

Adoption and Future Potential of QR Codes in Academic Libraries: Bridging Physical and Digital Resources

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ABSTRACT

QR codes have emerged as a valuable tool for academic libraries, transforming administrative, academic, and communication processes. This study explores the adoption of QR codes in academic libraries based on responses from 37 systems librarians across 104 Institutions of National Importance (INIs), achieving a 35.5 % response rate. The study underscores the growing role of QR codes in bridging physical and digital library resources while highlighting the need for strategies to improve user awareness and engagement. Future advancements in QR code technology, including integration with Augmented Reality (AR), the Internet of Things (IoT), blockchain, and Artificial Intelligence (AI), are expected to enhance their functionality and security further. By embracing these innovations, academic libraries can optimize their services and foster a more efficient and user-friendly digital environment.

Keywords: QR code; Academic libraries; User services; Information dissemination; India

1. INTRODUCTION

A QR code, or Quick Response code, is a two-dimensional barcode that can be scanned using a QR code reader or a smartphone camera and can store up to 7,089 characters of data¹. Developed in 1994 by the Japanese company Denso Wave, unlike traditional barcodes, which store data in a series of vertical lines, QR codes store data both horizontally and vertically, enabling them to hold a substantially larger amount of information².

QR codes are used across a wide range of industries for various applications. In providing consumers with instant access to detailed product information, reviews, and promotions³. In advertising, QR codes can link to videos, websites or social media pages, enhancing user engagement by providing interactive content⁴⁻⁵.

Additionally, they are used in ticketing for events and transportation, offering a convenient and secure method for verifying authenticity and managing entry⁶.

Despite their numerous advantages, QR codes also pose some security concerns. Malicious factors can create QR codes that direct users to phishing websites or download harmful software onto their devices⁷. As technology continues to evolve, QR codes are likely to remain a versatile tool for bridging the physical and digital worlds, provided that security measures keep pace with their growing use.

2. TECHNICAL ASPECTS

QR codes can store various types of data. Their technical design and functionality allow for quick and efficient data retrieval, making them versatile in multiple applications, including library services.

2.1 Structure and Anatomy

The structure and anatomy of a QR code are designed to ensure efficient and accurate scanning, encoding, and error correction, as shown in Fig. 1⁸. Version information indicates the version or size of the code, which helps decoders interpret high-capacity codes. Separators distinguish the position pattern of the cells from the rest of the data. Timing patterns consist of alternating black and white modules between position detection patterns to enable precise alignment and help locate individual rows and columns. Near the position patterns, small areas store format information, which includes the error correction level and mask patterns, providing metadata to guide the decoding process. The data modules, make up the area containing the encoded data in binary form (represented by black and white squares). Built-in error correction redundancy allows for data recovery even if part of the code is damaged, with four levels of error correction balancing recovery and storage capacity. A quiet zone, or margin of blank space surrounding the QR code, ensures that the scanner can distinguish the code from

its surrounding elements. Alignment patterns, which are smaller squares located near the bottom-right corner (and additional locations in larger QR codes), help correct distortions during scanning. Finally, position detection patterns, large squares located at three corners of the QR code, assist the scanner in recognising and orienting the code correctly.

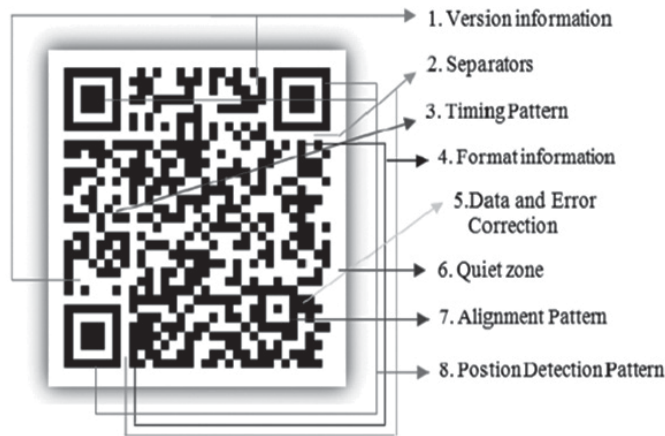


Figure 1. QR code structure.

2.2 Types of QR Codes

Broadly, QR Codes can be classified into Static and Dynamic QR codes. Static QR codes encode fixed data that cannot be modified, whereas Dynamic QR codes allow updates and offer greater flexibility. Again, QR codes are further categorised into five types as per format, as seen in Fig. 2.

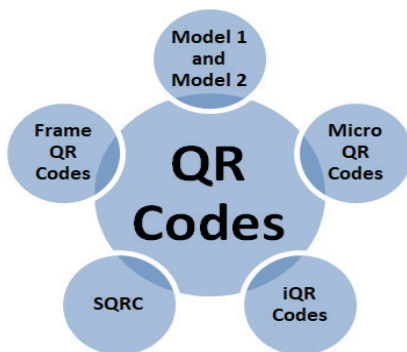


Figure 2. Diagram of QR code types.

Model 1 and Model 2 are widely used and serve as the foundation for other QR code types. While Model 1 is now obsolete, Model 2 remains relevant due to its higher error correction and storage capacity. Micro QR Codes are compact versions designed for small spaces, efficiently storing limited data. iQR Codes support both square and rectangular layouts, optimising space usage. Secure QR Codes (SQRC) restrict access to encoded data, ensuring high security and data integrity, though they require encryption and decryption capabilities. Frame QR Codes incorporate customizable design elements to enhance visual appeal while retaining full functionality⁹.

2.3 Data Encoding

QR Code data encoding is for converting information (such as text, URLs, or other data) into a format that can be stored in the QR code. The encoding process involves three major components.

- **Content:** Store alphanumeric characters, URLs, phone numbers, SMS messages, V-cards, and Wi-Fi credentials.
- **Capacity:** Hold up to 4,000 alphanumeric characters or 7,000 numeric characters.
- **Error Correction:** Reed-Solomon error correction, enabling data recovery up to 30% in case of damage.

In libraries, QR codes facilitate access to catalogues, e-resources, and user guides, reducing the time and effort required to find information. Their adaptability, from static to dynamic formats, ensures they cater to diverse needs while remaining user-friendly. Moreover, features like error correction and encryption enhance their reliability and security, making them indispensable in the digital age.

3. LITERATURE REVIEW

QR codes were first developed in 1994 by Denso Wave for industrial purposes and later adapted for diverse applications, including libraries. Their library adoption aligns with broader technological advancements, such as barcodes and RFID systems¹⁰. QR code tracking systems in academic research can be integrated to enhance sample tracking, data accessibility, and traceability in interdisciplinary, multicampus collaborations. They emphasised the benefits of QR codes in improving data management, reducing experimental failures, and ensuring resource efficiency in bioengineering research¹¹. Quick Response (QR) codes in libraries emphasise their potential to augment physical spaces and services. Many studies have highlighted the widespread adoption of QR codes for tasks like resource access, library tours, and promotional activities¹². Integration of QR codes in educational settings has shown significant potential to enhance interactivity and technology acceptance. They emphasised developing a system that integrates QR code functionality with user-centred design, improving usability and cognitive load while supporting scalable educational applications¹³. QR codes play a transformative role in academic libraries by emphasising their capacity to enhance user engagement, improve accessibility to resources, and streamline library operations¹⁴.

The use of QR codes in libraries has gained prominence as an innovative tool to extend library services to mobile users. Challenges like user awareness and the need for smartphones are acknowledged, but the technology's potential to streamline library services and engage patrons more effectively is widely recognised¹⁵. QR codes simplify access to information while supporting self-directed learning and integrating seamlessly with mobile technology. It has the potential to provide “just-in-time” support, linking users to resources like instructional videos, library services, and contextual information¹⁶. Institutions like the University of

Bath have implemented QR Codes in bridging physical and digital spaces, enhancing access to bibliographic records and other library resources due to their low cost and ease of use. Applications in libraries include cataloguing, research guides, and linking to online resources¹⁷. Quick Response (QR) codes and Augmented Reality Applications (ARAs) like the Layar app can bridge the gap between traditional physical libraries and the mobile-centric needs of today's users by creating an engaging, interactive library experience. They address key accessibility challenges, including limitations posed by physical formats and copyright restrictions¹⁸. Intriguingly, the primary issue confronting the QR codes is their familiarity with the users¹⁹. To improve the visual appeal, the use of embedded images and logos has become a new trend. Adding to this, A. Mittal had even proposed a model where the use of circular modules to reduce the visual distortion and make the decoding smoother²⁰.

Despite this, user awareness and engagement remain low, indicating barriers like insufficient promotion and technological readiness. While QR codes have the potential for personalised experiences, their practical use is often limited to one-way information sharing²¹. Though libraries can utilise QR codes to enhance user engagement, some challenges exist, such as software adoption, user awareness, and mobile data costs²².

4. RESEARCH OBJECTIVES

The objective of the research is as follows:

- To explore the use of QR codes in academic libraries for user services and information dissemination across Indian libraries.
- To identify the reasons behind the adoption of QR codes in library services.
- To examine the challenges encountered during the implementation of QR codes in library services.
- To raise awareness and educate libraries about the benefits of using QR codes while offering strategic guidance for their effective implementation.

5. METHODOLOGY

This study utilised a survey design to explore the use of QR codes in academic libraries in India. Since the adoption of QR codes has not been widely explored or extensively researched in the Indian context, this study focused exclusively on Institutes of National Importance (INI), which are expected to be at the forefront of such technological advancements. The study aimed to gather primary data from librarians at prominent Indian institutes of higher education, such as IITs, IIMs, IIITs, NITs, and IISERs. According to the Ministry of Education, Government of India, there are 24 Indian Institutes of Technology (IIT), 21 Indian Institutes of Management (IIM), 32 National Institutes of Technology (NIT), 20 Indian Institutes of Information Technology (IIIT), and 7 Indian Institutes of Science Education and Research (IISER) across the country. The survey questionnaire, developed using Google Forms, was sent to librarians of all those institutes through

e-mail in mid-2024. The online data collection method was chosen for its convenience, low cost, ease of use, and minimal intrusion on the respondents' privacy. The collected data was then analysed using Excel and presented in the results and discussion section.

6. DISCUSSION

The study received responses from 37 systems librarians across 104 institutions, as seen in Fig. 3, yielding a response rate of 35.5 %. This response rate is considered adequate, ensuring the findings surpass the minimum required threshold and are deemed valid and reliable. The low response rate clearly suggests that the institutes have not yet implemented the QR code-based service in their libraries.

According to the survey, among the 24 IITs, responses were received from 13 institutions. From the IIMs, we received submissions from eight institutions. Only IIIT Chittoor and IIIT Manipur contributed responses from IIITs. Among the NITs, 10 institutions submitted their responses within the stipulated timeframe.

Based on their professional experience, the respondents are again classified into five distinct age categories. The Librarians with 5-10 years of work experience had the

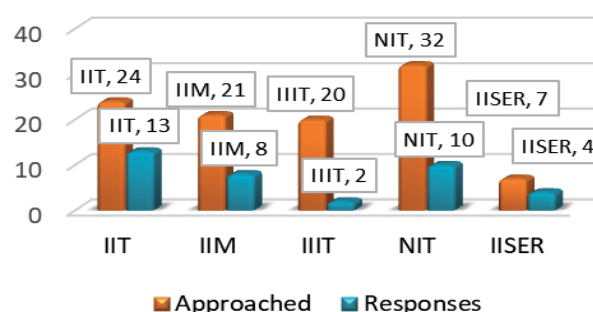


Figure 3. Participating institutions in survey.

highest number of participants, having a response rate of 43 %. The next significant section includes those who have worked for 21-25 years, recorded at 22 %. After that, 16 % is attributed to the participants with 11-15 years of experience. Those with more than 25 years of professional experience shared by 11 %, while the lowest in this respect is the age group of 16-20 years at 8 %.

Data analysis revealed that 86.49 % of participants have been actively using QR codes since 2011, as illustrated in Fig. 4.

Among the 32 libraries surveyed, the purposes for using QR codes varied from library to library, as 59.46% used them for accessing library catalogues and 8.11% for payment purposes. Other uses included e-resource access (54.04%), accessing the library website (37.84%), event promotion (35.14%), feedback and surveys (35.14%), and workshops and tutorials (27.02%), as seen in Fig 5.

Linking QR codes to library resources provides users with a fast and convenient way to access materials and services²³. Based on the inputs, data revealed that the linkage of QR codes to library resources is notably high for catalogues at 35.14%. Other resources linked via QR codes include E-Journals (18.92%) and E-Databases (10.81%).

Library guides, bibliographic databases, and other e-resources each have a linkage percentage of 8.11 %. Fine collections, study room reservations, and theses/dissertations have the lowest linkage rate at 5.41 %.

The primary motivations for QR Code implementation are to provide users with quick access to digital resources (78.38 %), enhance user engagement (62.16 %), and promote library events and services (56.76 %). Secondary being improving data collection and feedback (43.24 %), reducing staff workload (43.24 %), and offering contactless services (40.54 %) in libraries.

The majority (31 %) reported no faced in implementing QR codes and had a positive outlook (Fig. 6). However, some identified user-related challenges, such as a lack of awareness (16 %) and low engagement (11 %). Other challenges included budget and technical limitations, such as limited resources or budget constraints (4 %) and difficulties in updating QR code content (9 %).

Data revealed that most participating libraries (81 %) are tracking QR code usage statistics to understand

user awareness of the services provided by the library. Findings indicated that user awareness ratings vary, with 33% rating it at 1, 16 % rating it at 2, 27 % rating it at 3, 8 % rating it at 4, and 16 % concluding with a 5.

7. KEY FINDINGS

The study collected responses from 37 systems librarians across 104 institutions, yielding a 35.5 % response rate. Responses were received from 13 IITs, 8 IIMs, 2 IIITs, 10 NITs, and several IISERs. The majority of respondents (43 %) had 5-10 years of professional experience. Of the libraries surveyed, 86.49 % reported using QR codes, with the most common applications being catalogue access (59.46 %) and e-resource access (54.04 %). QR codes were also used for event promotion (35.14 %) and feedback/surveys (35.14 %). The primary motivations for implementing QR codes included providing quick access to digital resources (78.38 %), enhancing user engagement (62.16 %), and promoting library events (56.76 %).

Despite the positive feedback from 31 % of libraries among the respondents, challenges such as a lack of user awareness (16 %) and low engagement (11 %) were noted, along with technical and budget constraints. 81 % of libraries in the participants' track QR code usage in order to know the uses of the QR-based services. The user awareness levels also varied significantly. The study emphasises the increasing adoption of QR codes in libraries to bridge physical and digital resources while also highlighting challenges related to user engagement and awareness.

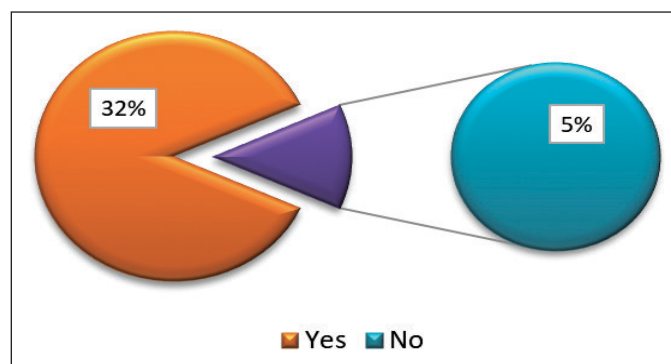


Figure 4. Number of libraries using QR codes.

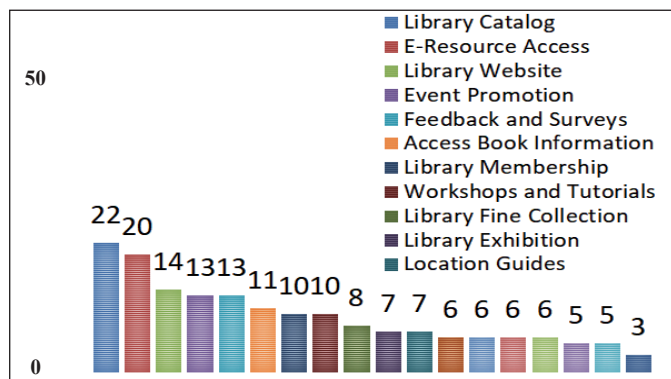


Figure 5. Purpose for using QR code.

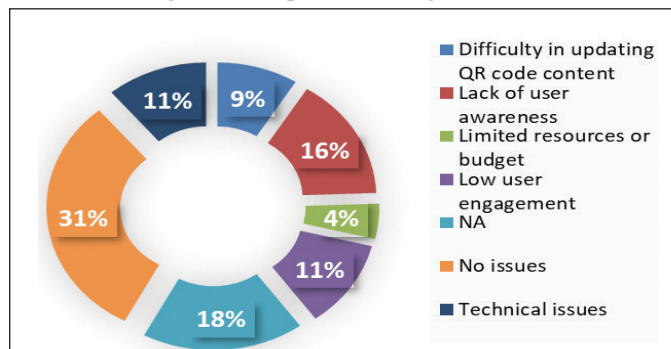


Figure 6. QR codes implementation challenges.

8. RECOMMENDATIONS

From the literature review, it is clear that QR codes can serve multiple purposes in libraries, with the primary benefit being the enhancement of the overall patron experience. However, this survey also gathered new insights from the Librarians on how QR codes can further benefit libraries. In addition to its typical use for sharing information about library events and activities and paying overdue fines, QR codes can also be integrated as location guides and shelf lists, making it easy for patrons to access book information and check for availability. QR codes can allow users to check book availability, view summaries, or place holds directly from their smartphones, as suggested by the Librarians. Experts also claim that QR codes can help access faculty publications by linking directly to their academic works, allowing patrons to easily view and download the latest research and publications from faculty members.

Another great option is to link a QR code to the library's event calendar, workshops, and special programs. This can be placed on event posters or newsletters to keep visitors informed about upcoming events. QR codes can also be used to create links to the library's policies, hours, or rules, which would be helpful for first-time visitors or as reminders for regular patrons. Additionally,

QR codes can be used for feedback forms or surveys, making it easy for patrons to share their thoughts on library services, book collections, or events. Strategically place them in areas like checkout counters or reading spaces to encourage feedback. It is also advisable to personalize the QR code with the library's logo or colours for branding and include clear instructions like "Scan to Explore Our Catalogue" or "Scan for Events" to enhance its application and usability.

9. CONCLUSION

QR codes are the most used technology in libraries for flexible and reliable data encoding. This makes them an increasingly popular medium in the present digital world. QR code technology is easy to implement, cost-free, and rapidly expanding. Integrating QR codes into libraries provides their users with an engaging experience²⁴. They offer several advantages in libraries by efficiently bridging physical and digital resources, enabling patrons to easily access guides, library maps, and online catalogues, enhancing their overall library experience. QR codes can also provide direct links to electronic journals, multimedia content, and other digital resources, making it easier for users to engage with library materials. However, there are security considerations to keep in mind. QR codes can link to malicious content if not properly verified. It is important to use secure QR codes and trustworthy generation tools, ensuring that patrons can safely access library resources without concerns about security threats.

QR codes may be less effective in areas with limited smartphone access or internet connectivity. User education is essential to encourage secure and reliable scanning practices, as malicious QR codes can lead to phishing attempts and other cyber threats. QR codes can become more universally accepted, highly secure, and well-integrated into augmented reality (AR) and the Internet of Things (IoT)²⁵⁻²⁶. The adoption of QR codes will likely increase with future technologies that are to be built in coordination, such as blockchain for creating secure transactions and AI for delivering personalised experiences²⁷.

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ACKNOWLEDGEMENT

The author(s) thankfully acknowledge the support of the participating Library Managers from INIs around the country.

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He contributed to the work in collecting the data was instrumental to the success of this project.

Prof. Atul Bhatt is an Associate Professor at Gujarat University, Ahmedabad, India. He has vast experience teaching and librarianship in the field of library and information sciences. He has published over 50 papers in several national and international journals and conferences.

In this study, his input included formulating the research questions, overseeing the data analysis, and revising the manuscript.