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Corresponding Author: Aktarul Islam (Email: aktarul.clic@brur.ac.bd)

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Application of Smart Technologies in University Libraries to Spearhead Smart Library Program in Bangladesh

Md. Aktarul Islam [a] Abdur Razzak [b] Md. Dulal Uddin [c] Md. Sohel Rana [d] Md. Rashed Nizami [e]

Abstract: *Libraries around the globe are now adopting emerging and innovative technologies to offer prompt and transparent library and information services to users. The application of these cutting-edge technologies harnesses libraries' efficiencies and efficacies to fulfill users' needs and requirements to a great extent. However, public and private university libraries in Bangladesh are now leveraging the blessings of emerging technologies like RFID, Digital borrower IDs, Dspace, Instant Reference Service, IoT, and other smart appliances to keep pace with the rest of the world in meeting challenges in proficiently dealing with savvy library users. This paper is mainly a qualitative approach aiming to focus on the status of the application of smart technologies by university libraries in Bangladesh. Besides, the authors highlight the emerging technologies currently adopted in academic libraries. This paper provides a comprehensive understanding for librarians, researchers, and policymakers regarding the application of smart technologies in university libraries.*

Keywords: Smart Library, Emerging Technologies, Internet of Things, Cloud Computing, OPAC

Introduction

Smart devices such as smartphones, laptops, tablets, and other digital apparatus have become indispensable parts of our everyday lives. The effects and blessings of these smart technologies are adding new dimensions to students' learning process and helping them immensely to stay in touch with the academic world (Goksu et al., 2016). Besides, Smart Technologies can play crucial roles in rejuvenating information management systems. Radio Frequency Identification (RFID) tools, artificial intelligence gadgets, robotics, augmented Reality, and other smart technologies are making libraries self-sufficient and opening new doors to reassess the users' needs and requirements (Kumar and Kumar, 2019). However, smart technology reshapes contemporary contexts of smart library framework to transform the conventional campuses into smart educational hubs (Ekere et al, 2022). The application of the Internet of Things in libraries and information centers has brought noticeable advancement in curbing data privacy risks. Besides, it enables the librarians to streamline library operations and enhance user expertise in dealing with information delivery, check-in and check-out procedures, inventory management, and other activities to safeguard patron information (Ram, Kumar, and Pal, 2023).

The library is an academic nerve center that plays its role in promoting teaching, learning, and research by providing necessary resources to academics, researchers, and students (Azolo, 2019). Besides, it is an entity dedicated to organizing knowledge and information (Tripathi et al. 2016). However, the 'Smart Library', which assimilates cutting-edge technologies and the Internet of Things to enhance library services, efficiency, and customer experience, has gained popularity worldwide in recent years (Kumar & Malhotra, 2021; Chen &Bhuvaneshwari, 2021; IFLA, 2019).

In this age of massive globalization and the explosion of the internet and technology, the traditional roles of libraries are changing by leaps and bounds to meet the requirements of the masses (Ameen&Ullah,

[a] Central Library & Information Center, Begum Rokeya University, Rangpur, Bangladesh.
[b] Department of Library and Information Science, School of Human Science, Khwaja Yunus Ali University, Bangladesh.
[c] Central Library, Jagannath University, Bangladesh.
[d] Department of Physical Education, Begum Rokeya University, Rangpur, Bangladesh.
[e] Daffodil International University Library, Bangladesh.

2020). Library roles are no longer confined to the periphery of organizing and preserving books, non-books, journals, periodicals, and other information items. With the rapid march of time and to keep pace with the technological revolution, libraries are adopting different technologies to provide prompt and quick library services to the users (Islam, 2023). Moreover, automation and digitization initiatives in libraries are taking strong shape across the globe to provide hassle free services and ensure round the clock accessibility to students, teachers, researchers, and other stakeholders (Chowdhury, 2023). As the world moves closer to information superhighways, the need to introduce smart library programs becomes increasingly pertinent to library and information science specialists (Rashid, 2022).

However, the paper is a qualitative approach, primarily focusing on the use of smart technologies in Bangladeshi public and private university libraries to provide prompt and quality information services to the end users. Besides, this paper also discusses the emerging technologies currently adopted in academic libraries. Furthermore, this paper provides a comprehensive understanding for the policy makers, university stakeholders and library professionals of the smart technologies employed by the university libraries in Bangladesh, along the indications of challenges to be considered before the adoption of smart library initiatives.

Literature Review

Overview of Smart Library Concepts and Technologies

Igwe and Sulyman (2022) figured out the smart library's potential benefits and revolutions in ensuring better library operations and information services to the target users. They opined that libraries can adopt emerging technologies to provide smart services facilitated by smart librarians in collaboration with other information experts. Wang et al. (2018) investigated Radio Frequency Identification (RFID), the Internet of Things (IoT), and cloud computing-based smart systems that offer specific interfaces for parcel delivery services, which can largely assist in managing storage, distributing parcels, arranging transport, and related tasks. On the other hand, Steehler et al. (2022) found that smart technologies aid in handling multitasking and information overload by motivating learners to engage in technological innovations.

IoT Applications and Smart System Developments

Zhu and Fu (2015) constructed a supply chain simulation system based on the Internet of Things (IoT) to incorporate GPS, sensors, ZigBee, and RFID technology by analyzing the system's architecture, introducing the key technology of the system implementation, and the function and process of the system. Similarly, Sah (2016) demonstrated a setup of IoT for residences that allows users to regulate electrical applications over smartphones or other electronic devices through the Internet.

Challenges of Smart Library Implementation in Developing Countries

Ekere et al. (2022) revealed that the creation and management of smart libraries face multifaceted challenges in developing countries. Idiegbey-an Ose et al. (2014) investigated how libraries in Nigeria are adopting ICTs and other smart technologies to upgrade their functions and services for users. Siddike et al. (2011) explored the culture of adopting ICTs in university libraries in Bangladesh. They revealed that administrative complications, a lack of support from the authorities, insufficiently computer-literate staff, interrupted internet connections, financial barriers, and other issues are hindering the progress of digitization in university libraries. In another study, Alam and Islam (2011) investigated the progress of digitization and digital information systems as unsatisfactory. They identified library activities closely related to the development of bibliographic and full-text databases, hosting e-papers and metadata on the web, and offering online searching and downloading facilities.

Recent Developments and Advanced Technologies

In a study, Bhuyan and Bipasha (2023) found that the Dhaka University Library is trying to transform conventional library services into digitally accessible formats, leveraging the benefits of emerging technologies. Rahman (2020) revealed that various technological tools are being utilized in university libraries to serve users promptly under the guidance of well-trained librarians. For example, Yang and Li (2019) found that AI-generated Chatbots are adopted by universities to ameliorate library services to

increase user participation and automate reference service to a great extent. Whereas Achugbue et al. (2023) suggested that university libraries should concentrate on the utility of library services and the development of smart technologies to ensure prompt user access to library resources. Kumar and Singh (2021) discussed the effectiveness of blockchain technology on the library's overall development to bring administrative efficiency, guarantee safety for digital transactions, and prevent valuable data from being manipulated. Jahan and Kabir (2023) highlighted the value of mobile applications in university libraries, which boost information retrieval efficiency and provide remote access to educational resources. However, Hasan et al. (2022) addressed the advantages of smart technologies being used in libraries to foster digital literacy training programs for librarians and end-users. They opined that the application of smart technologies might not always bring desired results due to the lack of well-trained and skilled library professionals.

Research Gap

The above papers dealt with the insightful understandings and different aspects of smart technologies being used in libraries around the world. None of the research articles addressed the current scenario of the application of smart technologies in public and private university libraries in Bangladesh. Besides, the state of technological usage in public and private universities, along with the challenges in adopting smart technologies, remained unaddressed in these research papers.

Purpose of the Study

The main purpose of this paper is to focus on the application of smart technologies in Bangladeshi university libraries. Besides, this paper aims to achieve the following objectives.

a) To discuss the smart library and its key elements
b) To identify the emerging technologies currently adopted in academic libraries
c) To highlight the challenges in adopting smart technologies

Methodology

The researchers applied a qualitative approach to carry out the study. They received substantive literature relevant to the study to draw a comprehensive picture of the smart library movement in Bangladesh. The researchers visited the university library websites to investigate the current status of the smart library movement reflected in library functions and services. They have selected twenty university libraries, comprising 10 public and 10 private universities, to point out the usage of ICTs, automated library technologies, and other innovative technologies to provide prompt and transparent information services to the end users.

Table 1

Public University Library

S#	Name of the University	Name of the Library	Web address
1	Dhaka University	Dhaka University Library	https://www.du.ac.bd/offices/LIB
2	Rajshahi University	Rajshahi University Library	http://library.ru.ac.bd/
3	Jahangirnagar University	Jahangirnagar University Library	https://juniv.edu/office/university-library
4	University of Chittagong	University of Chittagong Library	https://library.cu.ac.bd/
5	Shahjalal University of Science and Technology (SUST)	SUST Library	https://library.sust.edu/
6.	Khulna University	KaziNazrul Islam Central Library	https://opac.library.ku.ac.bd/
7.	Islamic University, Kushtia	KhademulHaramain King Fahad Bin Abdul Aziz Central Library.	https://www.iu.ac.bd/index.php/pages/view_1/Nzc=

S#	Name of the University	Name of the Library	Web address
8.	University of Barishal	Central Library, University of Barishal	https://library.bu.ac.bd/
9.	Rajshahi University of Engineering & Technology (RUET)	Rajshahi University of Engineering & Technology (RUET)	https://www.library.ruet.ac.bd/
10.	Bangladesh University of Engineering and Technology (BUET)	Bangladesh University of Engineering and Technology (BUET) Library	http://lib.buet.ac.bd/home/

Table 2

Private University Library

S#	Name of the University	Name of the Library	Web address
1	North South University	North South University Library	https://library.northsouth.edu/
2	BRAC University	Ayesha Abed Library	https://library.bracu.ac.bd/
3	East West University	Dr. S. R. Lasker Library	http://lib.ewubd.edu/
4	Daffodil International University	Daffodil International University Library	https://library.daffodilvarsity.edu.bd/
5	Independent University, Bangladesh	IUB Library	https://library.iub.edu.bd/
6.	University of Liberal Arts Bangladesh (ULAB)	University of Liberal Arts Bangladesh (ULAB) Library	https://www.ulab.edu.bd/library
7.	Asian University for Women	Asian University for Women Library	http://www.auw.edu.bd/library/index.php
8.	United International University	Shaheed Irfan Library	https://library.uiu.ac.bd/
9.	American International University-Bangladesh (AIUB)	American International University-Bangladesh (AIUB) Library	https://www.aiub.edu/library
10.	Green University of Bangladesh	Green University of Bangladesh Library	https://library.green.edu.bd/

Smart Library

The concept of a "Smart Library" refers to the next-generation library, embedded in the advancement of information and communication technologies, that disseminates prompt information services to end-users regardless of geographical barriers (Singh and Tripathi, 2023).In other words, a smart library is the amalgamation of hardware and software installed tactfully to serve as a skilled librarian (Orji and Anyira, 2021). It leverages modern technology to enhance its operations and services, providing users with improved information services and increased efficiency in managing housekeeping operations through the use of artificial intelligence, machine learning, the Internet of Things, and distributed computing (Iroroeavwo et al., 2023).

Key Elements of Smart Library

A smart library is the amalgamation of smart technologies being organized and monitored on a regular basis to provide smart library services to smart users with the supervision of technologically proficient smart library professionals. The key elements of a smart library are:

Smart Librarian: Smart library professionals are the key driving force behind the success of the smart library movement. Installing smart technologies to ensure the smooth running of library functions and services is next to impossible without the supervision and guidance of a technologically sound librarian.

Smart Technologies: Libraries are now turning into information centers and research hubs due to the blessings of cutting-edge technologies. Smart Resources like the Internet of Things, Artificial intelligence-based search mechanisms and information retrieval systems, Augmented Reality, Virtual Reality, and other smart technologies can greatly serve the information needs of end users.

Smart Service: Smart library services are meant to guide users in leveraging technological advantages to fulfill their specific demands and requirements. Automation and digitization initiatives ensure smooth library circulation systems, enhance efficiency in searching for a required document, and make the information retrieval process quick and transparent. Zhang and Liu (2024) explored that introducing the Scan to Borrow application in libraries can assist users in borrowing books by scanning the barcode. Besides, strengthening collaboration and efficiency in research and adopting Artificial Intelligence to enhance service quality can create a bright ambiance in libraries to ensure smart services to the end users.

Smart Users: The principal motto behind adopting smart technologies in libraries is to make users resourceful enough to evaluate their problems and take part in the decision-making process. Jagadeesha (2024) opined that a smart library user can significantly generate new knowledge and collaborate with the library staff and other users under any circumstances.

Smart Technologies Used In Libraries

The revolution in the world of the Internet has made broadband connections available at minimal cost. The rapid development of ICT has enabled different gadgets and devices, such as Radio Frequency Identification (RFID), infrared sensors, and other smart devices, to be useful means for communication systems and knowledge sharing beyond borders (Ukamaka and Kakiri, 2021). Here are some of the notable innovative technologies widely used in libraries and information centers around the world.

Internet of Things (IoT)

The term "Internet of Things" was used by Kevin Ashton, who invented Radio Frequency Identification (RFID) technology, an innovative radio communication system, first applied in Supply Chain Management. It implies a system of interconnected and interdependent equipment, responsible for storing and transferring information in the presence of a wireless network and without human involvement (Mouha, 2021; Mondal, 2021). It is needless to mention that IoT, as an innovative form of smart technology, is an advanced form of Information and Communication Technology (ICT) that makes the exchange of information, library housekeeping operations, book rental, inventory, tagging, and access control much easier with the blessings of an intelligent library management system (Makwana, 2021).

Radio Frequency Identification (RFID): RFID (Radio Frequency Identification) incorporates a wide range of technologies that utilize radio frequencies for the automatic identification of individuals or objects across distances from a few inches to several hundred feet (Parkash et al., 2012).In libraries, Radio Frequency Identification offers transformative potential. It enables the inventorying of large collections, often consisting of hundreds of thousands of items, in a matter of days instead of months. Additionally, it supports automated checkout and return procedures, allowing patrons to access services speedily at any time of day (Singh, 2014).

Integrated Library Software (ILS): Open Source Integrated Library Systems (ILS), which have been designed with Comprehensive Library Management Features for Cataloging, Circulation, Acquisitions, and other functions of a library, are easing the hassle of library professionals to a great extent. At present, the most popular Integrated Library Software, like Koha, Evergreen, and NewGenLib, are receiving attention from the library experts for their enormous impact in searching the catalog, keeping track of book purchases and other expenditures, and entering MARK entries into the catalog to make an item available in OPAC (Chow and Bucknall, 2012).

OpenBiblio: It is an open-source and freely available integrated library management system designed and modified specifically for small libraries. It offers valuable features like cataloging, Online Public Access Catalogue (OPAC), bibliography service, and circulation. Additionally, it is very popular among library professionals for its simplicity and user-friendly interface (Bwalya, 2017).

Dspace: DSpace preserves and facilitates open access to various forms of digital materials, including text, images, videos, MPEG files, and datasets. It is an open-source software package aimed at establishing library repositories for academic documents and published digital resources of a university (Das, 2015).

Greenstone: Greenstone enables users to search the complete text of documents and select from indexes created from various sections of the materials. It also offers adaptable browsing features, allowing users to explore listed authors, titles, dates, classifications, and more (Das, 2015).

Cloud Computing: Cloud computing refers to the instant access to computing resources, which may include physical or virtual servers, data storage solutions, networking features, tools for application development, software, artificial intelligence-enhanced analytics platforms, and additional services delivered over the internet with a pay-as-you-go pricing model(Susnjara& Smalley,2025). Nowadays, Libraries are embracing cloud-based solutions for various services, including e-journal access management, digital library hosting, statistics tracking, integrated library sys-tem (ILS) hosting, and so on (Gonzales, 2023).

Bibliographic Reference Tools: Bibliographic reference tools or reference management software, like Mendeley, EndNote, Reference Manager, Zotero, BibTeX, etc., can assist researchers, academics, and authors in combining, managing, and citing their sources. These tools can automatically format references and bibliographies in different styles, saving time and guaranteeing precision (D. Samuel Gottesman Library,n.d).

Artificial Intelligence (AI): Artificial Intelligence, or AI, introduces libraries to the digital era. It transforms the traditional atmosphere and enhances the library's capability to fulfill the ever-changing needs of end users. Library and information centers around the globe are now using AI technology to enhance accessibility and streamline procedures for state-of-the-art services around the clock (Mandal, 2024)

Information retrieval through AI: Information Retrieval (IR) is one of the key functions of a library for organizing and managing knowledge. At present, Artificial Intelligence technology is employed throughout the novel Information Retrieval process to offer standard library services. This process includes comprehending user inquiries, organizing and structuring information, and delivering customized outcomes that are more pertinent and precise compared to conventional search techniques (Mandle, 2008).

Expert System: An expert system, which is a set of programs and a popular branch of Artificial intelligence technology, can manipulate encrypted knowledge in order to solve problems within a specified area that entails human expertise. However, with the growth of powerful and affordable computers, libraries are now trying to implement expert systems for accomplishing classification, cataloguing, collection development, reference services, information services, indexing, and other important operations effectively (Muqueem, 2014).

Use of Broadband Internet Connectivity: Robust broadband connectivity should be given the highest priority for ensuring quick and prompt access to the library resources. Besides, cutting-edge libraries with innovative cataloguing facilities make libraries a worthwhile place for exploring the world of knowledge and information. Visser& Ball (2013) insisted that robust Broadband Internet Connectivity is an essential element for an organization to share and receive information. Additionally, the efficiency and utility of the smart library technologies depend solely on uninterrupted and robust internet connectivity.

Apart from the above innovative library technologies, Application Programming Interface, E-Granthalaya 4.0, Data Analytics, Smart Kiosks, New Media, Web 2.0, Geographic Information Systems (GIS), Mobile Technologies, and many other emerging smart technologies are creating a paradigm shift in leveraging the blessings of prompt library and information services.

Status of Smart Technologies in Bangladeshi University Libraries

There is a slow and steady growth of smart technologies in Bangladeshi academic libraries. The researchers have visited the web pages of some of the country's famous university libraries to reveal the present scenario of smart technology usage.

Dhaka University Library: The Dhaka University Library provides a wide range of facilities to its users. The library incorporates OPAC facilities to simplify access to the library's vast collection. Library users can leverage the facilities of digital borrowing ID cards to get books and access digital content with ease and comfort. The library had made numerous old and rare documents, microfilm, and microfiche available in CD/DVD formats for its users. Besides, the availability of high-speed internet service enables the library users to access different online databases, E-Books, and journals for research and other purposes. Furthermore, the library facilitates its physically challenged users with Braille Books, sufficient computers with specialized software, and up-to-date Braille Printers through a modern and international standard Resource Center.

Rajshahi University Library: Rajshahi University Library is an automated academic library that incorporates an OPAC system, utilizing integrated library software Koha, to help users search and access necessary books, non-book materials, periodicals, audio-visual materials, and other information items promptly. The library provides high-speed internet to facilitate quick access to its repository, online databases, e-journals, e-books, and other online resources, including Project Muse, Synergy, Blackwell, and others. Besides, the library issues smart ID cards to its patrons to make circulation procedures faster. Further, the library is also using DSpace to publish and distribute research publications and other resources of the university. Furthermore, the library offers a plagiarism checking facility through Turnitin to generate similarity reports for teachers and researchers.

Bangladesh University of Engineering and Technology (BUET) Library: BUET library provides access to its huge collection of books, periodicals, and intellectual resources through its OPAC. The library offers digital borrower ID cards to expedite the circulation procedure and ensure prompt access to both digital and physical resources. Library patrons can leverage enormous digital resources due to the blessings of high-speed internet. Besides, this library maintains online institutional repositories to preserve research papers, theses, dissertations, and other items of knowledge. Further, the library offers RFID cards for the new students to ensure secure access, payment dispensation, and identification. Additionally, the library provides prompt access to numerous e-books and e-journals to expedite research and innovative activities.

Jahangirnagar University Library: Jahangirnagar University Library offers a smart library app to provide access to the university library's wide range of resources. It is now available in the Google Play Store. However, the library employs borrower ID cards for its patrons to access all the resources. The adoption Online Public Access Catalogue (OPAC) in the library makes content searches simple and convenient. Users can access a wide range of digital resources from any corner of the world. A computerized system for inventory tracking assists library staff in improving the quality of services. Further, the Institutional Repository helps the library to provide uninterrupted access to academic publications, research

documents, and intellectual property from the institution. Finally, the adoption of Plagiarism Detection Software in the library ensures academic integrity among teachers and researchers.

Chittagong University Library: The library incorporates an OPAC system to facilitate an advanced searching mechanism for its patrons to provide access to the vast library collections. However, the incorporation of the E-learning Center in the library, the first ever in Bangladesh, opens windows for the physically-challenged students to access software and hardware facilities. Besides, RemoteXs facility, a cloud-based platform, allows access for university teachers, students, and researchers to e-books and e-journals. Further, the adoption of a Barcode scanner helps library staff to check in and out, manage inventory, and verify patrons' membership. Moreover, the library maintains its repository through DSpace to easily ingest valuable documents, audio-visual materials, datasets and their equivalent Dublin Core metadata.

Shahjalal University of Science and Technology (SUST) Library: The entire library has been computerized using ILS KOHA, which has developed its database in MARC21 format, providing digital library services to university students, teachers, and researchers since 2013. The adoption of the OPAC system in the library makes the circulation process of books and other items of knowledge within seconds. To ensure the security of a book, RFID technology has been used as part of the digitization of the library. Additionally, 32 CC Cameras are being operated round the clock to ensure the security of the library premises. Further, the library facilitates access to E-Journals, E-Books, and Research Databases for the researchers. Furthermore, the library adopts an electronic payment system for users to pay library usage fees.

Khulna University Library: Khulna University Library, also known as KaziNazrul Islam Central Library, is an automated one that provides its users prompt access to a vast range of collections. The library introduces digital ID cards for its patrons to borrow and return the library's books, periodicals, and other items of knowledge. The adoption of the OPAC system helps the library ensure remote access to its resources. The availability of high-speed internet across the library premises allows users access to numerous e-books, e-journals, and other online databases.

Islamic University Library, Kushtia: The Islamic University Library is also known as KhademulHaramain King Fahad Bin Abdul Aziz Central Library, which provides its users with a digital borrower ID card to facilitate borrowing of books faster. The e-library facility of the library provides access to numerous e-books and e-journals for academics and researchers. Besides, the adoption of the OPAC system facilitates its users with interactive searching mechanisms to access online services outside the campus. The integrated library management system makes day-to-day operations faster and guarantees a seamless experience for the university stakeholders.

Barishal University Library: The Central Library of Barishal University issues digital ID cards for its patrons to make borrowing books easier. Besides, the integration of the automated library management system with KOHA and the OPAC makes library operational procedures faster to ensure prompt access to various online databases, e-books, and e-journals. In addition, library's computerized system maintains the inventory and circulation procedures to fulfill the needs and requirements of the end-users.

Rajshahi University of Engineering & Technology (RUET) Library: RUET library is dedicated to fulfilling the academic and research needs of students, faculty members, and researchers. Its Online Public Access Catalogue (OPAC) system provides convenient search capabilities, and digital borrower IDs simplify resource access. High-speed internet connectivity enables users to explore digital resources, such as academic journals and databases. Automated resource management helps maintain the organization of physical and digital collections, reducing manual tasks and enabling the library to serve as an efficient, user-focused research environment.

North South University Library: North South University library has initiated the country's first RFID based automated university library by incorporating the KOHA Integrated Library Management System, which supports MARC21, web based online lending and receiving, browsing audio visual materials, searching full

text online books, tracking circulation system, maintaining Radio Frequency Identification (RFID) self-check and book drop records, auto email alert services, and so on. The users can issue and return books with the help of Self Check and Book Drop machines.

BRAC University Library: The Ayesha Abed Library of BRAC University introduced the RFID System in Bangladesh. In addition, this library completed its new Drupal-based website in 2012 and introduced SMS services for its patrons. However, the library has an institutional repository for the preservation of research materials and making them easily available and accessible. Moreover, it provides access to Turnitin for the assessment of the originality of any documents.

East West University Library: Dr. S. R. Lasker Library of East West University maintains institutional repositories to collect, preserve, and disseminate digital resources for its patrons to encourage scholarly communication. Besides, the library introduced an Instant Reference Service through WhatsApp, along with SciSpace Literature Review, to provide prompt reference queries and research assistance to scholars and academics. Furthermore, the library's OPAC system helps users to search and retrieve information quickly and efficiently.

Daffodil International University Library: Daffodil International University Library provides e-library facilities to ensure round-the-clock information services. Maintaining an institutional repository with the DSpace repository software package makes the library a unique hub for offering smart library services to the users. Besides, the library stores 47 e-resource publishers in its database to guide researchers to a wealth of resources. Moreover, the library assists the end users in searching for information promptly through the OPAC.

Independent University of Bangladesh (IUB) Library: IUB library is equipped with robust internet connectivity and 67 network-activated Computers to offer e-resources and other open-access materials to users. The library also possesses 4339 audiovisual materials and preserves Internship reports in electronic forms like CDs & DVDs. The library archive preserves official records, various artifacts, and other important documents like photographs, yearbooks, university publications, and records from various disciplines.

University of Liberal Arts Bangladesh (ULAB) Library: The ULAB library facilitates OPAC for users to search the library's books, journals, and digital resources. The library employs digital borrower ID cards to streamline the lending process, ensuring quick access to materials. Additionally, library users can access a vast range of online collections, e-books, and e-journals for academic and research purposes. The computerized library management system assists library staff in providing sophisticated user support and maintaining a well-ordered collection. However, the library provides Turnitin service to identify similarities to current sources from repositories, journals, and archived websites.

Asian University for Women (AUW) Library: AUW Library has adopted an OPAC system for smooth navigation of the physical and digital collections. The digital ID card facilitates easy borrowing facilities for library users. Additionally, the library repository provides access to numerous e-books, e-journals, and other online databases. The computerized system of the library assists the library staff in handling circulation procedures smoothly.

United International University (UIU) Library: The AIUB Library, also known as the Shaheed Irfan Library, is dedicated to serving the academic and research needs of the UIU students and faculty members. The library adopted an Online Public Access Catalogue to help library patrons search a specific items of information within seconds. Besides, the library's automated resource management system helps the library personnel to manage scholarly resources, oversee circulation procedures, ensure reference assistance, and perform bibliographic documentation. In addition, the adoption of audio-visual Kiosks in the library ensures access to a vast range of study materials in DVD format. Furthermore, the library has a Digital Institutional Repository to collect, preserve, and disseminate digital resources.

American International University Bangladesh (AIUB) Library: AIUB library provides access to a vast range of material through BOOK TRAXX and other library databases for facility members and students. The adoption of an OPAC system makes searching for library resources prompt and efficient. Besides, the library issues a digital ID card for its patrons to borrow any books and CDs. Additionally, the installation of a Kiosk terminal in the library allows users to perform the tasks of checking out, returning, renewing books, and other library-related activities. Moreover, the library ensures access to online databases, e-journals, and e-books for the researchers and faculty staff.

Green University of Bangladesh Library: The central library of Green University of Bangladesh has adopted an OPAC system by using KOHA for its patrons to ensure access to an extensive library collection. The e-library facility of the library provides access to e-books, e-journals, and various online databases. Besides, the adoption of Referencing Software helps researchers in collecting, storing, and organizing sources to automatically generate citations for their work. Additionally, library users can get up-to-date information and provide feedback regarding the library services through social media platforms. Furthermore, the inclusion of the Turnitin service in the library helps researchers with plagiarism detection and prevention facilities.

Table 3

Key Comparative Features

Aspects	Public University Libraries	Private University Libraries
Automation Tools	Mostly OPAC, some RFID (e.g., RU)	Advanced RFID, KOHA, DSpace
Digital Borrower IDs	Widely adopted	Universally adopted
Internet Connectivity	High-speed but shared across campus	Dedicated, robust connections
Institutional Repositories	Rare or developing	Well-developed (e.g.,BRAC, EWU, DIU)
User Services	Basic (borrowing, OPAC search)	Innovative (Turnitin, WhatsApp, self-check)
Facility for Physically Challenged Users	The DU library offers Braille Books, sufficient computers with specialized software, and up-to-date Braille Printers. Besides, Chittagong University library provides software and hardware facilities, dictionaries, and other facilities for physically-challenged users through the E-learning Center.	None of the surveyed libraries offers such facilities
Policy and Funding	Government-funded, slower innovation	Private-funded, rapid innovation
Examples	DU, RU, BUET, JU, CU, KU	NSU, BRAC, EWU, DIU, IUB

Challenges in Adopting Smart Technologies

The following challenges need to be considered before implementing a smart library program in libraries in Bangladesh.

Sufficient Funds: The adoption of emerging technologies in libraries entails a significant monetary expenditure. The cost of installation and maintenance of smart technologies like Kiosks, RFID, Expert systems, and other cutting-edge technologies is a challenging issue for many public and private universities.

Infrastructural Facilities: Managing sufficient infrastructural support for installing necessary hardware and software accessories can be a matter of concern among librarians and university administrations. University libraries can function properly if the necessary infrastructural facilities, along with administrative support, are provided for the attainment of academic efficiency.

Expert LIS Specialists: The success of the application of smart technologies in university libraries depends largely on the expertise of library and information science (LIS) specialists. They play important roles in managing, customizing, and troubleshooting library systems and services.

Change Management: Switching from a traditional library system to a smart technology-based system depends on the library staff's mindset toward change. This process involves a positive attitude of the library professionals in planning, implementing, and reinforcing massive change in the library system and services.

User Experience: The users have to be familiar with the use of smart technologies. Libraries need to train users on how to access information services through smart technologies. Besides, the library professionals must ensure that the users can interact with the systems easily.

Administrative Support: Administrative support in the application of smart technologies encompasses the tasks and duties that library professionals have to perform to ensure the library's housekeeping operations, organizing e-resources, managing effective communication, and other crucial functions of a university library. The growth of an academic library depends on the support of the university administration to a great extent.

Security and Privacy Issues: University libraries may face significant security and privacy issues due to the dependency on interconnected technologies like AI, RFID, Cloud Computing, and IoT appliances that have the possibility of data breaches. Therefore, library professionals need to build robust security measures to protect the library's data and information from being stolen, distorted, and hacked by cybercriminals.
Apart from the above challenges, library professionals must focus on eliminating digital divide to implement smart library initiatives. Therefore, librarians have to provide adequate user training and support to bridge digital divide, and ensure all the stakeholders of a university get the benefits from the smart technologies (Adhikari and Paswan, 2024).

Discussions

A smart library, as the pathway for the next-generation library, can bring a revolution in making library and information services accessible to users at the fingertips. The adoption of RFID, IoT, AI, Expert System, OPAC, and other emerging technologies in academic libraries reduces the workload of librarians and ensures prompt services to the academic community. In Bangladesh, the public and private universities are getting under the umbrella of smart technologies. Among the public universities, Dhaka University library has been implementing an OPAC system and digital borrower ID cards to simplify the circulation process and provide users with prompt access to e-resources and other research materials. However, like the Dhaka University library, other public university libraries have adopted OPAC facilities, along with digital borrower IDs, RFID, and an automated library management system. Moreover, these academic libraries are streamlining all the operations conveniently with the blessings of a robust Internet connection.

Among the private universities, North South University library claims to have initiated the country's first RFID-based system by incorporating the Integrated Library Management System in Bangladesh. Besides, BRAC University library introduced a Drupal-based website in 2012. The research findings clearly indicate that private universities have been playing the roles of trailblazers in adopting smart technologies. However, East West University Library, Daffodil International University Library, and other private university libraries maintain an institutional repository to offer research facilities to the teachers and students.

However, none of the university libraries claimed to adopt OpenBiblio, Expert System, and Information retrieval through AI facilities. Besides, to ensure security measures, University libraries can use blockchain technology to improve the library's administrative procedures, guarantee safe digital transactions, and stop data manipulation. Furthermore, the implementation of digital literacy training programs for the library staff can expedite smart library initiatives in University libraries in Bangladesh. Last but not least, both public and private universities have to allocate sufficient funds, recruit ICT-skilled library professionals, and develop a positive attitude for the adoption of smart technologies in the libraries.

Conclusions

Kumar and Kumar (2019) show that the use of technologies in libraries, such as Radio Frequency Identification (RFID) Tools, Robotics, AI-based gadgets, and software, makes libraries self-sufficient and gives them the ability to think for themselves, which opens a new door that is going to transform our library system. However, this study reveals that public and private universities have ushered in an era of automation and digitization by introducing a Radio Frequency Identification (RFID) based automated university library and incorporating the KOHA Integrated Library Management System. These universities foster an inclusive and resourceful, abundant setting and ensure the varied needs of their academic community by leveraging smart technologies like Public Access Catalogues (OPACs), digital borrower ID cards, high-speed internet services, online data-bases, e-journals, and other vital resources. In another study, Hussain and Ah-mad (2021) found that Pakistani university libraries are adopting Integrated Library System (ILS), Closed Circuit Television (CCTV) cameras, Radio Frequency Identifications (RFID), Self-service kiosks, Digital repositions of e-books, theses, and archival records, Library websites, Online resources, databases, and Information Literacy (IL) instruction. Nevertheless, the outputs of this study reveal that a few of the respondent libraries have introduced self-service kiosks and Information Literacy (IL) instruction. In a study, Igwe and Sulyman (2022) show that technological barriers, expert librarians, technophobia among the staff, poor power supply, and lack of sound ICT infrastructure hamper the progress of Smart Library initiatives. Similarly, this study highlights the challenges that Bangladeshi university libraries are facing while adopting smart technologies. Further research needs to be carried out to reveal the strengths and weaknesses in the application of smart technologies in university libraries in Bangladesh. Cheung et al (2025) suggest that potential data confidentiality and safety issues, and any moral consequences of using smart technologies, need to be taken into consideration for libraries in Hong Kong. They also advocated for the training of library professionals and taking precautionary measures against the potential risks of security breaches or privacy defilements.

The findings of this paper indicate that almost all of the surveyed libraries have adopted OPAC and an integrated library management system to fulfill the needs and requirements of University stakeholders quickly and efficiently. Besides, the adoption of high-speed broadband Internet connection makes users' access to e-resources quite convenient, and the lending of books and inventory management procedures quite speedier. However, the data collected from the University library websites provides a cursory view of the smart technologies being adopted during the decade. This limits the up-to-datedness of the actual picture of the technological implications and other aspects of these libraries. Besides, the status of technological usages in the surveyed University libraries might not be the same for other public and private University libraries. Since there are more than hundreds of Universities in Bangladesh, examining only 20 public and private university libraries cannot provide a comprehensive description of the techno-logical implications unless at least one third of them are covered for the study. Despite these limitations, this study will give a general overview of the application of smart technologies and the functions of these technologies to the researchers, academics, librarians, students, and policy makers. This research will assist them to delve deeper into current phenomena of smart technologies being adopted in academic, public, and other libraries.

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