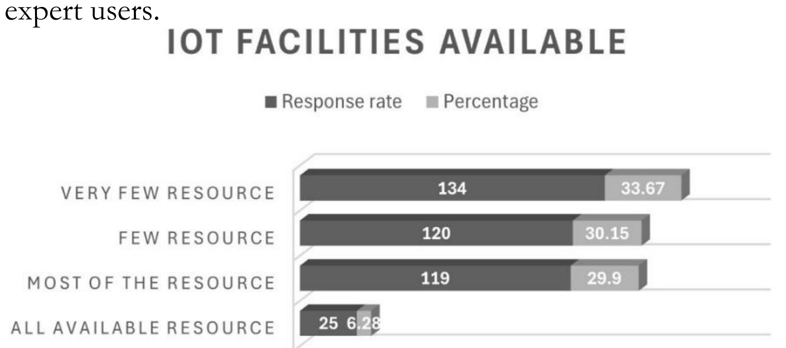


	Smartphones	Smartwatches	Tablets	Smart Whiteboards	iPads
Frequency	394	147	137	78	44
Percentage	99.00%	36.90%	34.40%	19.60%	11.10%

Figure 4. Availability of IoT Gadgets

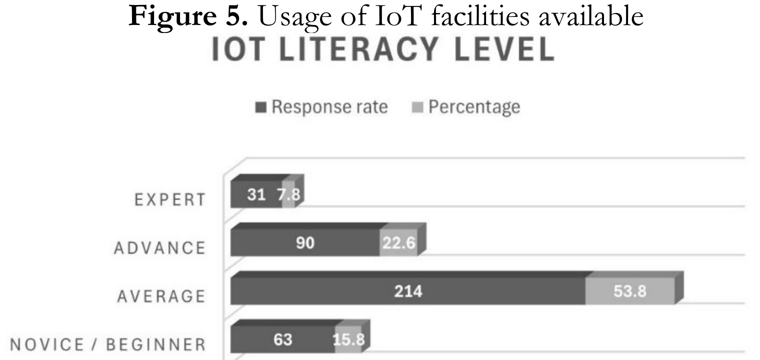
To Understand the Acceptability and Use of IoT in Public Sector Universities.

As presented in Figure 5, the quality of user experience with IoT resources varied among respondents. Only 25 participants (6.28%) reported that all resources were accessible, while 120 (30.15%) noted limited resource availability. A larger portion, 134 respondents (33.67%), indicated that IoT resources were used very infrequently. While 119 participants (29.9%) reported that the majority of IoT-related resources were accessible to users. The distribution of working capacities and ease of use, as reported by respondents about their daily lives, is based on the options provided, including smartphones, smartwatches, iPads, tablets and smart whiteboards. Figure 6 visuals show that most of the respondents (214 individuals) fall under the category of average users, which accounts for 53.8% of the sample. Additionally, 90 respondents (22.6%) indicated a high level of proficiency in operating IoT gadgets. In contrast, 63 individuals, or 15.8% of the sample, are labeled as beginners. Last but not least, a minority of the respondents, namely 31 individuals, or 7.8% of the entire sample, are categorized as expert users.



	All available resource	Most of the resource	Few resource	Very few resource
Response rate	25	119	120	134
Percentage	6.28	29.9	30.15	33.67

Figure 5. Usage of IoT facilities available



	Novice / Beginner	Average	Advance	Expert
Response rate	63	214	90	31
Percentage	15.8	53.8	22.6	7.8

Figure 6. IoT Literacy Level

Identify the Barriers to Successful IoT Adoption.

Figure 5, indicates that 212 respondents, representing 53.3% of the entire population, are not exposed to all IoT devices. On the other hand, 186 respondents (46.7% of the entire population) use IoT devices with some constraints or have exposure to partial capabilities. 330 respondents, representing 82.9% of the entire population, had no training in IoT devices. Conversely, 68 respondents, up to 17.1% of the whole population, got basic training on IoT device usage. Almost 370 respondents, or 93.0% of the total population, reported experiencing difficulty managing their time while studying or using any IoT devices. Contrariwise, 28 respondents, or 7.0% of the whole population, possessed solid time management skills, lacking which they could not learn to operate IoT devices successfully. A total of 289 respondents, accounting for 72.6% of the entire population, reported facing challenges due to a lack of interest, primarily stemming from unfamiliarity with IoT devices and their potential to improve daily life. Conversely, 109 respondents expressed a desire to understand and use IoT devices in their educational endeavors. A total of 228 respondents, or 57.3% of the entire population, are currently facing difficulties in accessing technical assistance. These individuals have expressed a clear need for technical assistance. In contrast, 170 respondents reported having access to some form of technical support.

Figure 7. Challenges to successful IoT adoption

To Validate the Crucial Success Attributes for IoT Acceptance and Use.

Each variable's scale of internal consistency was analyzed for reliability using Cronbach's alpha. This statistical test checks if the items within a scale are measuring the same underlying construct. An alpha above 0.7 is considered significant and good, above 0.8 is good, above 0.9 is excellent, and below 0.6 is poor. Thus, values closer to 1 indicate greater reliability. In this study, the reliability scale ranged from 0.819 to 0.951, which is considered acceptable to excellent. This suggests that the factors examined have a significant effect on an individual's behavioral intention to adopt IoT. The reliability results are presented in Table 1.

Table 1. Reliability Statistics

Ser.	Constructs	Items	Reliability
1	WEB	3	.915
2	BI	3	.911
3	IoTS	8	.951
4	PI	3	.835
5	T	6	.936
6	PE	4	.912
7	EE	4	.896
8	SI	3	.865
9	FC	4	.875
10	HM	4	.914
11	PV	3	.819

Discussions.

Findings show that the level of IoT acceptance and use in universities in Sindh, Pakistan is diverse, with widespread elementary participation but a significant gap in mature integration and structure. This survey of 398 students provides an in-depth analysis of its present circumstance, noting both areas of strength and essential need for reform.

The results of the study disclosed remarkable smartphone adoption among students at 99.0%, signifying nearly universal interaction with the most basic IoT functions. The broad adoption reflects how smartphones have become an integral part of students' everyday lives and education. Smartphones, as the primary gateway to IoT, give connectivity and access to a diverse set of educational applications. This broad use means that students are adequately prepared to interact with IoT technology on an initial scale, and this awareness might act as an opening for the introduction of deeper IoT skills.

One of the most alarming elements of IoT deployment is that many educational institutions may lack proper infrastructure support for all devices. According to the survey, 80.4% of respondents had not before made use of Smart Whiteboards, which are essential for contemporary collaborative educational circumstances. This demonstrates a serious lack of fundamental IoT infrastructure at all of the universities and institutions examined. Not only does poor infrastructure prevent students from accessing novel learning tools, but it also impedes the further integration of IoT into the educational environment.

The degree of technical skill among students fluctuates although nearly all (53.8%) are classified as average users. While 22.6% of respondents have advanced competency, 15.8% are beginners, and just 7.8% are expert users. This distribution represents a wide range of IoT skill levels within the student population. The preponderance of ordinary users is most likely due to their limited exposure to and experience with sophisticated IoT devices. Improving technical expertise is critical for realizing the full potential of IoT technology, necessitating specific training and support activities. This demonstrates a great desire among students to include IoT in their instructional activities. However, the availability of technical support and a conducive learning environment have a significant impact on IoT efficacy. The lack of core IoT infrastructure and insufficient technical support are key barriers to IoT adoption.

Conclusion.

In summary, apart from the other concluding my remarks on the level of IoT integration in universities of Sindh province and the possible strategic recommendations to improve what was identified as a low level of integration on IoT adoption scheme, there are several aspects of IoT infrastructure development areas that Universities in Sindh are lagging and is a commonly known gap at a national level. Firstly, wide-scale development of IoT frameworks is required at all levels. Higher educational institutions need to focus on the deployment of intelligent whiteboards, smart attendance recording devices, smart Learning Management Systems, smart classroom environment monitoring devices, Smart Seminar bookings systems, Smart Libraries, and other advanced IoT devices at all units and multidisciplinary IoT centers of excellence, advanced degrees should be offered in all faculties, and multi-disciplinary approaches should be incorporated into the teaching and learning. Making sure that all the necessary tools are provided equally, and through uniform implementation of Internet of Things technologies will lead to better experiences in education.

Technical support and required training and routine aids to students, as well as flawless support to teachers, are required. This enhances productivity and knowledge of tools related to IoT while enabling educators to understand its greater usefulness in the case of teaching and learning. Campaigns to inform the public may mitigate the misconception associated with IoT technologies, highlight their advantages, and encourage a more favorable attitude toward integration.

Promoting Creative thinking and Research can genuinely boost the uptake of innovation and research in IoT applications among academics. Universities must support projects and activities that assist analyze where prospects for implementing IoT exist, as well as create a continuous cycle of evaluation, which may be supported by creative new IoT technologies and curriculum improvement.

Ultimately, the results of IoT technology adoption across universities of Sindh are somewhere transitional phase, with widespread smartphone usage and yet being confined by significant infrastructure and resource scarcity. Resolving these snags by directing funds for physical infrastructure, advisory support, and participative service delivery can significantly foster the adoption of IoT technologies. Consequently, a more current, and productive learning environment capable of fulfilling the shifting demands of smart education. As a result, the government has to strengthen financial grants for universities so that they can adopt contemporary technologies based on their needs.

Future Work.

This study's scope was confined to one province in Pakistan. Therefore, more study is needed from all regions of Pakistan to gain a complete picture of IoT adoption and acceptance at Pakistan's higher educational institutions. Furthermore, this research focused on facts concerning the implementation of IoT at target institutions, while basic statistics were done to determine the validity of proposed constructs in the Framework. Though the results substantially support the determinants in quantitative data, they also accomplished the aims of this work. Meanwhile, advanced statistics such as structural equation modeling (SEM) and hypothesis testing will be undertaken in the future.

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