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Adopting Internet of Things (IOT) In Smart Libraries to Increase Usability, Efficiency, And User Satisfaction

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ABSTRACT

Artificial intelligence and smart tools are invading every aspect of life. Now they are taking over libraries and academic institution in a new concept and approach. Current study hypothesized that internet of things (IoT) in smart libraries is able to positively influence usability, efficiency and user satisfaction within the library. We have developed a questionnaire for this matter, and (96) librarians within academic libraries in Jordan responded. SPSS was used to deal with collected primary data, results of analysis indicated that usability appeared to be highly influenced by IoT within academic libraries (R2 = 0.419), as the second result, user satisfaction (R2 = 0.327), and efficiency (R2 = 0.254) respectively. This trend indicates that the main effect of the IoT is increased ease of interaction between users with the library systems, which further increases their level of satisfaction. Though the efficiency increases are also important, they can be indirectly perceived by users in comparison with the usability improvements. In general, the results indicate that IoT is a very vital force in the process of converting conventional libraries into smart libraries. Study recommended that the implementation of IoT technologies in libraries should be user-focused by the library administrators. As usability exhibited the most significant influence (R2 = 0.419), libraries need to worry about creating easy-to-use interfaces, customized services, and ease of digital experiences, which will match the needs of the users. The libraries should also carry out regular user feedback evaluation to improve the IoT applications to increase satisfaction and service quality. Further recommendations were presented in the study.

Keywords: Internet of Thing IoT, Smart, Usability, Academic, Library, Efficiency, Satisfaction, Library Users.

INTRODUCTION

The advent of intelligent solutions has hugely changed academic libraries by turning them into traditional information depositories into dynamic and technology-oriented learning institutions. The use of advanced digital technologies, including the Internet of Things (IoT), artificial intelligence (AI), big data analytics, and cloud computing, in order to improve service delivery, resource management, and user experience, has become popular in smart academic libraries. The technologies allow libraries to be proactive and responsive toward the changing needs of students, researchers, and faculty members.

Olakunle Victor et al. (2025) argued that among the most significant ones, the use of the IoT-based systems, such as smart shelves, RFID tags, and system-based tracking, stand out as the most significant advancements that enhance inventory management, minimize material waste, and optimize the use of space. Smart search engines and recommendation systems, which are artificial intelligence powered, facilitate the process of retrieving information on a personal basis, i.e. by recommending the relevant academic materials depending on the interests of the

research and the current behavior. Besides this, chatbots and virtual assistants are also being employed to offer twenty-four-hour reference services, responding to common questions and directing patrons through library materials in an effective manner (Khan and Ghouse Pasha, 2025).

Lamberty (2025) noted that the smart solutions also play a role in data-driven decision making in the academic libraries. Through user behavior and use patterns analysis, the library administrators will be able to learn more about the demand trends, enhance the development of collections, and be able to provide a service to a particular group of users. In addition, cloud-based solutions enable efficient access to digital content, collaborative solutions, and distance learning materials and support hybrid and distance learning models (Alimadani et al., 2025).

From another perspective, Asim and Aref (2025) noted that the smart solutions introduced in academic libraries are helpful to increase operational efficiency, enhance the quality of services provided, and promote user satisfaction. As universities are increasingly digitalizing higher education, smart libraries are likely to be a key component in the achievement of academic excellence, innovation, and access to knowledge in contemporary universities. The Internet of Things (IoT) is a growing technological invention in academic libraries and one of the factors that add to the modernization of the library services and the improvement of user experience. IoT means a network of physically attached devices that are connected, have sensors, software, and connectivity to each other and can be used to collect, share, and process data in real time (Cheung et a., 2025). The IoT technologies, applied in the context of academic libraries, aid in the smart operations, management of the resources, and services that are more user-focused.

Oyedokun (2025) stated that IoT is also able to improve the physical space of academic libraries. Smart lighting, heating and occupancy sensors can maximize the use of energy and can also make study areas comfortable. The libraries can effectively use resources, cut the operational expenses and facilitate sustainability efforts by tracking the usage of each room and the environmental conditions in the libraries. In addition, the occupancy data is available in real time, and it helps students identify vacant study rooms and quiet places, which increases general usability (Naikar and Paul, 2025).

In terms of service, IoT-collected data would help libraries to learn more about user behavior and preferences. It can be utilized in the personalization of the services, better space planning, and facilitate the making of evidence-based decisions (Aslam et al., 2025). Incorporated with mobile applications, IoT systems have the potential to offer the user notifications, navigation, and specific alerts concerning borrowed materials or library events. In spite of these benefits, there are challenges associated with introduction of IoT in academic libraries as concerns data privacy, security and integration of the system. It is necessary to address such issues with the help of ethical rules and strong governance. On the whole, IoT is very crucial in making academic libraries Smart, effective, and user-friendly knowledge centers (Hye et al., 2025).

Aslam et al. (2025) argued that the adoption of smart services in innovative ways in libraries is gaining momentum. The paper explores the current status of smart library service, the role of university librarians in supporting the progress of innovation in library service through their capacities and flexible approaches, the implications of innovative initiatives and their impact on the overall effectiveness, and challenges faced by university librarians. Authors adopted the mixed-method approach was used. In the qualitative method, in-depth interviews were conducted with 10 chief librarians of university libraries and 150 university library professionals made up the sample for the quantitative investigation from throughout Pakistan. The development and provision of smart services is obvious in the vision of the future for university libraries in Pakistan and most of the university librarians also engage in discussion regarding challenges in innovations and solutions to these challenges. The study reveals there are many challenges to implementing innovative library services, including loss of employment caused by technology and budget limitations. But in highlighting these developments, it also highlights the possibilities of targeted training, AI and IoT technologies for improving library services.

On the other hand, Khan et al. (2025) noted that a significant growth in information and communication technologies and, as a result of the Internet of Things (IoT), artificial intelligence and machine learning, massive disruption has been occurring across a number of sectors, including the education and library sectors. These new technologies are interwoven, and have transformed the way electronic devices communicate, share data, automate seamlessly and create unparalleled user experiences by learning from user data. There is a huge market for IoT technologies, which has never been seen before with artificial intelligence integration. However, there are several challenges to consider for the use of IoT in academic libraries such as the high initial investment requirements, absence of standardized protocols, security and privacy concerns. The aim of this study is to explore the level of IoT technologies acceptance and services, as well as the challenges of implementing and integrating IoT into the U.A.E university libraries. The study adopts descriptive quantitative research design, and involves 66 university libraries using online survey. The results indicate the presence of all the IoT technologies in UAE universities' libraries, with radio-frequency identification and user-centric IoT applications like mobile applications for various library services and self-checkout systems being the most prevalent. Advanced technologies such as artificial-intelligence based IoT applications including augmented reality, virtual reality, drones, robots and energy

management systems, on the other hand, are not widely used and are still in their infancy. Financial issues, cyber security threats, organizational obstacles and lack of qualified staff are the main challenges that have been identified. The study offers several policy and management recommendations, such as establishing a clear IoT adoption framework and policies, implementing an incremental approach, implementing strong security measures, and staff training. The challenges discussed above can be overcome by implementing IoT technologies in University libraries in the United Arab Emirates and across the GCC and the rest of the world, which will improve the operational efficiency of these libraries, the user experience and library sustainability.

Ebijuwa and Rajkumar (2026) argued that the application of AI and the Internet of Things (IoT) in academic libraries is revolutionizing the ways students, faculty and researchers access and utilize information. The present working paper discusses the different potential applications of AI and IoT in the library and its effect on research and education. Key innovations include intelligent search features, personalized recommendations, automatic cataloging solutions, digital library resource monitoring and intelligent spaces to improve user experiences. This analysis focuses on the efficacy of these technologies in enabling more efficient information retrieval, library operations and decision making based on data. Moreover, it tackles issues related to the implementation of these technologies like privacy concerns, digital literacy and infrastructure. This paper will discuss the best practices for the implementation of AI and IoT in academic libraries, explore their applications and benefits, and highlight strategies for their successful integration.

From the above argument, this research was carried out as an approach to understand the influence of IoT in smart libraries and its influence on libraries usability, efficiency and user satisfaction. We have depended on quantitative methodology to achieve the aim. Overall critical thread is that all above studies stand in contrast to our aim in current study, which seems to suggest that the more one invests in IoT, the better the outcomes will be, which is not the case as there are labor, cost, ethical and readiness barriers. For that reason, we have developed a questionnaire to collect primary data from librarians within Jordanian academic libraries through the academic year 2025-2026.

Understanding the relationship between variables was accustomed through the conceptual framework below in figure 1, and from which the study's hypotheses were reached:

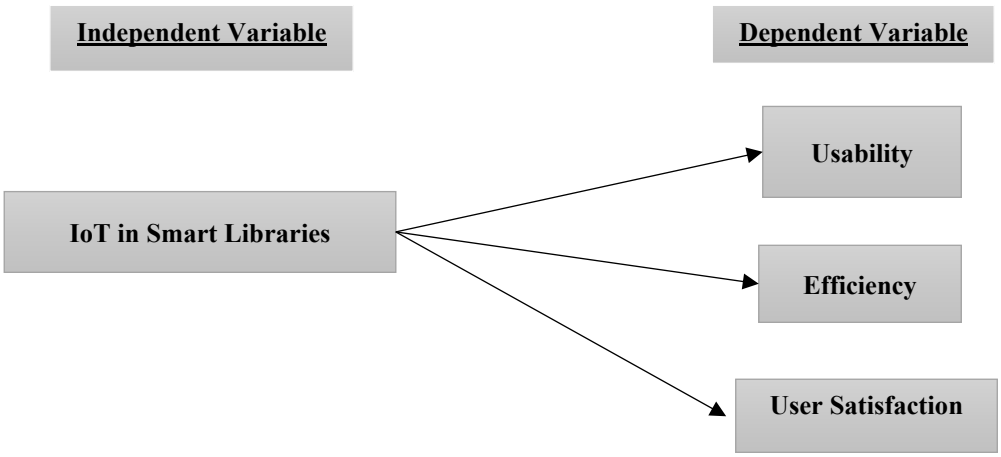

Figure 1. Conceptual Framework (Asim and Arif, 2026; Cheung et al., 2025; Rajkumar et al., 2025; Naikar and Paul, 2025)

From figure 1 we were able to formulate study's hypotheses as following:
H1: IoT in smart libraries has the ability to positively influence its usability
H2: IoT in smart libraries has the ability to positively influence its efficiency
H3: IoT in smart libraries has the ability to positively influence its user satisfaction

The model proposed herein is based on two models: Technology Acceptance Model (TAM) and Diffusion of Innovation (DOI) theory, to explain the measurable outcomes of the library, as the result of the integration of IoT. TAM proposes that perceived usefulness and ease of use are responsible for adoption behavior, and that the IoT capabilities (RFID tracking, occupancy sensors, mobile notifications) directly increase perceived usefulness by minimizing search and access friction and improving ease of use (H1). Efficiency gains (H2): The relative advantage of an IoT system, which is the benefits of adoption over existing business practices such as automated cataloging, real-time resource monitoring, and reduced manual workload, contributes to-increase in operational throughput and optimization of resources as the system diffuses through library operations. Lastly, user satisfaction (H3), which is based on Expectation-Confirmation Theory, is related to the user's expectation of IoT's personalized and data-driven services, which are expected to be received or fulfilled, thereby strengthening the user's intention to use. Together, these theories provide a basis for a causal sequence between IoT infrastructure and behavioral and

perceptual outcomes and recognize that the adoption process is constrained by cost, staff readiness and ethical governance concerns, in line with the critical gap identified in the previous literature.

LITERATURE REVIEW

Digitization in Academic Libraries

Jebet and Gichugu (2025) argued that academic libraries have become digitalized and this has altered the manner in which information is stored, accessed, and shared. Historically, academic libraries were interested in the accumulation and preservation of physical books, journals, manuscripts and other print resources. These resources still play a significant role, but due to the increased speed of the development of the digital technologies, the emphasis moved on the creation and management of digital collections that can increase the accessibility and efficiency.

According to Newman and Newman (2025), among the major advantages of digitization, there is the availability of information. E-books, online journals, institutional repositories and databases are some of the digital resources that enable students and scholars to access materials at any given time and place. Zareef and Jabeen (2025) agreed on the idea and added that this is especially useful to those distance learners, as well as scholars who work in different institutions or nations. Digitization also allows sharing the same resource by many users at the same time, as opposed to the restrictions of single physical copies.

As for Oyedokun (2025), it was argued that another major benefit is preservation. Rare books, delicate manuscripts and historical documents can be destroyed with time by reason of handling and the environment. The digitization allows the libraries to preserve the original pieces of materials and at the same time make their contents as accessible as possible. Intensive scanning and electronic archiving guarantees security of precious academic and cultural heritage collections to the future generations (Adeyemi et al., 2025; Niqresh et al.,2021).

From the perspective of Zhou (2025) and Cheung et al., (2025), high-tech research methods are also supported by digitization. Keywords allow searching digital texts rapidly, which saves time and enhances the efficiency of the research. Digital humanities research with the help of data mining, text analysis and other tools enable researchers to find the patterns and trends that are hard to detect in print sources. Yunus et al. (2025) added that academic libraries currently become active in the sphere of managing research data and contributing to the open access publishing efforts (Khan et al., 2025).

Aslam et al. (2025) stated that digitization presents such challenges as expensive technological systems, copyright concerns, and continuous digital preservation plans. To keep the digital services reliable, libraries are forced to invest in infrastructure, training of staff, and cybersecurity. Nevertheless, digitization still proves to be a significant phenomenon in academic libraries, which allows them to develop and adapt to the demands of the modern world of education and research.

The Concept of Smart Library

In their study, Elihaki Kanyika et al. (2025) argued that Smart Library is an idea of developing the traditional libraries by implementing the best technologies to improve the services, access, and usability. A smart library extends beyond being digitized and includes automation, artificial intelligence (AI), the Internet of Things (IoT), cloud computing, and data analytics to produce an intelligent and user-focused learning experience.

Molaudzi and Ngulube (2025) noted that automation is one of the major characteristics of a smart library. Radio Frequency Identification (RFID) is one of the technologies that help track books, use self-checkout and self-return systems, and manage inventory more efficiently. This saves manual labor of the library personnel and saving time by the users. Smart shelves can even tell when the books are misplaced and record changes automatically which will be better organized and more accurate (Gaikwad et al., 2025).

Chiriboga et al. (2025) stated that artificial intelligence contributes to service personalization to a large extent. Virtual assistants and chatbots based on AI can serve user needs and provide recommendations after reading history or direct students in research. Data analytics can assist the libraries in having insights into user behavior and preferences and, therefore, can shape services and collections to the needs of the academic requirements (Perera et al., 2025).

According to Nongalo (2025), smart library environment also comprises of digital learning spaces that have high-speed internet, interactive screens, collaborative workstations and access to online databases and e-resources. Through mobile applications, a user can search the catalogs, reserve materials, receive notices and access digital content remotely. Cloud-based systems provide an unhindered access to information through devices and places (Kaba et al., 2025).

Velliangiri (2025) noted that IoT-enabled surveillance, smart lighting systems, and climate control systems are used to help increase security and resource management, protect physical collections, and conserve energy. These

are technologies that are associated with sustainability and operational efficiency. While Varadarajan et al. (2025) saw that a smart library is the redefinition of the traditional library function as a passive storage of information to an active, technology-intensive knowledge center. Through innovation, the smart libraries facilitate current teaching, research, and lifelong learning, thus ensuring access to information is efficient, personalized and interactive in the present digital era.

Internet of Thing IoT in Libraries

Yaseen and Gul (2025) argued that Internet of Things (IoT) can be described as a network of interconnected physical devices, which are integrated with sensors, software, and communication technologies and can gather, transmit, and respond to data via the internet. Verma et al. (2025) noted that IoT is used in the context of smart libraries to link library resources, infrastructure, and services and form an intelligent, responsive and user-friendly environment (Hashem et al.,2022). Giving libraries the use of IoT, users can use the facilities better, the libraries can work more effectively, and the customers will be more satisfied.

Usability

Regarding usability, IoT eases the interaction between users and library services and resources. The presence of RFID (Radio Frequency Identification) tags on books and other materials enables fast self-checkout and check in using automated kiosks. Sensitive shelves will be capable of identifying the precise position of books and will assist individuals to locate materials with ease by using mobile apps or electronic records. Using IoT beacons, indoor navigation systems assist users in locating certain parts or study areas of a big library building. Also, mobile applications powered by the IoT could send live information about the seats, rooms, and resources. The features render library systems easier to use and use, particularly to newcomers or huge academic populations (Jilani, 2026).

Efficiency

The other significant advantage of IoT in smart libraries is efficiency. The automated inventory management systems can immediately monitor borrowed, returned or lost products which saves a lot of time spent by the staff performing manual duties. Intelligent environmental monitors like temperature and humidity sensors serve the purpose of preserving treasured books and archives by keeping the best conditions. Motion-sensitive lighting systems that are energy efficient offer advantage of reducing the consumption of electricity since the lights are activated when people are in the areas. Smart cameras and entry monitors equipped with IoT allows making security operations safer and reducing the number of individuals required to observe the equipment at all times. The automation of tedious tasks and the enhancement of resource management make the IoT enable the library employees to spend more time on academic service and interaction with users instead of management processes (Sultana et al., 2025).

User Satisfaction

The IoT ensures that personalized and responsive services are offered to users, which improves user satisfaction significantly. Information gathered on interconnected devices may give information about user behavior, including parts of the site that are often visited or regularly accessed resources(Hashem,2016). This information enables libraries to maximize the use of space, increase high demand collections, as well as enhance delivery of services. Live messages on the due dates, book reservations, and events will help make the user experience seamless. Smart climate systems and lighting systems keep the study room comfortable and thus enhance the satisfaction and productivity. In cases of smooth accessibility, less waiting period, and the proper maintenance of facilities, the overall view that the user has of the library is enhanced (Khan et al., 2025).

Smart Library Architecture and Governance Challenges with IoT.

A typical smart library architecture relies on Internet of Things (IoT) infrastructures, which are typically deployed in four interconnected layers: perception layer (consisting of RFID tags, sensors, beacons to track resources, occupancy and environmental conditions); network layer (Wi-Fi, Zigbee and cloud gateways for data transmission); middleware layer (APIs and integration platforms for data aggregation and processing); and the application layer (which provides services like automatic check-in/check-out, real-time inventory management, personalized recommendation engine, and predictive space management). The multi-layered approach allows libraries to

enhance the usability, operational efficiency, and patron satisfaction, as evidenced by previous empirical studies showing measurable improvements in these three areas with IoT implementation (Behera, 2026).

Chen and Grzybowicz (2025) argued that this architecture does come with significant difficulties that require further examination. Because ongoing tracking of data from the sensors produces detailed information about how the patrons are browsing the library, walking around the building, and using the resources, questions of privacy are raised, including consent, data minimization, and respect for frameworks like GDPR (or national data protection laws where applicable), especially where the legal infrastructure is thin, as in many parts of the Jordanian context and beyond the MENA region. Magara and Zhou (2024) noted that the heterogeneity and limited resources of IoT endpoints only compound the cybersecurity risks, as many lack the resources needed for strong encryption or patching, and may be susceptible to denial-of-service attacks, data interception by unauthorized parties, and lateral network penetration.

One of the primary barriers to interoperability is the lack of standardization among vendors in the RFID, library management, and cloud sectors, made more complex by the need for expensive middleware solutions or proprietary integrations that are not scalable and not vendor independent (Xu et al., 2024).

Lastly, information governance issues address the lack of accountability in data ownership, retention and in algorithmic decision-making processes of recommender systems, which calls for formal governance mechanisms involving audit trails, role-based access control, and cross-departmental oversight committees in institutions (Xu et al., 2025). These four challenge areas need to be addressed as a whole, not as separate issues, for the successful implementation of a smart library, especially when institutions must manage these challenges while maintaining institutional risk management requirements and patrons' rights.

METHODS AND MATERIALS

Methodological Approach

The study used a quantitative and cross-sectional research design to explore the impact of the Internet of Things (IoT) on usability, efficiency and user satisfaction in Jordanian academic libraries. Given the specific nature of the hypothesized relationships (H1, H2 and H3) and the need to examine the relationships with larger sample size and to be able to make statistical generalization within the study population, the adoption of the quantitative approach was considered appropriate to test the hypothesized relationships and to find the answers to the research questions, as also indicated in the existing literature on IoT use in libraries (e.g., Khan et al., 2025; Asim and Arif, 2026).

Constructs' Definition

The study constructs were operationally defined as follows in order to support the measurement model:

IoT in Smart Libraries (independent variable): the extent to which the library staff perceive the presence and integration of interconnected sensor- and network-based technologies (e.g., RFID tagging, smart shelving, automated kiosks, environmental sensors) in library operations.

Usability: the perceived ease of interaction between library staff/users and IoT-enabled library systems and interfaces.

Efficiency: increased operational speed, accuracy and resource management as a result of IoT-based automation.

User Satisfaction: overall perception of library service experience, influenced by IoT personalization, responsiveness and service.

Tool of Study

The questionnaire was in two sections. The demographic data (gender, education qualification, years of professional experience) was gathered in section one. Section Two assessed the four constructs of the study on a 5-point Likert scale (1 Strongly Disagree, 5 Strongly Agree). The wording of the items was adapted from validated scales used in the studies of Asim and Arif (2026), Cheung et al. (2025) and Naikar and Paul (2025), and the items were modified to suit the terminology and operational context of academic libraries in Jordan. The instrument was translated from English into Arabic (and back translated into English again) according to the back translation method recommended by Brislin (1970) because English is the working language of the Jordanian university library administration. Testing the reliability of the questionnaire was done depending on Cronbach's Alpha as in table 1. It was seen that all variables scored an (α) that was higher than 0.70. regarding the validity of questionnaire items,

we have arbitrated the questionnaire through the help of academics and scholars in the field. They made sure that all statements were related to the main aim and are valid to be distributed on the sample.

Table 1. Alpha Value

variable	α
IoT in Smart Libraries	0.882
Usability	0.847
Efficiency	0.809
User Satisfaction	0.859

Population and Sampling

The study involved academic librarians of Jordanian universities as a target group. The population of all Jordanian academic libraries was not available, so a non-probability convenience sampling approach was used. This study was conducted using a convenience sampling approach because there was no central directory in Jordanian universities that lists librarian contact details publicly and the time and resource limitations of the study. The use of convenience sampling is not ideal for statistical generalizability, but is employed extensively in the exploratory study of library and information science, in which formal sampling frames are lacking. The questionnaire was handed out using Google Forms and spread to social media groups of library workers.
Total of (125) librarians were invited to participate in a convenience sample. 96 questionnaires were returned and usable, giving a response rate of 76.8% of these. There were no systematic differences between early and late respondents with regard to key demographic variables, so there was little sign of non-response bias, but this could not be formally tested using a wave analysis. No formal a priori power analysis was performed, but the attained sample size (n = 96 sample points) is greater than the suggested minimum for single predictor regression models and should be viewed with some consideration to the exploratory nature of this study.

Screening and Analysis

Responses that were not complete or had inattentive response patterns were screened out of the completed responses before analysis. IBM SPSS [v.27] was used to analyze data. H1–H3 were tested using multiple/simple linear regression while means (μ) and standard deviations (σ) were calculated for items in the questionnaire and frequencies and percentages were used to summarize the demographic data.

ANALYSIS AND RESULTS

Demographic Results

Frequencies and percentages were calculated for sample demographics. It was seen that majority of respondents were females forming 53.1% of the total sample, who held BA degree forming 70.8%. according to results, it was seen that majority of respondents has experience in library management of more than 18 years forming 54.2% of the total sample.

Table 2. Demographics

	f	%
Gender		
Male	45	46.9
Female	51	53.1
Education		
BA	68	70.8
Postgraduate Studies	28	29.2
Experience		
Less than 5	5	5.2
6-11	15	15.6
12-17	24	25.0
+18 years	52	54.2
Total	**96**	**100.0**

Questionnaire Analysis

Mean (μ) and standard deviation (σ) were used to test participants attitudes towards statements of questionnaire. The survey results indicate that all participants held the questions in high regard. Every statement exhibited a score beyond the mean of 3.00 on the scale, and these scores were demonstrated to be statistically significant, corroborating this finding. The statistics in the aforementioned table, which presented the mean and standard deviation of the survey statements based on participant replies, provided proof for this.

Table 3. Questionnaire Results

Statement	μ	σ
The emergence of intelligent systems increased the appearance of IoT in academic libraries	3.771	.946
Smart libraries are now more efficient than conventional libraries	3.698	.985
IoT emerged as a facilitator for smart libraries' services	3.688	.874
Academic libraries now are more connected to intelligent services compared to the past	3.521	1.015
IoT came to better present academic libraries in a way that supports user satisfaction	3.542	1.132
IoT in Smart Libraries	**3.644**	**.820**
IoT facilitates the ease of use in libraries	3.167	1.202
Through IoT there would be a friendly interface design	3.698	.896
IoT increases the interoperability of smart libraries services	3.802	1.012
Accessibility is much higher through IoT in smart libraries	4.167	.829
IoT increases the reliability of smart libraries' services	3.604	.989
Usability	**3.687**	**.782**
The automation of smart libraries' services through IoT increases its efficiency	3.500	.808
Real-time processing is a part of IoT in smart libraries	3.375	.987
IoT increases connectivity of smart libraries	3.615	.875
The scalability of smart libraries is much higher with IoT	3.771	.912
The data accuracy is more attainable through IoT in smart libraries	3.792	1.075
Efficiency	**3.610**	**.704**
IoT increases the security and privacy of smart libraries which increases user satisfaction	3.937	.856
Through IoT, personalization in smart libraries services is higher and more satisfactory	4.031	.989
The responsiveness that IoT presents in smart libraries increases user satisfaction	4.031	.876
IoT works in increasing service quality in smart libraries which is for the benefit of user satisfaction	3.760	.949
IoT highlights the usefulness of smart libraries which increases the user satisfaction	3.427	1.122
User Satisfaction	**3.837**	**.770**

Hypotheses Testing

As in table 4, linear regression research has showed that IoT in smart libraries has the ability to positively influence its usability. This result is supported by a substantial F-value of 67.731, deemed significant at the 0.05 level. Moreover, it is essential to emphasize that the independent variables explain 41.9% of the variance seen in the dependent variable. The correlation coefficient of r= 0.647 indicates a high relationship between the variables.

Table 4. H1 Testing

H1: IoT in smart libraries has the ability to positively influence its usability								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R	R^2
		B	Std. Error	Beta				
1	(Constant)	1.437	.280		5.130	.000	.647[a]	.419
	IoT in Smart Libraries	.618	.075	.647	8.230	.000		
a. Dependent Variable: Usability								

Table 5 below indicated that IoT in smart libraries has the ability to positively influence its efficiency. This result is supported by a substantial F-value of 32.075, deemed significant at the 0.05 level. Moreover, it is essential to emphasize that the independent variables explain 25.4% of the variance seen in the dependent variable. The correlation coefficient of r= 0.504 indicates a moderate relationship between the variables.

Table 5. H2 Testing

H2: IoT in smart libraries has the ability to positively influence its efficiency								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R	R^2
		B	Std. Error	Beta				
1	(Constant)	2.031	.286		7.108	.000	.504[a]	.254
	IoT in Smart Libraries	.433	.077	.504	5.663	.000		
a. Dependent Variable: Efficiency								

As for the 3rd hypothesis, table 6 indicated that IoT in smart libraries has the ability to positively influence its user satisfaction. This result is supported by a substantial F-value of 45.697, deemed significant at the 0.05 level. Moreover, it is essential to emphasize that the independent variables explain 32.7% of the variance seen in the dependent variable. The correlation coefficient of r= 0.572 indicates a moderate relationship between the variables.

Table 6. H3 Testing

H3: IoT in smart libraries has the ability to positively influence its user satisfaction								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R	R^2
		B	Std. Error	Beta				
1	(Constant)	1.881	.297		6.344	.000	.572[a]	.327
	IoT in Smart Libraries	.537	.079	.572	6.760	.000		
a. Dependent Variable: User Satisfaction								

DISCUSSION

The present study aimed at investigating the effect of Internet of Things (IoT) applications on three critical performance indicators such as usability, efficiency and user satisfaction for smart academic libraries. The findings were then analyzed using linear regression analysis with 96 librarians from academic institutions in Jordan and are consistently supportive of the positive and statistically significant effect of IoT on improving library services.

With respect to usability (H1), the regression model demonstrated a strong explanatory capacity, with IoT accounting for 41.9% of the variance in usability ($R^2 = 0.419$, $F = 67.731$, $\beta = 0.647$, $t = 8.230$, $p < 0.001$). These findings suggest that the use of technologies that enable IoT, such as RFID systems, smart shelves, automated check-in and check-out kiosks, and real-time indoor navigation tools can significantly decrease the mental and physical strain of library users. The present results are in line with the ones drawn by Asim and Arif (2026) who also found that the more IoT is used, the better the accessibility and ease of interaction with the library services are. Additionally, Olakunle Victor et al. (2025) confirmed the trend and found that the most significant innovations for minimizing inventory friction and maximizing spatial efficiency include smart shelving and RFID-based tracking. This was echoed by Jilani (2026) when she showed that the use of mobile applications with live data on the library's occupancy and resources through the IoT was especially useful in large academic libraries. Together, these studies and the present results indicate that usability is the main domain in which the influence of IoT is felt, since the benefits of improving the interfaces are immediately felt by the end users.

As far as efficiency (H2), the regression results show that there is a statistically significant relationship ($R^2 = 0.254$, $F = 32.075$, $\beta = 0.504$, $t = 5.663$, $p = 0.001$); however, the relatively low explanatory power suggests that technology is not the sole factor influencing operational efficiency. Other variances that cannot be fully captured independently from IoT are institutional policies, quality of infrastructure, training of staff, and financial resources. This discovery corroborates Cheung et al. (2025), which states that IoT can also automate repetitive tasks, minimize errors, and improve inventory management, but that the benefits of IoT efficacy can be moderated by organizational ability to implement and maintain such systems. A similar opinion was offered by Sultana et al. (2025), who found that the use of IoT automation frees library staff from tedious administrative tasks, allowing them to focus more on engaging with academics and providing user services. The present study builds on these findings and examines the impact of efficiency gains in Jordan where resource limitations could affect the impact of the gains, an issue that was not always highlighted in previous studies in developed countries.

With regard to user satisfaction (H3), the model was moderately but significantly affected ($R^2 = 0.327$, $F = 45.697$, $\beta = 0.572$, $t = 6.760$, $p < 0.001$), which means that about one-third of the variance in user satisfaction can be explained by the enhancements in services related to IoT. Smart climate control, real-time notifications regarding due dates and reservations, and reduced waiting times all contribute to a more seamless and responsive library experience. The findings corroborate with Naikar and Paul (2025), who found that user satisfaction is significantly

improved when access obstacles are reduced and the service is efficient and user friendly. The importance of providing mobile platforms with personalized alerts and remote access, which significantly improve users' perceptions of service quality, was also highlighted by Khan et al. (2025). The findings of the present study are in line with the existent body of evidence, and it also reveals that satisfaction, despite being strongly affected by IoT, is also related to the overall quality of the service environment which accumulates over time.

When the effect sizes are compared with the three dependent variables, usability is the one with the highest effect size ($R^2 = 0.419$), followed by user satisfaction ($R^2 = 0.327$) and user efficiency ($R^2 = 0.254$). This hierarchy is theoretically meaningful: IoT's most direct effects take place at the interface level, where users feel the direct impact of the technological improvements, which then lead to greater satisfaction. Conversely, efficiency improvements are more likely to appear in the operational and administrative aspects, which are not as conspicuous to users. The results as a whole support the strategic importance of IoT adoption in academic libraries and provide empirical support from a non-traditional context in a developing country where previous research was conducted mostly in institutional settings with a technologically advanced context.

CONCLUSION AND RECOMMENDATIONS

Generally speaking, the introduction of the Internet of Things to smart libraries turns the conventional library procedures into active, effective and convenient systems. IoT technologies can meet the emerging needs of the contemporary academic communities by providing a high level of usability, efficiency, and user satisfaction to ensure the libraries can transform into the innovative hubs of learning and research in the digital era. To sum up, the findings suggest that the use of IoT has a tremendous positive effect on usability, efficacy, and user satisfaction within smart libraries. Policymakers and library administrators ought to thus focus on investment in IoT infrastructure and training programs in order to exploit such benefits. In future studies, it can be addressed to examine further factors of efficiency and satisfaction, and may also examine possible moderating variables like organizational readiness or technological competence.

Recommendations

According to the discussion above, we can come up with the following recommendations:

- Jordanian academic libraries need to invest more in the IoT infrastructure including RFID systems, smart shelves, automatic circulation systems, and real-time tracking systems. The results indicate that IoT contributes greatly to the usability, efficiency, and user satisfaction, which means that the improvement of technological infrastructure will boost library performance further.
- The implementation of IoT technologies in libraries should be user-focused by the library administrators. As usability exhibited the most significant influence ($R2 = 0.419$), libraries need to worry about creating easy-to-use interfaces, customized services, and ease of digital experiences, which will match the needs of the users. The libraries should also carry out regular user feedback evaluation to improve the IoT applications to increase satisfaction and service quality.

Limitation for Study

Current study was limited to the following:

- Small Sample size and Geographic coverage.

The research was carried out based on 96 academic libraries librarians in Jordan. Despite the statistically significant results, the small size of a sample could restrain the generalization of the findings as the study has been conducted in one country. The following research might involve more subjects and other categories of libraries (public, school, or special libraries) in more than one country.

- Cross-Sectional Research Design.

The research took a cross-sectional design, which involved the gathering of data at a single point in time. This restricts the possibility of studying long-term impact or causality of the implementation of the IoT and library outcomes. Longitudinal research might be helpful to gain a better understanding of the nature of the IoT integration process and the way in which its effect on usability, efficiency, and satisfaction are formed.

Theoretical and Practical Implications

Carrying out this current research was built on practical and theoretical implications. From a practical perspective, the results are applicable to the library managers and policymakers because they indicate that the adoption of the IoT has a direct positive impact on the usability, efficiency, and user satisfaction. This evidence can be used by

decision-makers to support strategic investments in smart technologies within the initiative of digital transformation. The use of IoT solutions can enhance the clarity of service delivery, streamline the academic library processes, and make the organizations competitive.

From a theoretical perspective, the proposed study will be relevant to the current literature on smart libraries and the use of technologies because it will provide empirical confirmation of the positive correlation between the application of IoT and main performance indicators in the environment of developing countries. It builds the work of previous researchers by numerically showing how IoT is a meaningful source of explaining the large differences in usability, efficiency, and user satisfaction. The results can be used as a basis of other theoretical frameworks that can discuss the transformation brought by technology in library and information science.

The implementation of the IoT is helping to bolster digital library services, bring greater accessibility, automation, and a better user experience. It also facilitates the management and organization of information in real-time and assists policy makers and library managers in making decisions based on data to inform efficient and innovative user-centred services in both academic, public and special libraries.

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