

# Mobile-Based Library Automation in Resource-Constrained Academic Libraries: A Thematic Review of QR-Enabled Circulation, Integrated Systems, Usability and Implementation Barriers

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## ABSTRACT

*Small academic libraries often cannot sustain conventional integrated library management systems because of limits on funding, infrastructure, technical skill and maintenance capacity. Smartphone ownership is growing, which makes mobile systems a plausible alternative. This thematic review examines the published literature on mobile library services, QR-enabled identification and circulation, usability, operational outcomes and implementation barriers. The objectives of the review are to synthesise the published evidence on these themes, to distinguish what has been measured from what has been described and to propose a framework for empirical study. Three findings follow. First, mobile access services are well established and the integration of staff workflows is less developed. Second, QR-based identification and circulation are described mainly through case accounts and prototypes. Third, usability and user perception are the best-represented themes, while no reviewed study measures transaction accuracy, inventory outcomes or lifecycle cost in an operating library. The article proposes a literature-derived framework linking institutional readiness, system design, implementation processes, operational performance, usability and lifecycle cost. The framework is a proposal for empirical testing and has not been validated.*

**KEYWORDS:** mobile library systems; QR codes; library automation; integrated library management; usability; academic libraries

## 1. INTRODUCTION

Many small academic libraries operate with limited budgets, few trained staff and intermittent connectivity. Conventional integrated library management systems require licensing, servers, networking and specialist maintenance and such libraries often cannot sustain these over time. Smartphone ownership has grown quickly, including among students in developing regions, which has renewed interest in mobile alternatives.

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A parallel concern appears in the literature on library use. Gulati and Iftekhar (2026) report, in a survey of 375 users at three government institutions, that library services were widely valued but seldom used. They call for stronger institutional support and the strategic integration of library services into users' work. The present review takes that call as a starting point and asks what the evidence says about making mobile services part of the library's operational workflow.

The research on this interest falls into three broad strands. The first concerns mobile applications and their application in libraries. Singh and Madhusudhan (2023) mapped mobile application-based technologies in libraries and information centres and Safdar et al. (2025) reviewed the benefits and challenges of mobile access to library services. The second strand concerns the design of mobile library services. Pu et al. (2015) describe the design and implementation of a mobile library application and Bridges et al. (2010) set out how a library can plan a mobile web site and choose between vendor and in-house catalogue options. The third strand concerns the conditions under which such services can be sustained. Nalluri and Gaddam (2016) argue that mobile technology cannot deliver library services on its own. It has to be integrated with electronic service delivery, a digitised information base and staff expertise.

Most of this work concerns the user-facing layer. Whether a mobile system can also carry the staff-side workflow, including bibliographic record management, circulation, stock verification and reporting, has received less attention. This review distinguishes three levels of mobile involvement. *Mobile access services* let users search catalogues, view availability and manage their own accounts. *Mobile-assisted functions* use smartphones for specific operations, most often item identification through QR codes. *Integrated mobile management* combines these functions and the staff workflow behind them, in one system. The literature supports the first two levels far more strongly than the third.

The review is organised around five themes: the move from mobile access to integrated management, the role of QR codes in identifying items and recording transactions, usability and user satisfaction, the evidence on operational outcomes and the barriers of cost, capacity and access. Together these themes address four questions: how mobile access services and QR-enabled functions have been applied to library management; what evidence exists on efficiency, accuracy and usability; which financial, technological and organisational barriers affect implementation; and how far integrated mobile systems have been evaluated, rather than isolated services.

## **2. REVIEW APPROACH**

This is a thematic narrative review. Its purpose is to organise the evidence around the five themes and to show where the evidence is strong, weak or absent.

Sources were identified through a search of Google Scholar carried out on 14 July 2026, with preprints excluded. The search covered mobile library services and integrated management, QR-code circulation, usability of mobile library services, stock verification and automation outcomes and implementation barriers in library technology.

Each included source was classified by evidence type: measured (objective performance), self-reported (perceptions or survey responses), descriptive (case or practice account), prototype (functional testing only), or review. The classification is used throughout the synthesis to distinguish what each source can and cannot support.

### **3. THEME 1: FROM ACCESS TO INTEGRATION**

Mobile access services and integrated management differ in kind. A mobile catalogue or website lets users search holdings and check availability and an application may add renewals and notices. Neither necessarily supports staff tasks such as creating bibliographic records, reconciling stock or producing circulation reports. The mobile application described by Pu et al. (2015) for National University of Tainan goes further than search. Members log in to view their borrowing records, renew items and reserve books and these functions read from and write to the library database. This is a closer approximation of integration than a catalogue alone, although the authors did not evaluate its transaction accuracy.

The choice between vendor and in-house routes is the main practical decision in this theme. Bridges et al. (2010) describe vendor-supplied modules, such as Innovative Interfaces' AirPAC, which offer mobile catalogue searching, holds and account access but are a smaller version of the desktop interface and allow little customisation. Oregon State University built its own mobile catalogue instead. It shows call numbers, availability and floor location and it can send call numbers by text message or e-mail. The authors also recommend a phased rollout, beginning with location-based information such as hours and floor maps. Their paper describes implementation experience rather than measured outcomes, but it shows how a library can control more of the workflow.

Integration depends on what the institution can sustain. Rajkumar et al. (2025) describe cloud-based integrated library systems, such as Koha, Alma and Sierra, that coordinate circulation with other modules and they note the growth of mobile apps and responsive web entrances for remote renewal and reservation. Their scoping review does not report search counts, so its coverage cannot be assessed. Acheampong and Dei (2020) surveyed the delivery of library services on mobile technology platforms in Ghanaian academic libraries. The most common services were a mobile digital repository, a mobile catalogue, referencing services, SMS alerts, selective dissemination of information and mobile instructional guides. The authors identify insufficient ICT infrastructure, poor bandwidth, a shortage of IT staff, the absence of a policy framework, unstable power, financial constraints and weak support from university management as limits on full provision. Integration, in other words, depends on institutional capacity as much as on software.

Gulati and Iftekhar (2026) reach a similar conclusion from the side of users. They recommend greater involvement of librarians in continuous training, stronger institutional support and the application of new technology before library services are integrated into users' routines. Their conclusion links the institutional-capacity argument above to the staff-side workflow that a mobile system must support.

### **4. THEME 2: IDENTIFYING ITEMS AND TRANSACTING WITH QR CODES**

QR codes link physical items to records and to digital content. Walsh (2011) reports on the use of QR codes at the University of Huddersfield. The first application placed a code on each catalogue record so that users could carry the live record with them. Other codes were placed at help desks, on shelf ends linking to external legislation and on videos explaining library services. Walsh also reviewed location-aware technologies and concluded that they are impractical for most libraries. The paper describes implementation experience and does not measure outcomes.

Pathak and Jain (2018) describe a similar approach at IISER Bhopal Library, where QR codes support current awareness, alerting and quick reference alongside a planned library mobile app. Shettar (2017) describes QR codes

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at the National Institute of Technology Karnataka and argues that a code removes the need for users to remember a URL. Singha and Verma (2019) describe a QR-enabled website at Don Bosco College Central Library, Arunachal Pradesh. They distinguish static codes, which cannot be edited after generation, from dynamic codes, which can point to updated content. This distinction underlies the persistent-identifier design in the proposed framework (Section 8).

The circulation-specific evidence is more recent. Kharat, Nagarkar and Panage (2025) reviewed circulation methods in academic libraries using the PRISMA method. They searched ProQuest, Emerald, Library and Information Science Abstracts, EBSCO and Google Scholar. From 277 retrieved papers they included 43 and they classified 33 systems into manual, mechanised, automated and networked categories. Mechanised systems were the largest group (48.48%). The authors propose a QR-based self-issue and return model with an Android prototype. They state that the model has not been implemented and that it will be tested after a survey of library users and their smartphone knowledge.

Scanning identifies an item but does not, by itself, authenticate the borrower, confirm current status, prevent duplicate issue or verify that a return closes the correct loan. The sources reviewed here describe the scanning step in detail but do not report how these transaction controls were designed or tested. Walsh (2011), Pathak and Jain (2018) and Singha and Verma (2019) are implementation accounts and Kharat et al. (2025) propose a model that has not yet been implemented. The transaction-integrity question is therefore open. The constraint is also not only technical. The same sources stress that QR services depend on user awareness and on staff who can explain them, which links this theme to the barriers discussed in Section 7.

## **5. THEME 3: USABILITY AND USER SATISFACTION**

Usability is the best-represented theme among the sources reviewed and comparative designs give the strongest evidence within it. ChanLin and Hung (2016) compared a library mobile website with the full PC website. Fifty students completed a set of search tasks on each. Students using the mobile site finished more tasks and were more efficient than those using the PC site ( $p < 0.001$  for both). The study measures search performance, not circulation or inventory work.

Pendell and Bowman (2012) tested a library mobile website using a hybrid field and laboratory design with 12 student participants selected by phone type. The errors they recorded were attributed to site design, wireless network connections and phone hardware and software. Their study shows that device and network conditions can shape the usability of a mobile library service, so the usability of a mobile management system cannot be assessed on the interface alone.

The most detailed usability and satisfaction data in the set come from two studies of the same Taiwanese application. Pu et al. (2015) collected 216 valid questionnaires from students at National University of Tainan. Reliability coefficients ranged from 0.84 to 0.89 and mean item scores were above 3.7 on a five-point scale. Of the students, 28% reported that the system response was not timely, a performance problem that satisfaction scores alone would not reveal. Huang et al. (2015) applied the DeLone and McLean information system success model to 206 valid responses, a response rate of 68.7%. Information quality and system quality significantly influenced use

and satisfaction and system use influenced perceived net benefits. Service quality did not significantly influence use and the authors conclude that service quality and the training of service staff need improvement.

The contrast between satisfaction and performance matters. Users may report that a mobile service is easy to use while timed tasks show slower or less accurate completion. For a circulation system, where an error is costlier than a delay, usability should be measured through task completion, time and error rates rather than satisfaction alone.

## 6. THEME 4: EVIDENCE ON OPERATIONAL OUTCOMES

The evidence on operational benefit is perceptual. In Pu et al. (2015), 82% of students said the system helped them locate books quickly and 87% said it increased their personal work efficiency. Huang et al. (2015) treat perceived net benefits as an outcome variable and show that satisfaction and use predict them. Neither study measures search time, transaction time, error rates or stock accuracy. Walsh (2011), Pathak and Jain (2018) and Singha and Verma (2019) describe benefits such as faster access to information and easier alerting, but they report no measurements. Wang et al. (2018) examine behavioural intention rather than operational performance.

The absence of measured outcomes has consequences for the research question. Claims that mobile-assisted circulation speeds up transactions or improves stock accuracy are plausible, but the sources reviewed here do not test them. The outcomes that would test them are clear: timed logs of issue and return, error and duplicate-transaction rates and shelf-count discrepancies against the accession register. A study measuring these outcomes before and after introducing a mobile system, with a comparison condition, would address the most important gap identified in this review.

## 7. THEME 5: BARRIERS, COST AND SUSTAINABILITY

Barriers recur across the sources, although most of the evidence is self-reported or descriptive. Acheampong and Dei (2020) identify ICT infrastructure, bandwidth, staffing, policy, power, finance and management support as limits on mobile service delivery. Pathak and Jain (2018) state that QR services work only when users have a smartphone with a QR reader and an internet connection and that user awareness is still to be developed. Because these constraints are reported from a small number of national and institutional contexts, they should be treated as hypotheses for other settings rather than as general findings.

Access inequality sits beneath these barriers. Agarwal and Jaiswal (2023) surveyed 100 students at the University of Lucknow, 50 with rural and 50 with urban backgrounds. They found a significant association between residential background and frequency of internet use ( $\chi^2 = 12.59$ ,  $df = 3$ ,  $p = .006$ ) and between background and formal internet training ( $\chi^2 = 5.88$ ,  $df = 1$ ,  $p = .015$ ). Among urban students, 82% had formal training, against 60% of rural students. No significant association emerged for internet skills or purpose of use. A mobile service presumes a device, a connection and a degree of digital competence that are unevenly distributed, even within one university. The authors recommend training programmes and library-based computer access, which supports pairing system design with training and access provision.

Wang et al. (2018) add a demand-side barrier. Their survey of 201 Chinese university students and staff (an 80.4% response rate) found that information quality and the information environment affected perceived usefulness and ease of use and that ease of use shaped attitude to use. The authors note that the number of mobile internet users has grown much faster than mobile library use. Social influence did not have a significant effect. The sample was small and drawn from university students and the authors acknowledge this limit. Nalluri and Gaddam (2016) list further

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constraints that libraries face: privacy of patron usage data, digital rights and content licensing, the limited memory of mobile devices, dependence on external vendors and a shortage of staff with mobile expertise. Their discussion is an overview rather than an empirical study.

Access and use are distinct problems and both must be solved before a mobile system can deliver its benefits. Agarwal and Jaiswal (2023) show that access and formal training are unevenly distributed among users, so a service designed for mobile devices reaches some users far more readily than others. Gulati and Iftekhar (2026) find a complementary problem in a survey of 375 users across three government institutions. Most respondents rated library services as useful, yet 53 per cent sought librarian assistance only rarely or monthly and 18 per cent had never done so. Perceived value, in other words, does not guarantee use. The same survey points to training as the missing link: the most used services were training workshops (31.26% of service mentions), whereas critical appraisal training was used by only 6.42% of respondents. A service that is valued but rarely used contributes little to circulation or inventory outcomes, while a service that users cannot reach excludes the students it is meant to serve. The two problems point to the same design requirement: training, access and uptake have to be planned alongside the system itself.

Cost is the least evidenced barrier. Development cost is easy to report, while maintenance, licensing, device replacement, staff training and integration with legacy records are seldom counted. Dey et al. (2025) surveyed systems librarians in 37 of 104 Institutions of National Importance in India, a response rate of 35.5% and highlighted the need for strategies that improve user awareness and engagement with QR services. Such awareness work is an ongoing cost that development budgets rarely include. Until lifecycle cost data are collected, the case for affordability rests on an incomplete account.

## **8. DISCUSSION: RESEARCH GAPS AND A PROPOSED FRAMEWORK**

Taken together, the themes point to five gaps. (G1) Integration: few studies evaluate a mobile system across bibliographic, circulation and inventory functions together. (G2) Transaction integrity: the QR identification step is well described, but borrower authentication, duplicate prevention and reconciliation are not tested in any reviewed source. (G3) Objective measurement: usability is studied more often than operational outcomes and no study in the set measures operational outcomes in a library. (G4) Lifecycle cost: affordability is inferred from development cost rather than measured across the system's life. (G5) Multi-site evaluation: no study in the set evaluates a mobile management system across several libraries with differing resources.

Figure 1 presents a proposed framework derived from these gaps. It has four domains: institutional readiness (funding, connectivity, devices, staff competence and record quality), system design (mobile interface, bibliographic management, dynamic QR identification, circulation and inventory functions and secure transaction controls), implementation processes (training, workflow integration, technical support, maintenance and data cleaning) and evaluation outcomes (operational performance, usability and acceptance and lifecycle cost). The propositions below are hypotheses for testing. They appear in Figure 1 unless noted.

P1: Institutional readiness constrains the design choices a library can realistically adopt. P2: Institutional readiness shapes the quality of implementation. P3: System design influences operational performance, particularly transaction time and accuracy. P4: System design influences usability and acceptance. P5: Implementation processes

influence lifecycle cost through maintenance and data quality. P6: Usability and acceptance influence sustained use and therefore the cost-effectiveness of the system. P7: Design choices, including dependence on specific hardware and on the availability of a resolving service, influence lifecycle cost. P8 (not shown in Figure 1): implementation processes mediate the relationship between system design and operational performance, so a well-designed system may underperform where training and data quality are weak.

**Figure 1. Proposed literature-derived framework (not empirically validated)**

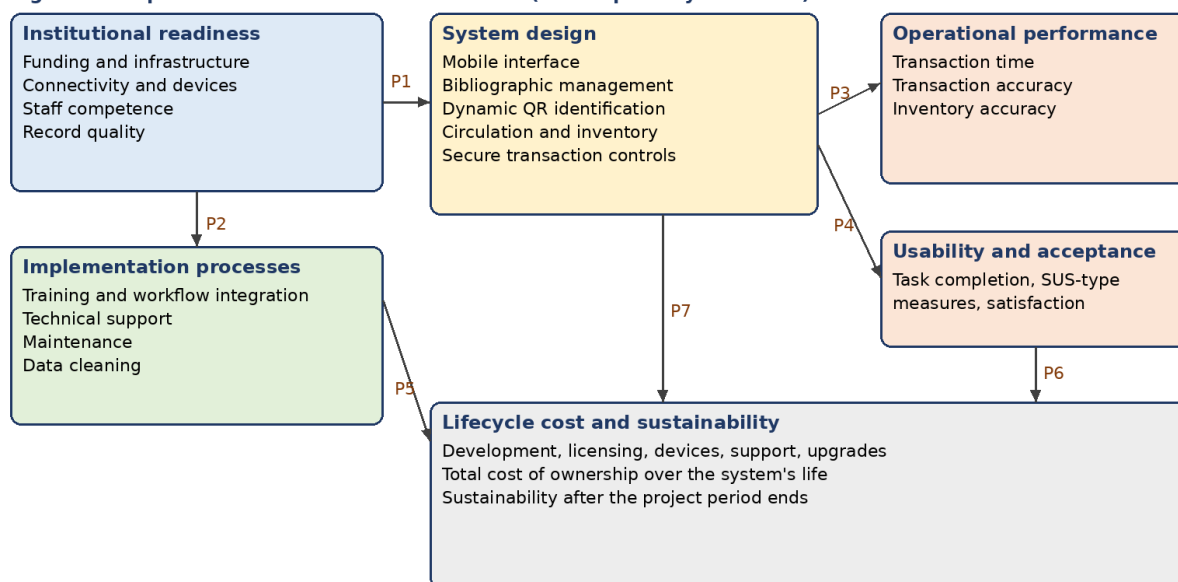


**Figure 1.** Proposed literature-derived framework for mobile library management in resource-constrained academic libraries. Arrows labelled P1–P7 correspond to the propositions in the text. The framework has not been empirically validated.

Each construct can be operationalised through the following indicators. Institutional readiness can be measured through connectivity records, device counts, training hours and an audit of a sample of records for error rate. System design is assessed through functional testing against a stated list of functions and transaction controls. Implementation processes are captured through support requests, maintenance events and staff time spent on data cleaning. Operational performance is measured through timed logs of issue and return, error and duplicate-transaction rates and shelf-count discrepancies against the accession register. Usability is assessed through task completion, time on task and System Usability Scale scores. Lifecycle cost is calculated as total cost of ownership over a stated period, including devices, licences, support and upgrades.

## 9. IMPLICATIONS FOR RESEARCH AND PRACTICE

For research, the priority is objective measurement with comparison. Transaction time, error and duplicate rates and stock-reconciliation accuracy can be captured through logs, timed observation and shelf audit. Designs should include a comparison condition, such as a staged rollout or a matched manual period, so that system effects can be separated from site effects. Transaction controls should be tested with real borrowers and staff, not only in design. Multi-site designs are needed to test whether results hold across libraries with different resources.

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For practice, libraries considering mobile systems should pilot before full adoption, budget for maintenance and support as well as development and treat record quality as a precondition for automation. Staff training should cover the management side of the system, not only the user side. Vendor and in-house choices should be made with a view to who will maintain the system after the project period.

### **10. LIMITATIONS**

This review has several limitations. It is a thematic narrative review and its findings depend on the selection and interpretation of sources by a single reviewer. The search used one database, Google Scholar, with preprints excluded. The evidence base is small and most sources are descriptive, self-reported or prototype-based. Many were assessed from abstracts and case descriptions rather than from full experimental data. Few sources measure operational outcomes, so claims about efficiency and accuracy are necessarily tentative. Most of the evidence comes from particular institutions and settings and results from one setting may not transfer to another. The findings should therefore be read as a map of what has been studied and of the gaps that remain, rather than as a measure of effect.

### **CONCLUSION**

Mobile access services are established and QR-based identification has moved from informational uses into circulation models. Usability is the best-studied dimension and the perceived benefits of mobile library services are consistently reported. The evidence that mobile systems can support integrated library management in resource-constrained settings is still thin. Measured transaction accuracy, inventory outcomes and lifecycle cost are absent from the reviewed literature. This review separates the claims that the evidence supports from those that remain hypotheses and it proposes a framework and propositions for a multi-site evaluation. Whether a mobile system delivers the operational benefits its proponents describe is a question for empirical study.

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