



Implementation of a Barcode-Based Digital Library System to Enhance Efficiency and Accuracy at MTs NU 01 Pecalungan

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ABSTRACT

Research Objective. This study aims to develop and implement a barcode-based digital library system at MTs NU 01 Pecalungan to improve service efficiency and data accuracy. **Research Method.** A sequential explanatory mixed-methods approach was employed, combining quantitative and qualitative data. The quantitative phase compared processing time and data accuracy between manual procedures and the barcode-based system, while user responses were collected through questionnaires involving 82 respondents. **Results.** The results showed that the barcode-based system significantly improved library service performance, reducing the average loan processing time from 122.4 seconds to 33 seconds and increasing data recording accuracy from 82% to 97%. In addition, most users expressed satisfaction with the system. These findings indicate that the implementation of a barcode-based digital library system effectively enhances the efficiency and accuracy of school library services at MTs NU 01 Pecalungan.

Keywords: *Digital Library, System Development Life Cycle (SDLC), Sequential Explanatory Mixed Methods*

A. INTRODUCTION

The school library plays a strategic role in supporting the learning process and fostering students' information literacy. In the context of school education, the library is not only a supporting facility but also an essential component in providing access to learning resources. Therefore, library management is expected to be carried out effectively, efficiently, and accurately in order to support educational services optimally.

At MTs NU 01 Pecalungan, library circulation activities, including book lending, returning, and report preparation, are still managed manually. This condition has resulted in several recurring problems, such as a high risk of data entry errors, long service queues, difficulties in tracing circulation records, and delays in preparing monthly reports. Based on preliminary observations, the report recapitulation process requires considerable time and often involves repeated data correction before archiving. As a result, the reporting process becomes less timely and less consistent.

The persistence of manual procedures indicates that the existing system has not been able to fully support efficient library services. Manual recording may still

be applicable in simple administrative contexts; however, it becomes less effective when transaction volumes increase and accurate record management is required. Consequently, the need for a more efficient and reliable system is increasingly urgent, particularly in school libraries that require fast service and accurate data management.

One solution that can be implemented is a digital library system integrated with barcode technology. Digital library systems are considered more advantageous than conventional systems because they facilitate faster information retrieval, simplify borrowing and returning transactions, and support more efficient report generation (Widya Laksmi et al., 2022). In addition, digital systems can reduce repetitive manual recording, which is often found in ledger-based administration where the same book data must be written repeatedly for similar copies, thereby increasing inefficiency and the risk of human error (Teknika et al., 2024).

A digital library system refers to the use of information technology to manage library collections, circulation, and reporting electronically. Such a system offers several advantages, including broader access, reduced dependence on manual records, and more systematic control of collections (Anastasya et al., 2024). However, the effectiveness of a digital library system depends not only on the digitization of records, but also on the extent to which it can support circulation activities quickly and accurately in everyday operations.

Several previous studies have discussed the implementation of digital libraries. For instance, the website-based digital library developed at SMAN 18 Tangerang Regency succeeded in addressing various limitations of manual systems, such as restricted access, vulnerability to data loss, and inefficient reporting processes (Junaedi et al., n.d.). Nevertheless, the study mainly focused on online access and computerized administration, without specifically integrating barcode-based circulation features to improve transaction speed and recording accuracy. This indicates that there is still room for further study regarding the operational role of barcode technology in library circulation systems.

Barcode technology has been widely applied in inventory and transaction management because it enables automatic identification, reduces human error, and increases operational efficiency. Previous studies on barcode-based systems in inventory management demonstrate that this technology contributes to more accurate data recording and real-time tracking (Luthfi Asari et al., 2025). These benefits are highly relevant to library circulation management, where accurate recording of loans, returns, and stock availability is essential. Furthermore, barcode-based systems can reduce manual workloads and improve data reliability, although their implementation requires adaptation by users (Ridha Permana & Savitri Puspaningrum, 2021).

Based on the problems and previous studies, the research gap in this study lies in the limited discussion of barcode-integrated digital library systems in the context of school library circulation, particularly at the secondary school level. Previous studies have generally focused on digital library development in general or barcode applications in non-library sectors. Meanwhile, studies that specifically examine the contribution of barcode technology to circulation efficiency,

recording accuracy, and reporting consistency in school libraries remain limited. Therefore, this study aims to implement a barcode-based digital library system at MTs NU 01 Pecalungan and evaluate its impact on service efficiency, data accuracy, reporting consistency, and user perceptions of system usability.

B. METHODS

This study employs a sequential explanatory mixed-methods design, consisting of two consecutive phases: quantitative followed by qualitative. In this design, quantitative data are collected and analyzed first, and the results are then followed up with qualitative inquiry to provide deeper explanation and contextual understanding of the findings (Khabibullah & Malik Imam Sholahuddin, 2024; Justan et al., 2024). The research flow is presented in Figure 1.

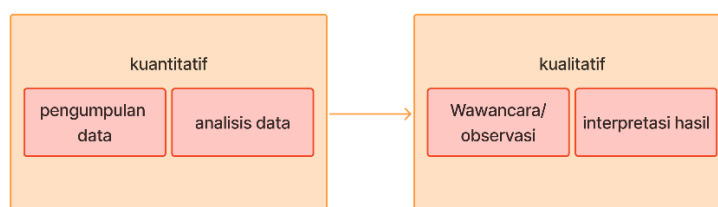


Figure 1. Methods Mixed-Method Sequential Explanatory

Phase I: Quantitative

The quantitative phase aims to measure the impact of implementing a barcode-based digital library system at MTs NU 01 Pecalungan. The study focuses on three main indicators: service speed, data accuracy, and report-generation efficiency. Quantitative data are collected through transaction time measurements, analysis of errors in lending records, and closed-ended questionnaires using a Likert scale to assess users' perceptions of efficiency and accuracy (Nur Sya'adah & Samsudin, 2022). This phase provides measurable evidence of whether the system improves library operations.

Phase II: Qualitative

The qualitative phase is conducted after the quantitative analysis to explain and enrich the statistical findings. Data are gathered through semi-structured interviews, observations, and documentation involving librarians, students, and teachers who use the system. This phase explores user experiences, perceived benefits, challenges during implementation, and suggestions for improvement. The data are analyzed thematically to identify patterns that explain how and why the barcode-based system affects library services and administrative processes (Wirsal et al., 2022).

Data Integration

The integration of data is carried out at the interpretation stage using a connecting approach, in which the results of the quantitative phase guide the focus of the qualitative phase. For example, when quantitative findings show faster

transaction times or fewer recording errors, qualitative data are used to explain the factors behind these improvements, such as simpler workflows, reduced manual entry, or increased familiarity with barcode scanning. Through this integration, the study provides a more comprehensive understanding of the effectiveness of the barcode-based digital library system in improving efficiency and accuracy.

I. Development Methods



Figure 2. Waterfall Methods

The SDLC Waterfall method was selected in this study because it provides a linear and systematic development process that is suitable for projects with relatively stable and clearly identified requirements. In the context of this research, the functional needs of the library system at MTs NU 01 Pecalungan—such as book data management, barcode-based borrowing and repayment transactions, member registration, and report generation—had already been identified at the beginning of the study through direct observation and interviews with library staff. Therefore, the Waterfall model was considered appropriate, as each development stage could be carried out in sequence with minimal changes in requirements.

The development process consisted of five stages. First, Requirements Analysis was conducted by interviewing library staff and observing the existing manual circulation process to identify system needs and operational problems. Second, in the System Design stage, the system structure, database design, user interface, and process flow were prepared based on the identified requirements. Third, during Implementation, the barcode-based digital library system was developed into a functional application that supports borrowing, repayment, book cataloging, and transaction recording. Fourth, in the Testing stage, Black-box testing was applied to verify that each system feature functioned according to its intended purpose. Finally, Maintenance was carried out to fix minor errors and ensure that the system remained usable after testing and initial implementation. Through these stages, the barcode-based digital library system was successfully developed and demonstrated its ability to improve service efficiency and data accuracy at MTs NU 01 Pecalungan.

Based on the implementation of these stages, the prototype digital library information system was successfully developed using the SDLC Waterfall method.

The testing results indicated that the main functional requirements of the system operated as expected and supported improvements in operational efficiency and data accuracy (Epta Saputra, 2022).

Black-box testing was used in this study to evaluate whether the barcode-based digital library system functioned properly from the user's perspective. The testing covered the main modules of the system, namely user login, barcode scanning, book lending and return transactions, data storage, and report generation. Based on the test results, all core functions operated according to the expected outcomes. Valid input data were successfully processed by the system, while invalid input data were correctly rejected or displayed appropriate warning messages. In addition, testing on boundary conditions showed that the system was able to handle critical input cases without causing functional errors.

The test results also indicate that the implementation of barcode scanning had a direct and measurable impact on system performance. As shown in Table 1, the mean time for the borrowing process decreased significantly from 122.40 seconds (manual) to 33.00 seconds (barcode), representing a reduction of approximately 73.1%. Similarly, the repayment process improved from a mean of 138.30 seconds to 25.00 seconds, a reduction of approximately 81.9%. The standard deviation also decreased notably — from 21.33 to 6.22 for borrowing, and from 18.90 to 5.32 for repayment — indicating not only faster processing but also greater consistency in transaction time. These results demonstrate that book data could be identified automatically without repeated manual typing, reducing the possibility of input errors and improving the accuracy of transaction records. Furthermore, the report generation feature was able to store and display circulation data more consistently, making library administration more efficient. These findings confirm that the developed system achieved the main research objectives, namely improving efficiency in library services and increasing accuracy in recording and managing circulation data at MTs NU 01 Pecalungan.

The testing process focused on key system modules, including user authentication, book lending and return transactions, barcode scanning functionality, data storage, and report generation. Each module was evaluated using functional testing methods to ensure the system behaved correctly under various input conditions. To improve testing effectiveness and efficiency, Equivalence Partitioning was used to categorize input data into valid and invalid classes, while Boundary Value Analysis (BVA) was applied to test critical boundary conditions that commonly cause functional errors (Hamid et al., 2025). The time comparison between manual and barcode-based methods was measured across 60 data samples per category, as presented in Table 1, providing a statistically sufficient basis for performance evaluation.

Table 1. Time Comparison Results

Type	Method	Amount of data	Mean (seconds)	Median (seconds)	Deviation
Borrowing	Manual	60	122	117	21
Borrowing	Barcode	60	33	31	6
Repayment	Manual	60	138	135	18
Repayment	Barcode	60	25	24	5

2. Data Accuracy

In addition to improving efficiency, the barcode-based system also had a positive impact on the accuracy of transaction data recording. In the manual system, of the 100 observed transactions, 82 records were accurate (82%) and 18 were inaccurate (18%). In contrast, the barcode-based system increased accuracy to 97%, with only 3 incorrect records out of 100 transactions. This difference represents an improvement of 15 percentage points, indicating that the barcode system effectively minimizes data entry errors that commonly occur in manual recording processes.

These results are consistent with previous studies, which reported that the use of barcode systems can reduce human error to below 5% by automating the identification process of books and library members. Table 2 below shows the recorded accuracy data.

Table 2. Accuracy of Recorded Data

Method	Accurate Data	Incorrect Data	Total Transactions	%
Manual	82.00	18.00	100.00	82.00
Barcode	97.00	3.00	100.00	97.00

3. Interpretation

The quantitative findings indicate that the implementation of a barcode-based digital library system significantly enhances both efficiency (service speed) and accuracy (data precision). From an operational perspective, librarians are able to complete transactions more rapidly with substantially lower error rates. Meanwhile, from the users' perspective, library services become faster and more structured, which has the potential to increase user satisfaction as well as students' interest in literacy. Accordingly, these results support the hypothesis that the implementation of a barcode system in school libraries contributes positively to improved performance and the overall quality of information services.

C. RESULT AND DISCUSSION

The barcode-based digital library system was built on the CodeIgniter 4 MVC framework with MySQL, a design choice that reflects a deliberate separation of concerns between data logic and interface layers. More critically, the shift from

manual ledger recording to automated barcode-based transaction logging directly addresses the root cause of inefficiency in traditional library operations: human dependency in data entry. This architectural decision is not merely technical it represents a fundamental change in the transaction workflow that removes the bottleneck of manual input, thereby enabling faster and more reliable record-keeping. Studies on barcode-based library systems consistently demonstrate that this transition raises inventory accuracy from approximately 85% in manual systems to 95% in barcode-enabled systems, while patron satisfaction increases from 70% to 85% (Sureshkumar et al., 2025).

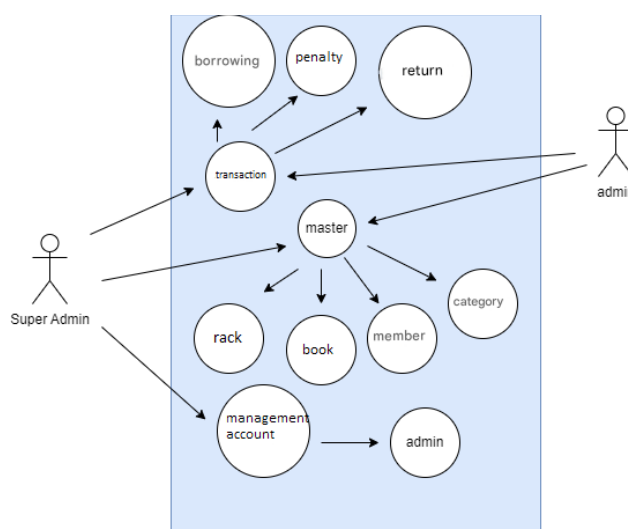


Figure 3. Use Case Diagram

Figure 3 below illustrates the system's use case diagram. System management is divided into two actors: Super Admin and Admin. Both the Super Admin and Admin have access rights to transaction features, including book loans, fines, and returns, as well as to master data features for library management, such as shelf data, book data, member data, and category management.

The system implements a dual-role access model Super Admin and Admin where the key distinction lies in account management privileges reserved for the Super Admin. This role separation reflects a principle of least privilege, ensuring that administrative control over sensitive operations remains isolated from routine transaction handling. Such a design reduces the risk of unauthorized data modification and aligns with security best practices in web-based information systems. The functional scope covering borrowing, returning, fines, and master data management covers the full transaction lifecycle of a library, which prior implementations such as QR code-based library systems at MTs. N. Binjai have similarly attempted, though without integrated satisfaction evaluation (Teknika et al., 2024).

The system's efficiency improvement is attributable to three converging factors. First, barcode scanning eliminates manual keyboard input per transaction, reducing the cognitive and physical load on library staff. Second, automatic

timestamp recording and real-time database updates remove the post-transaction reconciliation step that is inherent in paper-based systems. Third, the dashboard's real-time summary displaying loans, returns, overdue counts, and inventory consolidates information that previously required cross-referencing multiple ledgers. These factors collectively reduce the transaction cycle time and minimize recording errors, a finding consistent with research showing that barcode integration into library management systems improves tracking reliability and supports proactive library management.

The Naive Bayes model achieved 82.35% accuracy with an 80:20 training-testing split, which positions this study's result within the mid-to-high range of comparable classification studies. For context, a satisfaction classification study on LPG gas usage achieved 91.2% with the same 80:20 split (Adrian et al., 2025), while iPusnas library sentiment analysis using Naive Bayes yielded only 58% accuracy, and a POLRI Super App review classification reached 87% (Zaenudin Zidane & Nurapriani, 2025). The relatively moderate accuracy in this study is likely attributable to the small dataset size (82 respondents, 17 test samples), which limits the algorithm's ability to generalize patterns a known limitation of Naive Bayes when training data is sparse. A hybrid approach combining Naive Bayes with other algorithms (e.g., SVM or Random Forest) has been shown to push accuracy up to 98 - 99% in library user sentiment analysis, suggesting a viable direction for improving the model in future iterations .

The precision of 80% and recall of 88.89% for the "satisfied" class reveal an asymmetry worth analyzing: the model is more effective at confirming satisfaction than detecting dissatisfaction. This pattern is consistent with class imbalance where the majority of respondents (satisfied users) produce more training signal, making the minority class (dissatisfied users) harder to classify correctly. The three misclassifications likely involve borderline respondents whose responses straddle both categories. Among dissatisfied users, the two recurring concerns system responsiveness under concurrent use and interface complexity in certain menus point to scalability and UX design gaps rather than fundamental functional failures. This distinction is important: satisfaction with core functionality (barcode scanning, transaction recording) is high, while dissatisfaction is concentrated in non-functional quality attributes (performance, interface design). These findings align with the EUCS-based study on the INLISLite library system, where ease of use scored highest (4.04/5) but accuracy received the lowest score (3.92/5), indicating that digital library users prioritize functional reliability alongside interface accessibility.

Table 3. Result of Black-Box Testing

No	Features Being Tested	Conditions	Expected Results	Description
1	Log in to the dashboard	Entering the username and password correctly	Successfully logged into the dashboard	Succeed
		Entering the username and password incorrectly	An error appears and the dashboard fails to log in	Succeed
2	Log out	Pressing the logout button	Returns to the login page	Succeed
3	View book list	Pressing the logout button	Displays all available books	Succeed
4	Borrowed	Opening the book data page	Book borrowings are recorded in the system	Succeed
5	Returned	Borrowing a book	Book returns are recorded in the system	Succeed
6	Fines	Returning a book Automatically imposing a fine if the book is not returned by the due date	Fines are automatically recorded	Succeed
7	Members	Managing library members	Member management is possible	Succeed
8	Books	Crud members	Books, their stock, and shelves are recorded in the system	Succeed
9	Categories	Managing book categories	Book category management is possible	Succeed
10	Shelves	Managing library shelf data	Library shelf data management is possible	Succeed
11	Admin	Managing library admin data	Library admin management is possible to access the system	Succeed

The results of the Black-box testing indicate that all system functions operate in accordance with the requirements identified during the analysis phase. The

testing was conducted by directly executing each feature to obtain an accurate representation of real-world system usage.

Based on the questionnaire analysis of 82 users of the barcode-based digital library system, two primary categories were identified: satisfied and dissatisfied users. The data were processed using the Naive Bayes algorithm in RapidMiner, with an 80% training set and a 20% testing set. The evaluation results show an accuracy rate of 82.35%, indicating that the model is capable of predicting user satisfaction levels with a reasonably good level of performance.

Row No.	Saya meras...	prediction(S...	confidence(L...	confidence(L...	Tampilan an...	Proses pem...	Menu dan fit...	Sistem me...	Penggunaan...	Sistem berb...	Waktu resp...	Sistem me...	Saya berse...
1	tidak puas	tidak puas	0.775	0.225	sangat setuju	sangat setuju	sangat tidak ...	sangat tidak ...	setuju	setuju	sangat tidak ...	sangat tidak ...	sangat setuju
2	puas	puas	0.032	0.968	setuju	sangat setuju	sangat setuju	setuju	setuju	netral	setuju	setuju	sangat setuju
3	tidak puas	puas	0.091	0.909	sangat setuju	sangat setuju	setuju	netral	tidak setuju	setuju	sangat setuju	sangat setuju	sangat tidak ...
4	puas	puas	0.026	0.974	tidak setuju	netral	netral	tidak setuju	setuju	tidak setuju	sangat setuju	setuju	setuju
5	tidak puas	tidak puas	0.839	0.161	tidak setuju	netral	tidak setuju	sangat setuju	netral	sangat setuju	sangat tidak ...	sangat setuju	sangat setuju
6	tidak puas	tidak puas	0.892	0.108	tidak setuju	sangat tidak ...	tidak setuju	tidak setuju	setuju	netral	sangat setuju	sangat setuju	netral
7	puas	puas	0.030	0.970	sangat setuju	netral	netral	setuju	sangat setuju	sangat tidak ...	netral	setuju	tidak setuju
8	tidak puas	tidak puas	0.858	0.142	sangat setuju	sangat tidak ...	sangat tidak ...	netral	sangat setuju	setuju	sangat tidak ...	sangat setuju	setuju
9	tidak puas	puas	0.248	0.752	setuju	sangat setuju	sangat tidak ...	sangat setuju	sangat setuju	setuju	sangat setuju	tidak setuju	sangat setuju
10	puas	puas	0.062	0.938	setuju	sangat setuju	setuju	sangat tidak ...	tidak setuju	sangat setuju	setuju	sangat setuju	sangat setuju
11	puas	puas	0.050	0.950	sangat setuju	sangat setuju	sangat setuju	netral	tidak setuju	sangat setuju	tidak setuju	sangat setuju	tidak setuju
12	puas	puas	0.004	0.996	setuju	sangat tidak ...	sangat tidak ...	sangat setuju	setuju	tidak setuju	netral	netral	tidak setuju
13	tidak puas	tidak puas	0.976	0.024	sangat setuju	tidak setuju	netral	setuju	netral	setuju	sangat tidak ...	setuju	sangat setuju
14	tidak puas	tidak puas	0.636	0.364	sangat tidak ...	tidak setuju	netral	setuju	sangat setuju	netral	setuju	setuju	setuju
15	puas	puas	0.004	0.996	netral	netral	tidak setuju	tidak setuju	setuju	tidak setuju	sangat setuju	setuju	setuju
16	puas	tidak puas	0.882	0.118	tidak setuju	tidak setuju	setuju	sangat setuju	sangat tidak ...	sangat setuju	setuju	sangat tidak ...	sangat setuju
17	puas	puas	0.063	0.937	netral	sangat setuju	sangat tidak ...	netral	sangat tidak ...	sangat setuju	netral	setuju	sangat setuju

Figure 4. Naive Bayes Testing Results

Overall, the classification results show that most respondents fell into the “satisfied” category regarding the use of the barcode-based digital library system. Out of a total of 17 test samples, 8 instances were correctly classified as “satisfied,” while 6 were correctly classified as “dissatisfied.” Only three samples were misclassified, indicating that the model’s error rate is relatively low. The precision value for the “satisfied” category reached 80%, while the recall value was 88.89%, suggesting that the system is more effective in identifying users who are satisfied than those who are not.

These findings indicate that the system meets key usability criteria, including ease of use, efficiency, and clarity of information. The use of barcodes has also proven effective in reducing book data entry errors and accelerating transaction processes. These aspects contribute positively to overall user satisfaction. Meanwhile, among respondents who reported dissatisfaction, most concerns centered on system responsiveness and stability when used simultaneously by multiple users, as well as interface elements that require further simplification in certain menus. These insights provide valuable input for future system development to improve performance and enhance the overall user experience.

E. CONCLUSION

This study demonstrates that the implementation of a barcode-based digital library system at MTs NU 01 Pecalungan significantly improves library efficiency and data accuracy. The system reduced the time required for book lending and

returning by more than 70% compared to the previous manual method. It also decreased recording errors from 18% to 3%, indicating a substantial improvement in transaction accuracy. In addition, Black-box testing confirmed that all core system features operated according to user requirements. User evaluation results, supported by questionnaire analysis and Naive Bayes classification with an accuracy of 82.35%, also showed that most users were satisfied with the system, especially in terms of ease of use, speed, and barcode reliability. Overall, this study confirms that the system makes library services more efficient, accurate, and user-friendly. Future development may include automated return reminder notifications and a loan analytics dashboard to further support library management.

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