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Developing an SMS gateway-based library information system to enhance efficiency and accessibility

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Abstract: The integration of technology into library management plays a crucial role in improving operational efficiency and resource accessibility. This study presents the development of an SMS gateway-based library information system to digitalize book borrowing and returning processes. The system was developed using the System Development Life Cycle (SDLC) methodology, incorporating Requirement Planning, System Design, and Implementation phases. The implementation of the system was evaluated by using Black Box Testing to ensure functional correctness. The results indicate that the system effectively streamlines library operations by providing automated notifications for due dates, optimizing inventory tracking, and reducing manual record-keeping errors. Additionally, the integration of an SMS Gateway enhances user engagement and minimizes overdue returns. This study highlights the potential of digital solutions in modernizing library management and serves as a model for other educational institutions aiming to enhance their library systems through technology.

Keywords: library information system; SMS gateway; system development life cycle; automation

1. Introduction

In the era of rapid technological advancement, the role of information systems has become increasingly vital in various sectors, including education (Demigha, 2021; Dwivedi et al., 2020; He et al., 2021). The integration of technology in educational institutions has significantly improved the efficiency of administrative and academic activities. One of the critical areas benefiting from technological integration is library management (Ismail et al., 2022). As libraries serve as essential resources for students and educators, the implementation of an efficient information system is crucial for optimizing resource utilization and streamlining operations (Adigun et al., 2024; Egeubayeva et al., 2024; Sunarjo et al., 2024).

Modern education systems emphasize the importance of technology adoption to facilitate learning and administrative processes (Fortuna et al., 2024; Prasetya et al., 2024; Primawati et al., 2024). Libraries, being fundamental components of educational infrastructure, require systematic management to ensure accessibility, proper book inventory tracking, and efficient borrowing and return processes. However, many institutions still rely on manual library management, leading to inefficiencies and a lack of real-time information regarding book availability and student transactions (Sarwar, 2025). The reliance on manual documentation for library management often results in inaccurate records, delayed responses to student inquiries, and difficulties in monitoring book circulation. Without an automated system, the library staff faces challenges in keeping track of borrowed books, overdue returns, and book availability (Ikwuanusi et al., 2024). Additionally, the communication gap between library staff and students can lead to missed

deadlines and unreturned books, affecting overall resource management (Heinrich et al., 2022; Rawat et al., 2022).

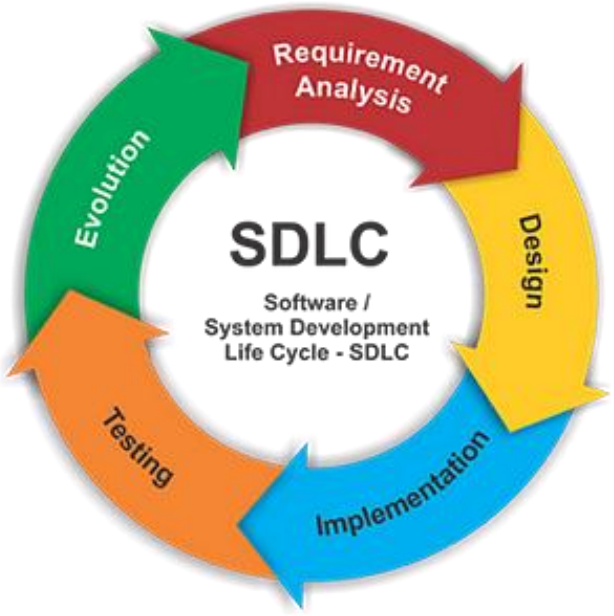
To address these challenges, an SMS Gateway-based Library Information System is proposed. This system is designed to automate book borrowing and return processes while enabling real-time communication between the library and students. By leveraging an SMS Gateway, the system can send automated reminders to students regarding due dates, notify them about book availability, and facilitate efficient data recording (Teves, 2024; Thapa et al., 2024). This approach ensures that both students and library staff can access up-to-date information, reducing the risk of lost or unreturned books and enhancing overall library efficiency.

The implementation of an SMS Gateway-based Library Information System aligns with current technological trends in smart education. The adoption of mobile communication for library management not only modernizes traditional methods but also supports a more sustainable and responsive library environment (Khan, Ma, et al., 2023; Khan, Rafi, et al., 2023; Liu et al., 2024). The research aims to design and develop a system that improves data accuracy, minimizes manual record-keeping errors, and enhances accessibility for students and staff. Through this innovation, educational institutions can optimize their library services, ultimately contributing to a more effective learning environment. By integrating this system into library management, the institution can benefit from improved efficiency, reduced administrative workload, and enhanced student engagement. The proposed solution serves as a model for other educational institutions seeking to modernize their library systems, ensuring that technology is effectively utilized to support academic success.

2. Methods

The development of the Library Information System at Vocational Schools Ar-Risalah employs the System Development Life Cycle (SDLC) as its primary framework. This methodology ensures a structured and systematic approach to system development. The SDLC phases implemented in this study include Requirement Planning, System Design, and Implementation.

Figure 1. System Development Life Cycle (SDLC)



In the Requirement Planning phase, data collection and system analysis were conducted to gather comprehensive information regarding the existing library operations. The main objectives of this phase include identifying the challenges and limitations of the current system, analyzing the users' needs and requirements for the new system, and understanding the workflow and functional expectations of the library system to ensure alignment with institutional goals.

Observations, an interview, and literature reviews were conducted in this phase. Observations were carried out at Vocational Schools Ar-Risalah to examine current library activities and system functionalities. An interview was administered to the Head of the Library to gain insights into the operational requirements and challenges. Additionally, the literature reviews were completed by including references from journal articles (2017-2023) related to web-based library information systems.

The System Design phase involved designing a prototype based on the findings from the requirement analysis. The system modeling includes Entity-Relationship Diagram (ERD) to define database structures, Unified Modeling Language (UML) diagrams to visualize system components and interactions, and User Interface (UI) Design to ensure structured menus and intuitive navigation for ease of use. To enhance system functionality, iterative design improvements were made based on feedback from stakeholders, ensuring that the system meets user requirements effectively.

During the Implementation phase, the actual system was developed and tested to ensure its functionality and usability. The key aspects of this phase include coding and development, where the system was developed using PHP as the programming language while the database was managed using phpMyAdmin. Additionally, testing and evaluation were conducted through Black Box Testing, focusing on verifying functional specifications without inspecting the underlying code. This method ensured that inputs, processes, and outputs aligned with user requirements, system functionalities operated as expected, and any discrepancies or issues were identified and addressed before deployment. In addition to the SDLC methodology, elements of Rapid Application Development (RAD) were incorporated to enhance system adaptability and responsiveness. This approach included initial data collection through observations and literature reviews, user feedback loops during design and development to make iterative improvements, and prototyping with rapid testing to ensure system usability and efficiency before full deployment.

To systematically address the challenges faced by Vocational Schools Ar-Risalah library, a structured problem-solving framework was developed. This framework involved identifying existing inefficiencies in the manual library system, developing a tailored digital solution aligned with user needs and institutional requirements, and testing and refining the system through iterative evaluation and user feedback. By integrating SDLC with RAD principles, this study aims to develop an efficient, user-friendly, and scalable library information system that enhances both library operations and user experience at Vocational Schools Ar-Risalah.

3. Results and discussion

The development of the Laboratory Inventory Information System at SMK Ibnu Sina adopts the Rapid Application Development (RAD) methodology. This approach consists of three primary phases: Requirement Planning, Workshop Design, and Implementation. The systematic structure of the RAD methodology is outlined below.

3.1 Requirement planning

In this phase, a comprehensive system analysis was conducted to understand the current operational workflow and identify existing challenges. The objective was to evaluate whether the current system meets user requirements and determine areas for improvement. If shortcomings were found, an alternative system design was proposed to enhance the inventory management process. The key activities in this phase involved analyzing the existing system workflow to identify inefficiencies, proposing an improved workflow that aligns with institutional requirements, and comparing the current and proposed workflows to highlight key enhancements. The analysis of the current system revealed inefficiencies in inventory tracking and management, prompting the creation of a process map to visualize bottlenecks and limitations. Based on these findings, a redesigned workflow was developed to enhance efficiency and

accuracy. The proposed system incorporated automated tracking and user-friendly interfaces, ensuring improved usability and streamlined operations.

3.2 Workshop design

Since the system was designed as a web-based application, this phase focused on developing a structured system prototype using various design tools. Several modeling techniques were employed, including Unified Modeling Language (UML) diagrams to illustrate system components and interactions, an Entity-Relationship Diagram (ERD) to define the database structure, and a detailed database design to ensure efficient data storage. Additionally, mockups and user interface (UI) designs were created to provide an intuitive and user-friendly experience. The system application is depicted in Figure 2, which presents the use case diagram.

Figure 2. Use case diagram of the library information system

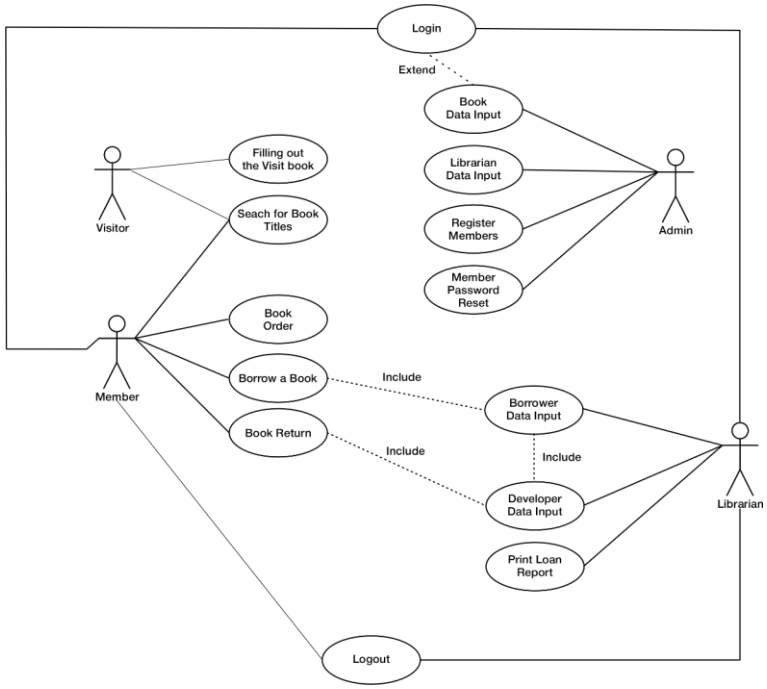


Figure 2 is a use case diagram that illustrates the interactions between users and the system in executing key functions. The diagram presents actors representing user roles, such as administrators and general users, along with various use cases that reflect the system's main features. Each use case is connected to the actors through association lines, indicating how users interact with the system to perform specific tasks, such as logging in, managing data, and carrying out transactions. This diagram provides a visual representation of the system's structure, aiding in the understanding of workflows and available functionalities. The Use Case Diagram provided an overview of the system's functionality and interaction between actors. The following table describes the key actors and their roles within the system in Table 1.

Figure 2. Use case diagram of the library information system

Actor	Description
Login	Validates users and the Head of Laboratory before accessing the system.
Head of laboratory	Manages inventory data within the system.
Vice Head of library	Handles the processing of inventory data.
Head of department	Views inventory records within the system.
Form submission	Processes data entry for new records.
approval	Validates all data before finalizing transactions.

Additional system design components included Activity Diagrams, which mapped out key processes such as login, user interaction, borrowing, and returns. Sequence Diagrams were utilized to illustrate interactions between system components, ensuring a clear understanding of the system's operational flow. Furthermore, Class Diagrams were developed to define the system's database structure, providing a comprehensive representation of data organization and relationships.

3.3 Implementation

The database structure for the Library Information System was designed using the Unified Modeling Language (UML) to visualize the relationships between different entities. Figure 3 presents the Class Diagram, which outlines the core components of the system, including book management, member data, borrowing, and return processes. The database tables were structured to support the system's operational efficiency, ensuring seamless data retrieval and management.

Figure 3. Class diagram of the library information system

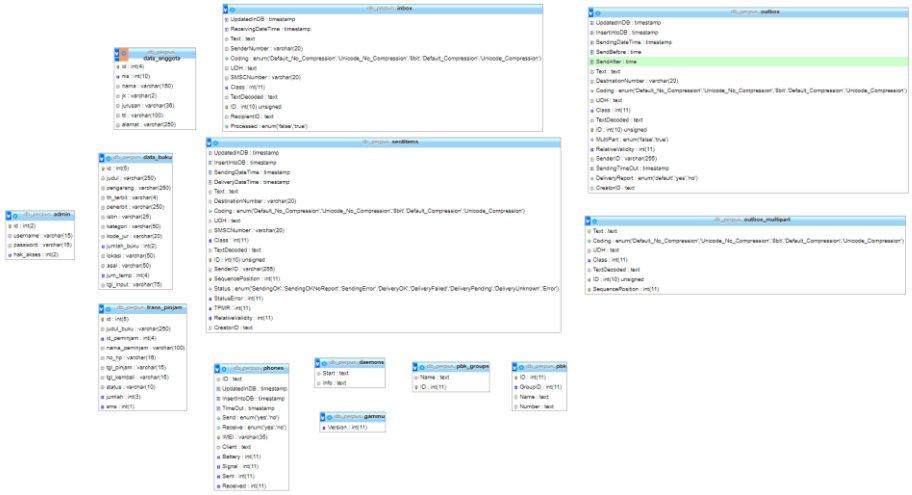


Figure 3 the Class Diagram of the Library Information System represents the structure and relationships between different database tables essential for managing library operations. The admin table stores administrative user data, while data_anggota contains information about library members. The trans_pinjam table records borrowing transactions, ensuring proper tracking of book loans. Additionally, the system includes a messaging module comprising inbox, outbox, and sentitems, which manages communication, likely for loan notifications or system alerts. The pbk and pbk_groups tables organize contact lists, while phones and gammu support system functionalities. This structured database design ensures data integrity, efficient library management, and streamlined operations.

Furthermore, database design in the Unified Modeling Language modeling above where we can see the design of the Library Information System. Figure 4 illustrates the database tables in phpMyAdmin, providing an overview of the tables essential for the system's functionality. The database design follows a relational structure, ensuring data consistency and integrity.

Figure 4. Library information system database in phpMyAdmin

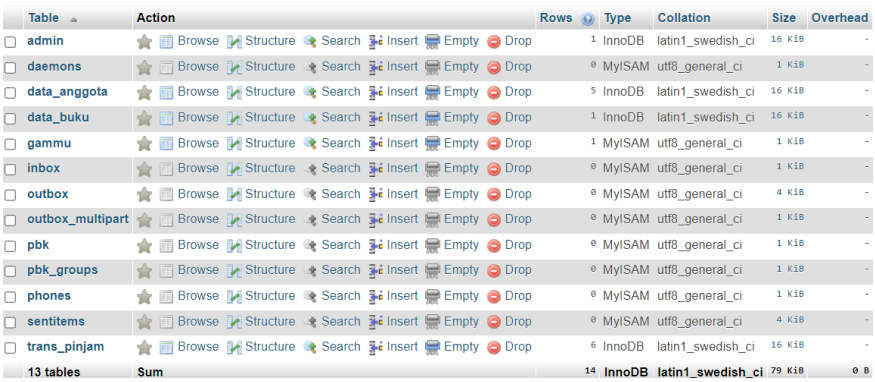


Table	Action	Rows	Type	Collation	Size	Overhead
admin	Browse Structure Search Insert Empty Drop	1	InnoDB	latin1_swedish_ci	16 KiB	-
daemons	Browse Structure Search Insert Empty Drop	0	MyISAM	utf8_general_ci	1 KiB	-
data_anggota	Browse Structure Search Insert Empty Drop	5	InnoDB	latin1_swedish_ci	16 KiB	-
data_buku	Browse Structure Search Insert Empty Drop	1	InnoDB	latin1_swedish_ci	16 KiB	-
gammu	Browse Structure Search Insert Empty Drop	1	MyISAM	utf8_general_ci	1 KiB	-
inbox	Browse Structure Search Insert Empty Drop	0	MyISAM	utf8_general_ci	1 KiB	-
outbox	Browse Structure Search Insert Empty Drop	0	MyISAM	utf8_general_ci	4 KiB	-
outbox_multipart	Browse Structure Search Insert Empty Drop	0	MyISAM	utf8_general_ci	1 KiB	-
pbk	Browse Structure Search Insert Empty Drop	0	MyISAM	utf8_general_ci	1 KiB	-
pbk_groups	Browse Structure Search Insert Empty Drop	0	MyISAM	utf8_general_ci	1 KiB	-
phones	Browse Structure Search Insert Empty Drop	0	MyISAM	utf8_general_ci	1 KiB	-
sentitems	Browse Structure Search Insert Empty Drop	0	MyISAM	utf8_general_ci	4 KiB	-
trans_pinjam	Browse Structure Search Insert Empty Drop	6	InnoDB	latin1_swedish_ci	16 KiB	-
13 tables	Sum	14	InnoDB	latin1_swedish_ci	79 KiB	0 B

Figure 4 the Library Information System database in phpMyAdmin consists of 13 tables, each serving a specific function in managing library operations. The admin table stores administrator details, while data_anggota holds information about library members. The data_buku table manages book records, including their availability. The trans_pinjam table tracks borrowing transactions, ensuring proper monitoring of book loans. Additionally, the system integrates a messaging feature with inbox, outbox, outbox_multipart, and sentitems tables, likely used for notifications and communication. The pbk and pbk_groups tables manage contact lists, while the phones and gammu tables support system functionalities. The daemons table may handle background processes. This structured database design, implemented in phpMyAdmin, ensures efficient library management by organizing data systematically.

Figure 5. Login interface and book page display

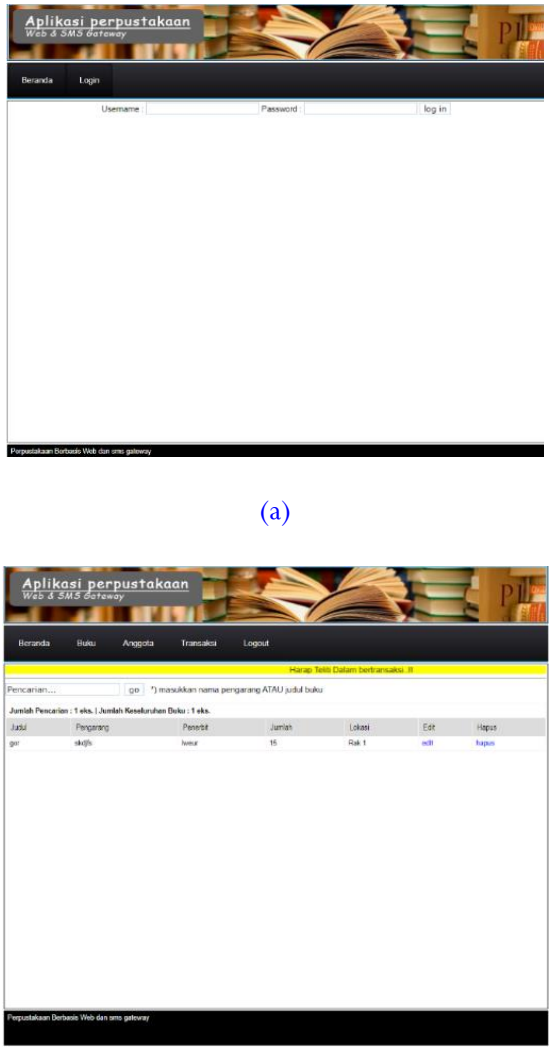


Figure 5 the login interface of the Library Information System features a simple and functional design. The system is labeled "Aplikasi Perpustakaan Web & SMS Gateway," indicating its integration with both a web-based platform and SMS notifications. The interface includes username and password input fields, along with a "log in" button for user authentication. At the top, a navigation bar provides access to the "Beranda" (Home) and "Login" sections. The background displays an image of open books, reinforcing the library theme. At the bottom, a footer states "Perpustakaan Berbasis Web dan SMS Gateway," highlighting the system's dual functionality. This login screen serves as the entry point for administrators, staff, and members to access library services, aligning with the database and class diagram models previously discussed.

Figure 6. Code for the book input page

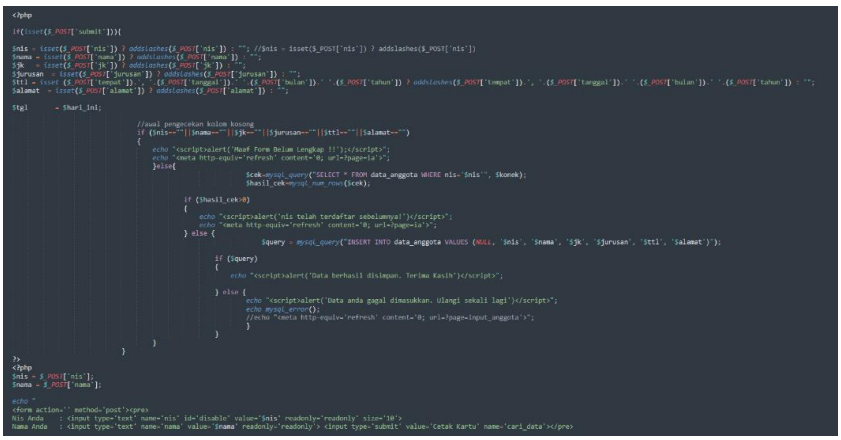


Figure 6 demonstrates code for the book input page is a PHP script responsible for handling the input of book data into the library's database. The code processes form submissions and ensures data validation before inserting new records into the data_anggota table in phpMyAdmin.

Figure 7. Loan transaction page

Figure 7 Loan Transaction Page is an interface in the web-based library system used to record book loan transactions. This page contains several input fields that must be filled in by the staff or user before completing the transaction. At the top of the page, there is a header displaying the application name, "Library Application Web & SMS Gateway", along with the main navigation menu, which includes Home, Books, Members, Transactions, and Logout.

3.4 Testing

At this stage, the system is tested to ensure that all features function as intended and meet user requirements. Testing is conducted to identify and correct any potential errors or shortcomings before the system is fully implemented. In this study, testing was conducted on the Library Information System, which includes an evaluation of both hardware and software components. Table 2 presents the tools used in the development of the system along with their respective functions.

Table 2. Tools used in system development

Tool	Function
Miro	Used by the author to design UML diagrams
Google Chrome	A web browser used to display the program
MySQL	The database used in the system
Sublime Text	A text editor used for writing program code
PHP	A programming language used to develop the library information system
XAMPP	Software that supports Apache HTTP Server, MySQL Database, and PHP programming language interpretation

Before conducting black-box testing to ensure the application is ready, a structured testing plan is developed. This plan outlines the steps involved in black-box testing, including test scenarios, input data, and expected output results. Once the application is fully developed, black-box testing is performed by providing various inputs to the system to verify whether the application produces the expected outputs. Table 3 presents the login system testing plan, detailing the test cases and their expected results.

Table 3. Login system testing plan

ID	Test case	Expected result
L01	Enter "admin" as the username and "admin" as the password, then click Login	Successfully logged into the system and redirected to the Menu page
L02	Enter "admin" as the email and "1234678" as the password, then click Login	A login failure warning appears because the email and password are incorrect

Table 4. Member data input testing plan

ID	Test case	Expected result
D01	Fill out the member data form according to the provided fields	The data is successfully saved, and a success notification appears
D02	Leave all or some fields in the member data form empty	A warning appears indicating that filling out the form is required

Table 5. Book data input testing plan

ID	Test case	Expected result
K01	Select a book and fill out the book data input form	The book data is successfully saved, and a success notification appears
K02	Do not select a book but fill out the book form	A notification appears indicating that selecting a book is mandatory
K03	Leave all or some fields in the book data form empty	A warning appears indicating that filling out the book data form is required

After the testing plan has been established, the next step is to execute the tests systematically. The primary objective is to verify whether the system functions as expected by comparing the actual results with the predefined functional requirements. If the input provided yields the expected output, the program is considered to be functioning correctly. However, if discrepancies are found between the expected and actual results, errors in the system must be addressed through further refinements. Table 6 presents the testing results, detailing the actual outcomes of each test case and their corresponding descriptions.

Table 6. Testing results

ID	Actual result	Description
L01	Successfully logged into the system and redirected to the Menu Dashboard page	Correct
L02	A login failure warning appears because the email and password are incorrect	Correct
L03	Login failed, and a warning appears indicating that required fields must be filled	Correct
D01	Member data is successfully saved in the database and a success notification appears	Correct
D02	The member data form cannot be submitted, and a warning appears indicating that all required fields must be filled	Correct

4. Discussion and contribution

The findings of this study emphasize the significance of integrating an SMS Gateway-based Library Information System to enhance the efficiency of library operations in educational institutions. The implementation of such a system addresses critical issues associated with manual library management, including inaccuracies in record-keeping, delays in responding to student inquiries, and inefficient tracking of borrowed books. These findings align with previous studies (Demigha, 2021; Dwivedi et al., 2020; He et al., 2021), which highlight the increasing role of technology in optimizing educational processes. The results suggest that by automating book borrowing and return processes, educational institutions can improve accessibility and streamline communication between library staff and students.

Moreover, the study supports previous research by (Ismail et al., 2022) and (Adigun et al., 2024), which underscore the necessity of modernizing library management systems to ensure efficient resource utilization. The SMS Gateway-based system effectively mitigates issues related to overdue books and communication gaps, enhancing overall library functionality. This is consistent with findings from (Heinrich et al., 2022) and (Rawat et al., 2022), who noted that automated reminder systems significantly reduce instances of unreturned books and improve students' compliance with library policies. By leveraging an SMS-based notification system, this study demonstrates a practical approach to modernizing library services while ensuring that students remain informed about due dates and book availability.

The methodological approach employed in this study, particularly the combination of System Development Life Cycle (SDLC) and Rapid Application Development (RAD), provided a structured framework for developing and refining the proposed system. This approach aligns with prior research (Kirpitsas & Pachidis, 2022; Sinabell & Ammenwerth, 2022), which emphasizes the importance of iterative development in ensuring system usability and effectiveness. By integrating UML-based modeling techniques such as Entity-Relationship Diagrams (ERD) and Use Case Diagrams, the study effectively visualized system components and interactions, reinforcing previous studies (Cohen & Gil, 2021; Lu et al., 2022; Lynch et al., 2024) that advocate for systematic software development methodologies in educational technology.

Triangulation of the research findings with previous studies further validates the effectiveness of the proposed system. The research aligns with (Egeubayeva et al., 2024), who argue that the adoption of technology-driven solutions in library management significantly improves operational efficiency. Additionally, studies by (Castro Benavides et al., 2020) highlight the limitations of manual library management, reinforcing the necessity of digital transformation in educational institutions. The current study extends these findings by demonstrating how an SMS Gateway-based system can bridge the gap between traditional and digital library management methods.

In conclusion, the implementation of an SMS Gateway-based Library Information System presents a viable solution for enhancing library operations in educational institutions. The study contributes to the growing body of literature advocating for technological integration in library management and highlights the practical benefits of automated communication and real-time information accessibility. Future research could explore the scalability of such systems across different educational and assess the long-term impact on student engagement and resource management.

5. Conclusion

The development of an SMS Gateway-based Library Information System significantly enhances the efficiency of library management at Vocational Schools Ar-Risalah. By automating book borrowing and returning processes, the system addresses challenges associated with manual record-keeping, delayed book returns, and ineffective communication between library staff and students. The integration of SMS notifications ensures timely reminders, reducing overdue books and improving student engagement.

Additionally, the use of SDLC and Rapid Application Development (RAD) methodologies contributed to a structured and adaptive system design, ensuring usability and scalability. The evaluation of the system through Black Box Testing confirms its functionality and reliability. This study underscores the importance of leveraging technology in library management to enhance operational efficiency and user experience. Future research can explore further enhancements, such as mobile application integration and AI-driven recommendation systems, to further optimize library services in educational institutions.

Author's Declaration

Author contribution

Wahyu Hidayat: Investigation, Software, Formal analysis, and Writing - Original Draft. **Okta Veza**: Data Curation, Methodology, and Review & Editing – Original Draft. **Afrina**: Validation, Methodology, and Review & Editing – Original Draft. **Novi Hendri Adi**: Supervision, Conceptualization, Methodology, and Review & Editing – Original Draft. **Ruslan Isaev** and **Sanzharbek Erdolatov**: Review & Editing – Original Draft.

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Conflict of interest

The authors declare no conflicts of interest related to the conduct or publication of this research.

Ethical clearance

This research does not involve humans as subjects.

AI Statement

This article is original; no sentence or image was generated by AI tools. Grammar corrections were made using Grammarly and ChatGPT, and the final content was reviewed by the authors with assistance from English language expert.

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