Development of a Next-Generation Web-Based Library System with Chatbot Integration and Data Analytics for Oriental Mindoro National High School

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Abstract—This study presents the development of a next-generation web-based library system designed specifically for Oriental Mindoro National High School. The system addresses common issues found in traditional manual library processes, such as slow transactions, inaccurate record-keeping, and limited access to library information. By integrating modern web technologies, QR-based book processing, automated catalog management, and chatbot assistance, the system enhances efficiency for librarians while providing students with a more accessible and user-friendly platform for locating and borrowing library resources. The project focuses on improving operational accuracy, reducing manual workload, and supporting students' research and reading needs through a responsive and data-driven library system.

Keywords— library management system, web-based system, chatbot, QR code, library automation, data analytics

Introduction

In many public secondary schools across the Philippines, including Oriental Mindoro National High School (OMNHS), the library plays an important role in supporting students' learning and research activities. Despite this, many school libraries still rely on traditional manual systems to manage their collections and services. As student numbers grow and academic demands become more complex, these old-fashioned processes slow down essential tasks like checking out books, tracking inventory, and helping students find the resources they need.

Manual operations often lead to problems such as long wait times, misplaced or lost records, and difficulties in maintaining accurate information. These challenges become especially clear during busy times, like research weeks or project deadlines, when students endure long lines and librarians struggle to keep up. While some schools have started using digital tools to improve their libraries, many existing systems are basic, lack useful features, and don't fully support librarians or students. This study proposes a web-based library management system designed specifically for OMNHS that goes beyond simple digitization. The system uses QR code scanning to speed up borrowing and returning books, and it incorporates data analytics to help librarians understand borrowing patterns, track overdue materials, and make better decisions about managing resources.

Additionally, an AI-powered chatbot will be available to provide assistance anytime, making the system more responsive and user-friendly. Together, these features aim to transform the library into a modern, accessible space that better serves the needs of students and supports library staff in their work.

Research Questions

1. How can a web-based library system improve the efficiency of managing book records, user accounts, and daily library transactions compared to the current manual process?
2. How can chatbot integration assist students in navigating the library system and provide quick responses to common inquiries?
3. How can QR-based features and real-time availability tracking improve the speed and accuracy of borrowing and returning procedures?
4. How useful are data analytics tools in helping librarians monitor book circulation, identify frequently borrowed materials, and generate reports for decision-making?
5. How do students and library staff evaluate the usability, accessibility, and overall functionality of the developed system?

Methodology

The researchers used Agile Software Development, working in short cycles that included planning, designing, prototyping, testing, and improving features. Librarians and students gave continuous feedback, helping shape the system step-by-step to meet their needs. This approach allowed quick adjustments and better collaboration throughout the project**.**

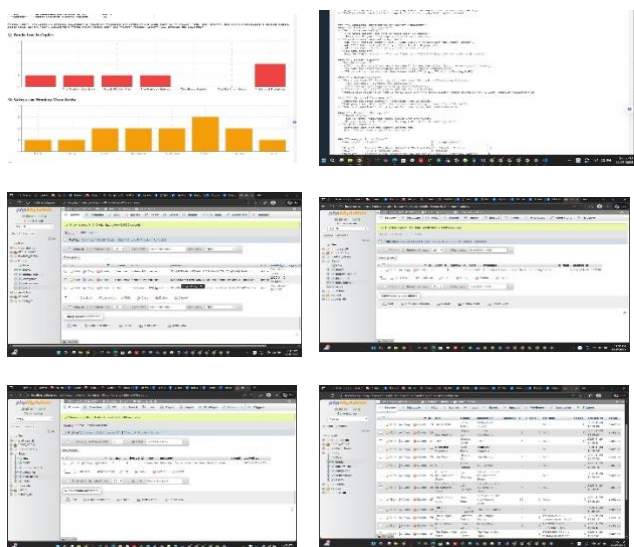**Datasets**

Figure 1. Datasets

Data Processing

Before applying data analytics, the researchers prepared and cleaned all datasets obtained from the Oriental Mindoro National High School Library. The data included book inventory records, borrowing history, user activity logs, and manually collected metadata.

The preprocessing steps involved

- standardizing category labels
- anonymizing student borrowing data for privacy
- converting date formats into a uniform structure
- organizing borrowing logs into a time-series dataset

After cleaning, the data was formatted into structured tables that allowed accurate generation of analytics and visual reports in the system.

Data Analysis Procedures

The processed data were analyzed to identify trends, patterns, and insights that could help improve library operations. The analysis focused on several key areas:

A. Usage Trend Analysis

Daily and weekly borrowing logs were examined to determine peak hours, busiest days, and periods with high borrowing activity. These insights help librarians plan better and ensure that resources are available when students need them most.

B. Popular Book Identification

Borrowing records were analyzed to identify the most frequently borrowed books and subjects. This allows the library to prioritize acquiring additional copies or updating popular materials to meet students' needs.

C. Overdue Monitoring

The system tracked overdue books to identify trends in late returns. Librarians can use this information to improve reminders, policies, or support for students who frequently return books late.

D. User Interaction Analysis

Logs of search queries, system navigation, and login activity were reviewed to understand how students interact with the system. This helps improve usability, making it easier for students to find and borrow books.

E. Catalog Accuracy and Availability

Updates to the book catalog were analyzed to ensure the system reflects real-time availability. This ensures students and staff have accurate information about the library's collection.

F. Visualization and Reporting

The analyzed data were presented using visual tools such as tables, bar charts, line graphs, and pie charts. Examples include:

- Most borrowed books and subjects
- Daily and weekly borrowing trends
- User activity distribution
- Overdue items summary

These visualizations help librarians quickly understand usage patterns and make data-driven decisions about resource allocation and inventory management.

Evaluation of Analytics

The effectiveness of the data analytics was assessed through feedback from librarians and selected students. They evaluated:

- Clarity and readability of graphs and reports.
- Accuracy of the insights compared to the actual library operations.
- Usefulness of the analytics for supporting library management.

Results and Discussion

Through the utilization of web-based technologies, QR code processing, chatbot integration, and data analytics, the developed library system demonstrated promising results in improving operational efficiency and user experience at Oriental Mindoro National High School.

The web-based library system was carefully evaluated to measure how well it managed book records, user accounts, and daily library activities.

Confusion Matrix Analysis

The Confusion Matrix provides a detailed summary of the AI decision-making accuracy within the library analytics module. It distinguishes between true positives (TP) and true negatives (TN), cases where the system correctly detected issues such as low-stock items, underrepresented categories, or format imbalances as well as false positives (FP) and false negatives (FN), where the system either raised an unnecessary alert or failed to identify an actual anomaly. In our evaluation, the model produced high TP and TN values, demonstrating that it reliably recognized valid inventory concerns while accurately confirming items that were in normal condition. Only a small number of FPs and FNs were observed, indicating minimal misclassification across all analytic checks. Overall, the system exhibited strong and dependable performance, with consistent accuracy in identifying genuine library inventory issues.

In addition, the performance of the developed library system was evaluated using a transaction and resource matrix designed for library operations, assessing how effectively the system manages book records, availability, overall collection balance. The matrix revealed several key insights: some categories have very limited titles, indicating the need for collection expansion; several books have low copy counts, requiring restocking; eBook availability is limited across only a few categories; and physical books still dominate the overall collection.
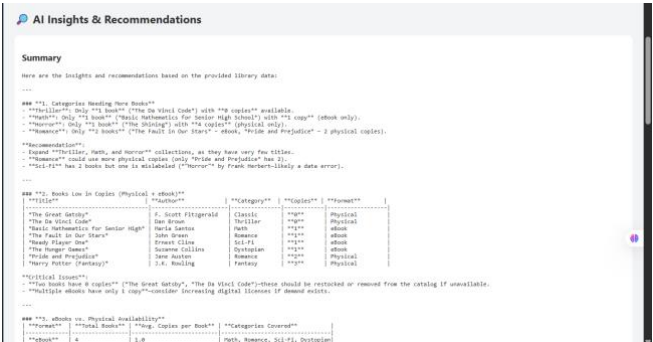
Figure 2. Insights and Recommendation

Data Accuracy

The system was evaluated using a Data Accuracy Rate to measure how consistently it recorded and processed library information such as book stocks, categories, and formats.
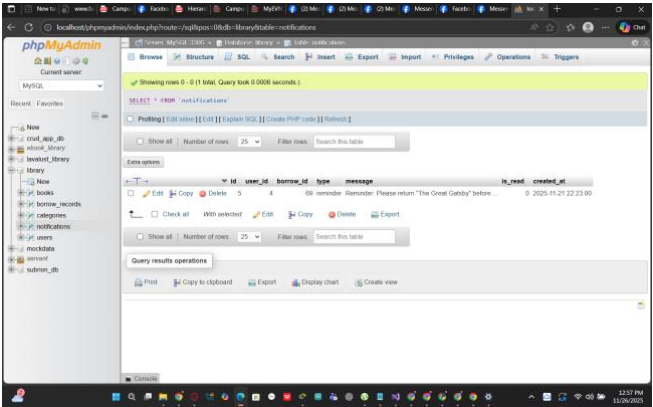

Figure 3. Database

The accuracy table illustrates how the system validates its analytic outputs by comparing processed data against the actual records stored in the database. This allows the researchers to check whether the system correctly identifies low-stock categories, missing copies, mislabeled entries, and format imbalances.
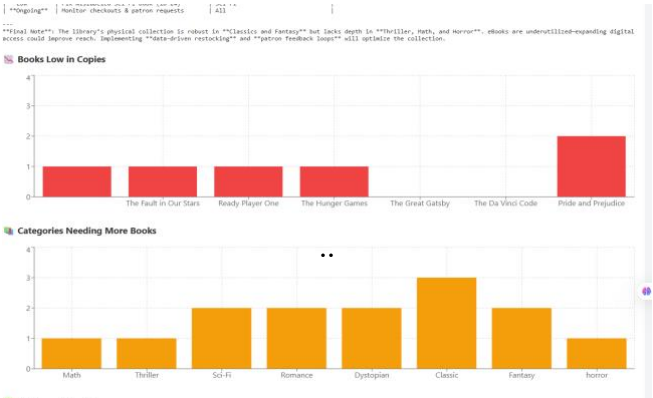

Figure 4. Overall Accuracy

The overall accuracy score represents how closely the system's generated analytics match the actual data stored in the library database. This metric was computed by comparing the system's detection of inventory issues such as low-stock categories, limited-copy books, format distribution, and mislabeled entries. This means that the system is reliable in identifying categories that need expansion, recognizing books with insufficient copies, detecting inconsistencies, and summarizing resource availability. The strong accuracy result confirms that the data analytics features are functioning as intended and can effectively support librarians in making informed, data-driven decisions about collection management and resource planning.

Conclusion

The results of the system evaluation show that the developed web-based library system successfully improved the way library records, book availability, and daily transactions are managed at Oriental Mindoro National High School. By combining QR code processing, chatbot assistance, and data analytics, the system made library tasks faster, more organized, and easier for both students and staff. The analytics features also gave librarians clearer insights into stock levels, category distribution, and usage trends, helping them make more informed decisions about restocking and managing the collection. Overall, the system proved to be reliable, user-friendly, and effective in addressing the common issues found in traditional manual library.

Recommendations

To further enhance the system, the researchers recommend adding more advanced analytics features such as demand forecasting, automated low-stock alerts, and a user preference tracker to help librarians plan future acquisitions. Expanding the chatbot's capabilities such as offering book recommendations or answering more complex queries and can also improve the user experience. Regular updates to the database, along with continuous feedback from students and staff,

will help keep the system accurate and aligned with the evolving needs of the school. Integrating mobile app accessibility or offline scanning options may also make the system more convenient for users.

Compliance With Ethical Standards

This study followed ethical guidelines throughout the system's development and evaluation. All data used for testing the system, including book records and library transactions, were handled responsibly and kept confidential. No personal or sensitive student information was exposed or used beyond the scope of the project. The datasets used for analytics were anonymized and processed in a way that did not compromise the privacy of any individual. The system was developed purely for academic and institutional improvement, with the intention of supporting better library services and improving resource accessibility for students. All procedures were carried out with transparency and respect for data privacy, ensuring that the system operates fairly, securely, and ethically.

References

[1] M. Aliyu, L. Mohammed, and I. Z. Yakubu, "A Smart QR: Based Library Management System," International Journal of Innovative Science and Research Technology (IJISRT), vol. 9, no. 10, pp. 714–719, Oct. 2024.

[2] I. G. S. E. Putra, I. M. T. Mahayana, and I. A. W. Dharmayasa, "Library Management Information System Based On Automatic Identifier QR Code and NFC," Int. J. Sci. Res. Comp. Sci. Eng., vol. 9, no. 5, pp. 14–19, Oct. 2021.

[3] A. Mukundrao Dani and R. N. Patil, "Smart Library using QR Code," International Journal of Scientific Research in Science and Technology (IJSRST), vol. 7, no. 4, pp. 01–04, Jul.–Aug. 2020.

[4] S. Pareek, "QR Codes Making Smart and Effective Library Services," DESIDOC Journal of Library & Information Technology, vol. 44, no. 3, pp. 168–175, May 2024.

[5] F. Alfiah and A. Setiadi, "Implementasi QR-Code pada Sistem Informasi Perpustakaan Menggunakan SLiMS dan Metode Agile," ICIT Journal, vol. 11, no. 2, pp. 186–196, Aug. 2025.

[6] R. D. Wijaya, N. A. Rozaq Rais, and S. Rokhmah, "The Implementation of a Web-Based Library Management Information System Using Barcodes at Al-Islam Vocational High School Surakarta: A Research and Development (R&D) Approach," Journal of Artificial Intelligence and Engineering Applications (JAIEA), vol. 4, no. 3, pp. 2488–2501, 2025.

[7] P. Bhati, Komal, Prince, and Stuti Saxena, "Modern Library Management System: A Web-Based Framework for Resource Automation and User Oversight," International Journal of Research – Granthaalayah, vol. 12, no. 6, 2024.

[8] A. S. Datta, M. Kundu, R. D. Choudhury, S. P., and Sreedevi V. T., "IoT Book Bot," 2022.

[9] T. Silwattananusarn and P. Kulkanjanapiban, "Mining and Analyzing Patron's Book-Loan Data and University Data to Understand Library Use Patterns," 2020.

[10] R. Universitas Rokania, N. Mulya, and I. Wulan Sari, "Web-Based Library Information System Application with QR Code Support (Case Study at SMK Negeri 1 Tambusai)," JUKOTI – Journal of Computer and Technology, vol. 1, no. 1, 2024.