

INTERNET OF THINGS (IOT) IN UNIVERSITY LIBRARIES: AN INVESTIGATION OF IMPLEMENTATION STATUS, OPPORTUNITIES, CHALLENGES, AND ETHICAL GUIDELINES

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ABSTRACT

This study investigates the implementation status of the Internet of Things (IoT) in university libraries in Khyber Pakhtunkhwa, focusing on the operational and technical challenges, as well as ethical considerations in IoT adoption. The research employs a qualitative design, conducting in-depth interviews with 16 university librarians to assess the integration of IoT technologies such as RFID-based book tracking, automated circulation, and smart surveillance systems. The findings reveal that while some libraries have introduced IoT solutions, adoption remains inconsistent due to financial constraints, lack of technical expertise, and insufficient infrastructure. Librarians also expressed concerns over data privacy, user surveillance, and the ethical implications of IoT deployment, indicating a need for clear ethical guidelines and policy frameworks. Despite these challenges, IoT presents opportunities to enhance library operations, such as improved resource management and user engagement through personalized services. The study concludes with recommendations for phased IoT implementation, capacity-building initiatives for library professionals, and the establishment of robust ethical guidelines to ensure responsible and sustainable adoption of IoT technologies in academic libraries.

Keywords: Internet of Things, University Libraries, Ethical Guidelines, Smart Libraries, IoT Challenges, Digital Transformation

INTRODUCTION

Background of the Study

The Internet is a vital component of the latest advancements in information and communication technology, particularly in the service industry. Devices are more connected than people in the twenty-first century. The majority of industries must boost revenue while maintaining

low operating costs. i.e. the sensor's low power consumption and cost, the amount of data stored, and the ease, speed, and efficiency with which data is transferred via cloud-based platforms nowadays, a lot of home equipment now use the Internet of Things technologies. The four layers of IoT are interface, networking, sensing, and service. (Liang & Chen, 2020). Weber, R. H. (2009) defined

“The Internet of Things is a rapidly developing worldwide information service architecture that runs on the Internet and makes it easier for supply chain networks to trade items.”

The Internet of Things (IoT) collects visible items, including instruments, gadgets, automobiles, buildings, and all items implanted in electronic sets, and software for network connectivity to collect and share or exchange data (Gokhale, Bhat & Bhat, 2018). The Internet of the thing permits different items to be identified and well organized without physical connection through available networks, and infrastructure, generating prospects for maximum direct incorporation of the visible world through computerized systems and for better results improved accuracy, and efficiency without barriers of time and place (Deshpande, 2022). The idea of internet networking of smart gadgets was presented in 1982 with a modified Coke machine at Carnegie Mellon University becoming a pioneer in internet-connected devices, capable of investigating its inventory and where freshly uploaded drinks were chilled. Kevin Ashton was a British inventor who is known for introducing the term "the Internet of Things" to explain a scheme where the internet is linked to the physical world via ever-present sensors (Gokhale, Bhat & Bhat, 2018).

IoT brought a new revolution in the internet which is very speedy, collecting/gaining movement due to the expansion in sensors' networks, wireless communications, handset devices, cloud technology, and internet networking (Bahga&Madiseti, 2014). All the above devices and tools are interrelated to each other for data sending and receiving through the internet. IoT is known as “a vibrant universal network set-up with auto-modifying characteristics founded on standard and relevant communication where visible and virtual ‘Things’ have individualities, visual qualities, and virtual characteristics and use intelligent interfaces, and are effortlessly interlinked into the information network” (Kranenburg, 2008).

The Internet of Things works like sharp and living objects via sensing and cooperating through rooted devices that intermingle with sensing

devices. The IoT evolves the networks of tangible things, the conventional network of the internet, and different objects e.g. gateways, routers, hubs, switches, etc., which attach these networks (Tkachenko&Brezhniev, 2019). Da Xu, et al. (2014) mentioned that Wireless Sensor Networks (WSNs) and Radio Frequency Identification (RFID) are the fundamental technologies of IoT and service-oriented construction as main technologies in joining compound devices or systems that can be used to assist IoT. The tracking and identification technologies, network technologies, communication technologies, and services supervision are the four-layer construction of IoT (Liang, 2018).

IoT has drastically changed many working systems in day-to-day life. The journey of the library and its services has also been changed by IoT (Deshpande, 2022). The developed world started the usage of information technology in the 1970s while in Pakistan it started in the late 1990s. However, the usage of information technology in Pakistani libraries was very slow in the near past, while in the last decade, young and information technology-equipped librarians have started to use and adopt emerging technologies in Pakistani libraries. The IoT is the modern-day need and technique to be used in libraries. The IoT is basically a new trend and phenomenon that refers to the use of the Internet in providing library services. The use of the internet is the use of ICT via the internet in libraries for quick and prompt services in the shortest possible time. Asim, Arif, and Rafiq (2022) mentioned that Pakistani university librarians introduced IoT-based applications in various forms, which included automatic fire alarms, smart air conditioners, smart hand sanitizer machines, and smart security doors. Moreover, the academic libraries in Punjab, Pakistan used limited IoT-based library services, which include issue (check-in) of the reading materials, auto-notification of Return (check-out), self-check-in and self-check-out systems, recognition of user's card, and the use of Radio Frequency Identification (RFID) tags for

theft/unauthorized access to information resources.

The applications of IoT spread to a vast range of systems containing cities, homes, energy systems, retail, environment, logistics, agriculture, industry, health, sports, and education sectors. The IoT application in libraries helps save time for clients and guides them toward a digital view of tangible items for searching for the location of things (Gupta & Singh, 2018). IoT improves workflow and services, incorporate available resources and system to obtain new media of services, and interlink library services, and resources to many library users (Pujar & Satyanarayana, 2015). The Internet of Things in university libraries has vital importance. Therefore, the aim of this study is to concentrate on IoT applications in the university libraries of Khyber Pakhtunkhwa (KP) by looking at the aspects related to the current status and challenges faced by librarians in the use of IoT. Moreover, it will also study the awareness level about the ethical guidelines of library professionals needed in the implementation of IoT applications.

Without the need for human interaction, IoT technology gathers data and sends it via a wireless network (<https://www.aeris.com/in/what-is-iot/>). For the goal of connecting and exchanging data with other devices and systems on the Internet, Oracle has defined "Things" integrated with sensors, software, and other technologies: <https://www.oracle.com/in/internet-of-things/what-is-iot/>. The Internet of Everything (IoE), which encompasses people, places, objects, and things, is now included in the definition of "IoT," according to Cisco. (https://www.cisco.com/c/dam/en_us/solutions/trends/iot/introduction_to_IoT_november.pdf) "A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies," is how the ITU defines it. In the physical or information realm, objects that are identifiable and incorporated into communication networks are objected to.

LITERATURE REVIEW

The Internet of Things (IoT) is an emerging technological paradigm that connects devices to the internet, allowing them to collect and exchange data. This interconnectedness between objects is transforming various sectors, including healthcare, education, transportation, and library services. The applications of IoT technologies in libraries are proving particularly transformative, enhancing library operations, resource management, user engagement, and service delivery. IoT allows libraries to automate tasks, streamline workflows, and improve user experiences by offering innovative solutions, such as real-time inventory tracking, automated book return systems, and smart surveillance systems.

The role of IoT in university libraries is becoming more crucial as academic institutions and libraries are increasingly adopting technological solutions to cater to the growing demands of students, researchers, and faculty. While IoT offers significant potential, its adoption in libraries is still in its early stages, especially in developing regions. Libraries face several challenges related to infrastructure, financial resources, and technical expertise, which hinder the widespread implementation of IoT solutions. Additionally, ethical concerns, such as data privacy and security, are emerging as critical issues that require careful consideration.

This literature review explores the current state of IoT implementation in university libraries, its potential benefits, the barriers to its adoption, and the ethical challenges that arise from its integration. It also examines the implications of IoT for library management and user services and outlines the need for clear policy frameworks to govern its use.

The Evolution and Scope of IoT in Libraries

The Internet of Things (IoT) refers to the networking of physical objects and devices embedded with sensors, software, and other technologies that enable them to connect and exchange data with other systems over the

internet. In libraries, IoT systems are designed to enhance the efficiency and effectiveness of library services, reduce manual labor, and provide a more interactive and personalized user experience. Through the integration of sensors and network connectivity, IoT technologies make it possible to track and manage library resources, monitor environmental conditions, and offer services such as smart book tracking, automated checkouts, environmental monitoring, and security surveillance.

The idea of the Internet of Things dates back to the early 1980s when the first internet-connected devices, such as a modified Coke machine at Carnegie Mellon University, were introduced. This concept, coined by Kevin Ashton in 1999, originally envisioned a world where physical objects could interact with the internet without human intervention (Gokhale, Bhat & Bhat, 2018). Since then, IoT has rapidly evolved, with its applications expanding across various industries, including smart homes, healthcare, transportation, and libraries.

In libraries, IoT has the potential to transform traditional systems of resource management and service delivery. RFID (Radio Frequency Identification) tags, for example, allow libraries to automatically track books and other materials in real time, minimizing the need for manual inventory checks and ensuring that items are easily accessible to users (Deshpande, 2022). Similarly, IoT systems enable libraries to provide automated circulation and book return systems, reducing wait times and improving user satisfaction (Pujar & Satyanarayana, 2015).

The integration of IoT in university libraries also helps improve the security of library resources. Smart surveillance systems, including CCTV cameras, motion sensors, and alarm systems, can monitor library spaces around the clock, ensuring that library materials are secure and users feel safe (Gupta & Singh, 2018). Moreover, digital catalogs and automated checkouts provide greater accessibility, allowing users to browse and borrow materials with ease using mobile apps or self-service kiosks (Hahn, 2017).

In addition to these functions, IoT technologies offer libraries the ability to gather valuable data about user behavior and library resource usage. By analyzing this data, libraries can make data-driven decisions to optimize their services, improve resource allocation, and better meet the needs of their patrons. For instance, IoT systems can help libraries understand the trends in book circulation or room usage, allowing them to adjust their operations accordingly. This ability to collect, analyze, and act on data aligns with the broader goals of digital transformation in libraries, which aim to provide more efficient and user-centered services (Liang & Chen, 2020).

Applications of IoT in University Libraries

The applications of IoT technologies in university libraries are vast and varied, encompassing several areas of library management and user services. Below are some of the key areas where IoT is making a significant impact:

1. Inventory Management and Resource Tracking

One of the most prominent applications of IoT in libraries is the use of RFID technology for inventory management and resource tracking. RFID tags, which are embedded in books and other library materials, allow for automatic tracking of library items. By using RFID scanners, library staff can quickly check inventory levels, locate misplaced items, and perform inventory audits without manually scanning each item (Rouillard, 2015). This technology reduces the time and effort spent on inventory management and ensures that library resources are always available for users.

Additionally, IoT-based systems provide real-time updates on the availability of resources, enabling libraries to manage their collections more effectively and minimize downtime (Addepalli & Addepalli, 2014). For example, if a book is in high demand, IoT systems can alert library staff to increase its availability or recommend similar materials to users, improving the user experience and resource accessibility.

2. Automated Circulation and Self-Checkouts

IoT technologies have revolutionized the process of borrowing and returning books in libraries. Many university libraries are now using self-checkout kiosks that allow users to independently issue and return books without the need for library staff to be involved (Bagavathi, 2023). These systems use RFID tags and barcode scanning to process transactions quickly and efficiently. Self-checkout kiosks improve the speed and convenience of library services, allowing users to borrow and return materials at their own pace.

Moreover, IoT-based systems can send automatic notifications to users about overdue materials, fines, or upcoming events, further improving user engagement and library management (Pujar & Satyanarayana, 2015). These features reduce the burden on library staff and allow them to focus on other critical tasks, such as assisting users or managing library programs.

3. Smart Surveillance and Security Systems

Security is a top priority in university libraries, and IoT technologies offer a powerful solution to monitor and protect library resources. IoT-based surveillance systems, such as CCTV cameras and motion sensors, can monitor library spaces in real time, providing 24/7 security for library materials and ensuring the safety of users (Gupta & Singh, 2018). These systems can detect unauthorized access to restricted areas and immediately alert library staff, minimizing the risk of theft or vandalism.

Additionally, smart alarms and access control systems allow only authorized users to access certain sections of the library, such as special collections or archives, improving security while preserving privacy. These technologies help ensure that library resources are protected, and users feel comfortable and safe while using library services.

4. Environmental Monitoring

Environmental factors, such as temperature, humidity, and air quality, play a crucial role in maintaining the condition of library resources. IoT-based sensors can monitor these environmental conditions in real time, ensuring

that the library's collections are kept in optimal conditions (Pujar & Satyanarayana, 2015). For example, temperature and humidity sensors can detect fluctuations that may damage sensitive materials like books, documents, and photographs, allowing libraries to take corrective action before any harm is done. This form of environmental monitoring is particularly important in libraries that house rare or valuable materials, such as manuscripts or archival collections.

5. Personalized Services and User Engagement

IoT technologies enable libraries to offer personalized services to users. By collecting data on users' borrowing habits and search queries, libraries can use predictive analytics to recommend relevant materials and services. For instance, IoT systems can suggest books or articles based on a user's previous borrowings, improving the library experience and increasing user satisfaction (Gupta & Singh, 2018).

Libraries can also use IoT to monitor user behavior and preferences, enabling them to optimize services and resources for maximum engagement. Smart digital shelves, for example, can display suggested materials based on users' previous interactions, making it easier for patrons to discover new content that is relevant to their needs (Roullard, 2015). This personalized approach enhances the overall user experience and fosters a deeper connection between library users and resources.

6. Library Facilities Management

IoT technologies can improve the management and efficiency of library facilities. For example, smart lighting systems can adjust the lighting levels in different areas of the library based on occupancy or time of day, reducing energy consumption and enhancing user comfort (Pujar & Satyanarayana, 2015). Similarly, IoT-based sensors can monitor the availability of study rooms, computers, and other library facilities, allowing users to easily find and reserve spaces without having to ask library staff (Qin, 2018).

IoT systems also help libraries manage other facilities, such as air conditioning, Wi-Fi, and printer usage, ensuring that resources are available and functioning properly when needed (Abo-Seada, 2019).

Challenges and Barriers to IoT Adoption in Libraries

Despite the clear benefits of IoT technologies, their adoption in university libraries is fraught with challenges. These challenges can be broadly categorized into financial, technical, and ethical barriers.

1. Financial Barriers

One of the most significant challenges to IoT adoption in university libraries is the high financial cost associated with implementing IoT technologies. These systems require a significant investment in hardware, software, infrastructure, and training. Libraries in developing regions, in particular, often lack the financial resources to invest in IoT-based systems. According to Asim, Arif, and Rafiq (2022), the financial constraints faced by libraries are one of the primary reasons why IoT adoption remains inconsistent.

2. Technical Challenges

IoT systems require specialized technical expertise to implement and maintain. Many libraries, particularly in smaller or rural areas, lack the technical staff needed to support these systems effectively. As Bansal et al. (2018) point out, technical challenges such as integration with legacy systems, maintenance issues, and interoperability between different IoT devices and systems are common obstacles that hinder IoT adoption.

Additionally, libraries face challenges in training staff to manage and operate IoT technologies. Since IoT-related courses are not part of the traditional Library and Information Science (LIS) curriculum, many librarians lack the necessary technical knowledge to handle IoT-based systems effectively. As noted by Hussain and Ahmad (2021), training is a critical factor that needs to be

addressed to ensure the successful implementation of IoT technologies.

3. Ethical and Privacy Concerns

The integration of IoT technologies in libraries raises ethical concerns related to data privacy, security, and user consent. IoT systems collect vast amounts of data about users' interactions with library resources, which can lead to privacy violations if not handled properly. As highlighted by Asim & Arif (2023), librarians need to be aware of the ethical implications of collecting and using this data, ensuring that it is protected and used responsibly.

Furthermore, surveillance technologies, such as smart cameras and motion sensors, raise concerns about user privacy. While these technologies can help secure library resources and improve safety, they must be implemented with clear guidelines that respect users' privacy rights (Bagavathi, 2023).

Ethical Guidelines and Policies for IoT in Libraries

Given the ethical concerns surrounding IoT adoption, libraries must develop clear policy frameworks to ensure the responsible implementation of these technologies. According to Asim et al. (2022), the lack of ethical policies in many libraries is a significant barrier to IoT adoption. Libraries should implement data privacy and security policies to protect users' personal information and ensure that IoT systems comply with relevant data protection laws. User consent should also be obtained before collecting personal data, and libraries should anonymize data whenever possible to protect users' identities (Rouillard, 2015).

Moreover, libraries must address concerns related to surveillance by developing ethical surveillance policies. These policies should ensure that monitoring is done transparently and for legitimate purposes, such as optimizing resource use, rather than for intrusive tracking of users (Bagavathi, 2023).

The Internet of Things (IoT) offers vast potential to enhance library services, improve resource

management, and provide personalized experiences for users. While IoT adoption in university libraries has shown promise, its widespread implementation faces financial, technical, and ethical challenges. Libraries must overcome financial constraints, develop technical expertise, and address ethical concerns related to data privacy, user consent, and surveillance to fully capitalize on the benefits of IoT. By establishing comprehensive policy frameworks and investing in training and infrastructure, university libraries can harness the power of IoT to transform their services and meet the evolving needs of their users.

METHODOLOGY & RESULTS

This study used a qualitative research design grounded in the constructivist paradigm to explore the implementation and use of the

Internet of Things (IoT) in university libraries across Khyber Pakhtunkhwa. A purposive sample of 35 head librarians was selected to ensure representation from those using or planning to adopt IoT technologies. Face-to-face interviews were conducted using a structured and pilot-tested interview guide that covered areas such as IoT implementation, associated challenges, and awareness of ethical guidelines. All interviews were recorded, transcribed, and translated where necessary, and then validated by participants to ensure accuracy. Thematic analysis was conducted using expert-reviewed codes, and direct quotes from interviewees were incorporated to strengthen the findings. Credibility and reliability were ensured through participant verification and by allowing interviewees to share their perspectives freely and without influence.

Table: 1 Demographic Information of Interviewees (N=16)

Group	Frequency	%
Gender		
Male	12	75.00
Female	04	25.00
Qualification		
MLISc	12	75.00
M.Phil.	03	18.75
Ph.D.	01	06.25
Experience (in years)		
1-10	03	18.75
11-20	08	50.00
21-above	05	31.25
Geographic affiliation of the Respondents		
Peshawar	09	56.16
Mardan	02	12.50
Others	05	31.25



The above-mentioned Table shows that the majority of the participants were male and held a qualification of Master of Library, and Information Science (MLIS) degree. Only four interviewees have a research degree (M.Phil/Ph.D.) in Library, and Information Science. Most of the interviewees (09 or 56.11%)

were affiliated with universities in Peshawar, Khyber Pakhtunkhwa. Similarly, majority of the respondents had 11-20 years of experience group.

Existing Status of IoT Implementation

Research objective 01 explored the current state of IoT implementation in university libraries across KP. To address this, two interview questions were posed to the university librarians. The analysis of their responses to these questions is detailed below:

Overview of the Overall IoT Devices and Systems Currently Deployed

The overall analysis of the interviewees' responses regarding deployment of internet of things (IoT) devices and system in university libraries of KP showed a gradual transformation from a traditional library operation into an efficient, user-centered and technology-driven environment. A review of the responses of the interviewees highlighted a varying level of adoption across university libraries based on differences in infrastructure and availability of resources.

Several libraries (12, 75%) have implemented library Management system that has streamlined their cataloguing, circulation and inventory tracking. A few librarians (4, 25%) mentioned that, as the single professional in their libraries, they are responsible for handling all tasks, leaving them with no time to focus on deploying IoT for automation and other library services. One of the chief librarians said that "...I am feeling lucky to be a part of the state-of-the-art library of the province, because, we have a lot of technologies here for use to facilitate our clients in search and retrieval of information".

Similarly, few more libraries (09, 55.25%) have implemented IoT powered surveillance system, including smart cameras and alarm systems which provided 24/7 monitoring, ensuring the safety of library resources and maintaining safe and secure environment for library users. Such as one of the interviewees from Peshawar stated regarding the use of IoT enabled surveillance system that "...our library has CCTV access through mobile phones also for the safety of our library resources".

In addition to the above very few libraries (4, 25%) have a plan to introduce IoT enabled Self-

checkout kiosks and automated book return systems which will allow users to independently issue and return materials, reducing time wait and user satisfaction. Similarly, few others (6, 37.5%) have a plan introduce IoT enabled remote access to library catalogue/databases, including access to digital collection, through mobile applications. Very few interviewees (4, 25%) mentioned that they have not yet implemented IoT due to certain limitations. Such as one interviewee said that "... due to the no-availability of necessary infrastructure in their university library they could not extend their services remotely".

Motivation for Adoption of IoT

The adoption of IoT in the university libraries of KP is driven by several motivational factors that highlight its potential to enhance operational efficacy and user experience. Table 4.2 enlisted the details of the motivational factors in the implementation of IoT in university libraries ranked on the basis of the frequency of the responses of the interviewees. Majority of the librarians (12, 75%) mentioned that better resource management in general such as library security through RFID (Radio frequency identification) and Inventory Management is a key motivator. However, few other (8, 50%) mentioned that grater user experience of or user facilitation is another key motivator. The other motivational factors that necessitated the adoption of IoT included Environmental Monitoring (5, 31.25%) like temperature and humidity control, Air quality check, and preserving books; Academic and research support activities (4, 25%) to facilitate access to digital resources and enabling remote access to library resources and services. While 3 interviewees (28.75%) stated that administrative efficiency is the motivational factor for them to go for IoT implementation. One interviewee stated that "...IoT technologies simplify administrative tasks and is no doubt an important motivational factor for me to apply IoT in my library".

Table 2: Descriptive Information about Motivational Factors to implement IoT (N=16)

S. No	Motivator	(n)/ %
01	Resource Management	12, 75%
02	Grater User Experience	8, 50%
03	Environmental Monitoring	5, 31.25%
04	Academic and research support activities	4, 25%
05	Administrative Efficiency	3, 28.75%

Challenges faced by Librarians during IoT implementation

In relation to research objective 02 and 03, which explores the challenges faced by university librarians in implementing IoT in their libraries, two questions were posed to university librarians during their interviews. The analysis of their responses to both questions is provided below:

Operational Challenges Faced by Librarians

The first question in this regard was about the operational challenges faced by the university librarians in the application of IoT in their libraries across Khyber Pakhtunkhwa. The interviewees openly discussed the various operational challenges related to IoT implementation. These operational challenges, along with their frequency of occurrence in the interview transcript, are summarized in Table 3.

Table 3: Operational Challenges in IoT Implementation (N=16)

S. No	Operational Challenges	n (%)
01	Lack of Financial Support	10, 62.5%
02	Lack of Administrative Support	8, 50%
03	Lack of Financial support to attend Training on IoT	5, 31.25%
04	Lack of staff In Libraries	4, 25%
05	Lack of Local Training opportunities	2, 12.5%
06	Lack of Personal Initiative	2, 12.5%
07	Limited awareness of IoT	1, 6.25%
08	Insufficient Research on IoT and its components	1, 6.25%

The responses of the librarians' highlights key technical challenges associated with IoT implementation in libraries. The most important challenge, reported by interviewees (11, 68.75) is the lack of IoT infrastructure. It indicates that majority of the university libraries lack necessary hardwares, softwares and connection to support IoT based services. This finding suggests a fundamental gap in technological foundation required in university libraries of KP for IoT integration. Closely related is another challenge the lack of IoT expertise, reported by (10, 62.5%) the interviewees. One of the interviewee mentioned that, "these...[IoT related courses/topics] are not the part of LIS curriculum

at master/BS level and therefore I lack these expertise". This reflects a shortage of skilled professionals who understands IoT systems, their implementation, and their potential applications in library settings. Additionally a few more interviewees (8, 50%) mentioned that another considerable challenge is maintenance and sustainability. This implies that even if IoT systems are implemented, their long term upkeep, troubleshooting, and continued functionality present major challenges. The associated contributing factors to this challenge are financial limitations, and lack of technical support. Few other interviewees (06, 37.5%) stated that lack of IT staff in libraries is the next technical challenge

that further exacerbates the difficulties in implementing IoT. With limited or no IT personnel, libraries may lack the capacity to manage, monitor and troubleshoot IoT-based services effectively. Lastly, **integration with existing systems** emerges as a challenge for (3) 18.75% of interviewees. Lastly few interviewees (2, 12.5%) said that slow internet connection and power outages are also the technical challenges that hinder the implementation of IoT in university libraries.

Awareness of Librarians Regarding Ethical Guidelines and Policies during IoT Implementation

The integration of the IoT in the university libraries is transforming library services such as offering automatic book tracking, smart surveillance, user consent, and enhanced resource management. However, ethical concern related to data privacy, user consent and security require a strong understanding of ethical guidelines and policies. The research objective 04 of this study was addressed through a number of different questions. The details of these are given below:

Levels of Librarians' Knowledge Regarding Ethical Guidelines and Policies

The first question regarding research question 3 was about the level of librarians' knowledge about ethical guidelines. The analyses of responses based on sixteen in-depth interviews with the university librarians in KP revealed these facts. A majority of Librarians (8, 50%) admitted to have only basic or limited understanding of IoT related ethical guidelines and policies. They were aware of general data protection concern but lacked in-depth knowledge of specific ethical frameworks governing IoT implementation in university libraries. One interviewee said that, "...as the IoT implementation is in its infancy in our library, therefore we are not fully aware of legal issues and ethical concerns regarding its implementation". Some librarians (5, 31.25%) demonstrated a moderate level of awareness/knowledge, primarily through institutional policies, peers, or IT department directives. These librarians

understood the significance of user data privacy and protection but relied on parent institution to handle ethical compliance. As one female university librarian mentioned that, "... a certain specified staff is appointed for the purpose of preserving students' personal data and they are solely responsible for any leakage of data". These librarians emphasized the need for transparent data usage policies and ethical considerations in IoT implementation.

Few librarians (3, 18.75%) were uncertain about their status of awareness regarding ethical guidelines, being unable to differentiate between ethical and technical aspects of IoT implementation. For example one librarian said that, "...I completely understand the benefits of RFID tracking system in libraries, but I am uncertain about how much user data should be collected and retained ethically".

Analyses of the Responses Regarding Policies Frameworks Needed for IoT Responsible Use

The integration of the IoT in university libraries raises critical ethical concerns, necessitating well-defined policy frameworks. The second question regarding research question 3 was about the policy frameworks needed to ensure responsible and ethical IoT implementation. The analyses of the sixteen Librarians' based on their insight is presented in the next paragraph.

Half of the librarians (8, 50%) emphasized the urgent need for data privacy and protection policy for ethical implementation of IoT. These interviewees admitted that their institutions lack specific guidelines to regulate the ethical handling of personal data in IoT enabled environment, if established. One interviewee mentioned that, "...their institution had general data privacy policy but lacked IoT-specific guidelines". Less than half of the librarians (6, 37.5%) mentioned that need for cyber security policy and risk management policy, who pointed out that IoT enabled libraries are vulnerable to hacking, data breached and unauthorized access. However, they mentioned that they lacked technical expertise in cyber security and mostly relied on the IT department of their university for security management.

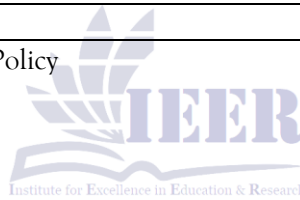
Similarly, they stressed the importance of risk management policy, particularly for data loss, system failure and ethical breached. One interviewee highlighted that, “...one of the challenge associated with the IoT implementation is the risk of illegal surveillance posing risk for the library management”.

Few librarians (5, 31.25%) mentioned the need for ethical surveillance policy. As in IoT implementation one of the popular applications of IoT is the use of RFID tracking of library materials and user movement in a library that necessitates such policy. Similarly, one-fourth of the librarians (4, 25%) highlighted that the lack of formal training on IoT ethics, privacy laws, cyber security and other aspects. They stated that librarians had to rely on their IT departments for guidance rather than having direct expertise. They therefore, stressed the need for specialized training sessions

and workshops under the coverage of sound institutional Training policy. One of the librarians mentioned that, “... a proper institutional training policy is mandatory to help library staff develop technical and ethical competencies”. Very few librarians (2, 12.5%) demanded for Academic integrity policy to prevent academic misconduct. They mentioned that IoT technologies facilitate seamless access to digital resources, but they can be misused for academic dishonesty, such as illegal or unauthorized collaboration, cheating, and accessing restricted materials. These policies would help librarians to implement authentication mechanisms and systems for monitoring to stop such problems while respecting user privacy. One interviewee mentioned that, “...such policies will not only be beneficial for libraries but will also help in educating users on responsible IoT use”.

Table 4. Policies Needed in IoT Implementation (N=16)

S. No	Needed Policy Framework	n (%)
01	Data Privacy and Protection Policy	8, (50%)
02	Cyber security policy	6 (37.5%)
03	Risk Management policy	6 (37.5%)
04	Ethical Surveillance Policy	5 (31.25%)
05	Institutional training policy	4 (25%)
06	Academic Integrity Policy	2, (12.5%)



DISCUSSION

The findings regarding the overall IoT devices and systems currently used represent substantial progress; the overall implementation of IoT in university libraries of KP is still in its nascent stage. Factors such as budget constraints, lack of technical expertise, and inconsistent policy frameworks limit widespread adoption. Nonetheless, these systems demonstrate the potential of IoT in revolutionizing library services and aligning them with global trends in library management and user engagement. This finding is in line with the findings of Ukamaka and Kakiri (2021) who reported that IoT is a dynamic novel technology that can be used in libraries in a number of ways.

The various motivational factors collectively underline the importance of IoT as a

transformative technology, encouraging university libraries in Khyber Pakhtunkhwa to embrace innovation and improve their services.

University librarians in Khyber Pakhtunkhwa are faced with several challenges while implementing IoT. Addressing these various operational and technical challenges requires strategic planning, investment in training, infrastructure development, and stakeholder engagement to ensure the effective adoption of IoT in university libraries. This suggests that libraries may struggle to align IoT solutions with their current digital and operational infrastructure, potentially leading to compatibility issues or disruptions in services. This finding also supports the findings of Ukamaka and Kakiri (2021) who also reported in their study the same nature of challenges.

Overall, these findings suggest that the successful adoption of IoT in libraries is hindered by infrastructural, expertise-related, and sustainability challenges, all of which need to be addressed through strategic investments, capacity-building initiatives, and supportive policies.

The findings regarding the awareness about ethical guidelines and policies indicate significant variation in librarians' knowledge of IoT ethical guidelines and policies. While some librarians possess a strong understanding, the majority has only basic or limited awareness and depends on institutional IT departments for ethical compliance. To bridge this knowledge gap, universities must invest in structured training programs and develop clear, standardized ethical policies for IoT applications in libraries.

The findings indicate that university librarians recognize the ethical and security challenges of IoT but lack the necessary policy frameworks to ensure responsible implementation. Data privacy and cyber security emerged as the most critical concerns, followed by risk management, ethical surveillance, and institutional training. Universities must take proactive steps to establish structured policies, provide specialized training, and develop ethical IoT governance frameworks to balance technological advancement with ethical responsibility. This finding is consistent with the findings of previous studies by Yusuf, Pervin & Roman (2024) and Smith, et al., (2024), which also stressed on protecting data privacy in all AI generated interactions.

Academic integrity in IoT-powered libraries requires a balance between leveraging smart technology for knowledge enhancement and maintaining ethical standards. Universities should develop clear guidelines on ethical IoT use, data privacy, and responsible information access to uphold academic integrity while embracing technological advancements. This finding is in line with the findings of Ullah, Naeem and Bolous (2024) who reported that academic integrity, avoiding misconduct and ensuring data privacy and security are the main focus of university ethical guidelines and policies in using various generative AI.

Implication of this study

The implications of this study highlight several key areas for the future of university libraries, particularly in Khyber Pakhtunkhwa, as they look to adopt and integrate Internet of Things (IoT) technologies. The study suggests that while IoT presents significant potential to enhance library services, such as improving resource management, user engagement, and security, its implementation remains constrained by various challenges. The financial limitations of libraries, particularly in developing regions, hinder the adoption of IoT solutions, which require substantial investments in infrastructure, technology, and expertise.

This research also underscores the necessity of capacity-building initiatives, including training programs for librarians to build the technical skills required to manage IoT systems effectively. The lack of specialized knowledge among library staff poses a significant barrier to the successful deployment of IoT, which further emphasizes the need for structured training on both the technical and ethical aspects of IoT implementation. The study also highlights the importance of developing comprehensive ethical guidelines and policies, particularly concerning data privacy, cybersecurity, and surveillance, to mitigate the risks associated with the use of IoT technologies in libraries.

Furthermore, the findings emphasize the importance of establishing clear policy frameworks to ensure that IoT adoption aligns with ethical standards, safeguarding user data and maintaining privacy. Libraries must prioritize the creation of policies to protect user privacy, ensure the security of IoT systems, and address potential misuse of surveillance technologies. In conclusion, this study not only sheds light on the operational, technical, and ethical challenges faced by university libraries but also provides valuable insights into how these challenges can be overcome to fully leverage the benefits of IoT for enhancing library services.

CONCLUSIONS

The findings of this study highlighted both the prospects and challenges associated with IoT

implementation in the university libraries across Khyber Pakhtunkhwa. While some libraries have begun integrating IoT -based solutions- such as Library Management system, surveillance system, and plans for self-checkout Kiosk- overall adoption remains in its early stages or beginning, not yet matured due to financial, technical, and administrative barriers. The study reveals that despite a clear recognition of the benefits of IoT in enhancing library operations and user experiences, librarians face significant challenges, including a lack of financial and administrative support, insufficient training opportunities, and infrastructural limitations.

Technical challenges such as the absence of IoT expertise, maintenance issues, and difficulties integrating IoT with existing system further hinder progress. Moreover, limited awareness of ethical guidelines, particularly concerning data privacy, cyber security, and surveillance, indicates the need for well-defined policy frameworks to ensure responsible IoT implementation.

To fully harness the benefits of IoT in university libraries, there is a need for strategic investments in infrastructure, capacity-building initiatives, and policy development. Universities must provide librarians with specialized training on IoT applications and ethical considerations while ensuring the necessary administrative and financial support for sustainable implementation. Establishing clear institutional policies on data privacy, cyber security, and risk management is essential to address ethical concern and ensure secure and efficient IoT adoption.

By addressing these challenges through a collaborative approach involving university administrations, policy makers, and librarians, IoT can become a transformative force in modernizing university libraries in Khyber Pakhtunkhwa, enhancing their efficiency, accessibility, and service quality for students and researchers.

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