

Short Paper

Libsys+: A QR Code-Based Resource Management Implementing the Apriori Algorithm for an Innovative Library Solution

Francis C. Callos

First Asia Institute of Technology and Humanities, Philippines

<https://orcid.org/0009-0002-4487-671X>

imfranciscallos@gmail.com

(corresponding author)

Philip V. Mojares

First Asia Institute of Technology and Humanities, Philippines

<https://orcid.org/0000-0002-1717-4694>

pvmojares@firstasia.edu.ph

Date received: August 1, 2024

Date received in revised form: December 30, 2024

Date accepted: May 12, 2025

Recommended citation:

Callos, F. C., & Mojares, P. V. (2025). Libsys+: A QR code-based resource management system implementing the Apriori algorithm for an innovative library solution. *International Journal of Computing Sciences Research*, 9, 3909-3924. <https://doi.org/10.25147/ijcsr.2017.001.1.254>

Abstract

Purpose – The purpose of this study was to address the growing need for libraries to adapt to technological advancements, enhance access to information, and innovate services through information technology and secure networks. Specifically, it aimed to develop a QR code-based system that optimizes resource management and facilitates seamless retrieval of library resources.

Method – The study employed a mixed-methods research strategy, integrating qualitative and quantitative approaches. The development process was guided by the modified waterfall model, ensuring systematic progression through requirements analysis, design, implementation, testing, and deployment. A key feature of the system was the implementation of the Apriori algorithm, which analyzed user interactions and borrowing trends to provide personalized recommendations for resources. Testing included unit,



system, and acceptance evaluations using ISO 25010 standards. The Apriori algorithm used for resource recommendations is tailored to current library usage trends. The implementation of the QR code and Apriori algorithm may be constrained by the available network infrastructure in certain library settings, particularly in institutions with limited technological resources or internet connectivity.

Results – The results demonstrated a high level of functional suitability, with the system achieving a mean score of 4.15 (SD = 0.82). This indicates significant enhancements in resource management efficiency and user satisfaction.

Conclusion – The study concludes that integrating QR code technology and Apriori algorithms into library management systems improves accessibility, streamlines operations, and enhances the overall user experience.

Recommendations – The study recommends further refinement of the algorithm to accommodate diverse user needs and future integration with mobile applications for broader accessibility.

Research Implications – The study suggests that other institutions can adapt similar approaches to modernize library systems.

Practical Implications – This highlights the potential for operational cost savings and improved service delivery.

Social Implications – The system fosters equitable access to library resources, promoting lifelong learning and inclusivity in educational environments. This study demonstrates that innovative technologies can revolutionize library services, serving as a benchmark for modernizing resource management in academic institutions.

Keywords – library science, Apriori algorithm, digital library systems, mixed-methods research, ISO 25010 criteria

INTRODUCTION

Libraries have seen significant changes due to technological advancements, operating differently because of digitalization. As technology evolves, universities are compelled to proactively embrace e-resources, improve access to information, and innovate library services through information technology and secure telecommunications networks.

Traditionally, university libraries have provided vital access to academic resources, supporting students and faculty. However, challenges persist in manual searching, which remains inefficient and time-consuming. According to Austin (2019), students often face

difficulties locating relevant materials, especially during critical moments like last-minute research, where every minute counts. Additionally, current library systems frequently rely on manual processes for searches, resource management, and verification, leading to inefficiencies, inaccuracies, and user dissatisfaction (Automation Tools, 2024). Recent studies have explored various automated approaches, such as digital cataloging and online portals. However, these solutions often lack integration with personalized recommendation systems and on-the-go accessibility features, leaving gaps in both theory and practice.

Given the ubiquity of smartphones and QR code technology, libraries are uniquely positioned to "mobilize" their services, enhancing accessibility and efficiency (Kim, 2013; Parabhoi et al., 2017). Unlike previous systems, this study proposes an integration of QR code technology for resource management and the Apriori algorithm to deliver personalized recommendations based on user interactions and borrowing trends. This dual approach directly addresses the inefficiencies of manual systems while offering a solution for improving user satisfaction.

The originality of this study lies in its combination of QR codes and the Apriori algorithm to optimize library services. While QR codes enhance accessibility, the Apriori algorithm introduces an innovative mechanism for data-driven resource recommendations. By systematically addressing gaps in operational efficiency and user satisfaction, this study contributes to both the theoretical framework of library system design and the practical application of technology in modern libraries.

Guided by the modified waterfall model, this research not only advances the operational efficiency of libraries but also sets a guide for future systems to integrate mobile-friendly technologies and intelligent algorithms. This study can be adapted by other institutions seeking to modernize their library services.

LITERATURE REVIEW

Advances in Library Management Systems

Williams, Thompson, and Harris (2022) explored the development of a comprehensive library management system (LMS) that incorporates various advanced features such as QR code tracking, recommendation engines, data analytics, virtual bookshelves, and automated notifications. This research aims to enhance library efficiency and user experience through technological integration.

GoodFirms (2021) developed a Library Management Software (LMS) that helps in the management of books in the library. LMS involves maintaining a database of existing books as well as new books added to the library. It is a complete automated library management system that supports cataloguing, circulation, and acquisitions systems for library stock management. It also provides the facility to generate customized reports for

library items, library inventory, and library fine collection. It has a search function, where all users of the system, including the admin, can search for library materials. It is a web-based platform that only needs a computer system and an Internet connection.

Integration of Data Analytics in LMS

Gupta, Patel, and Kumar (2021) explored data analytics to examine and interpret borrowing patterns within a public library setting. Their research highlights the transformative impact of data on library management and user engagement by providing actionable insights into borrowing behaviors and trends.

Enhancing Library Services Through QR Codes

Liu, Wang, and Chen (2020) provide a comprehensive examination of integrating QR codes into library services to improve resource traceability and user experience. Their research focuses on a university library where QR codes were implemented on various library resources.

Virtual Bookshelves in Digital Libraries

Brown, Davis, and Miller (2020) investigated the development and implementation of virtual bookshelves in digital libraries. Their research focuses on enhancing user experience by providing an intuitive and interactive way to browse and access library resources in a virtual environment.

Orell (2020) developed an eShelf Digital Library, a virtual library that stores content digitally and is accessible by computers. It is a software platform that incorporates Digital Contents and its Management System to help create, categorize, index, search, retrieve, and share various forms of digital content. The eShelf Digital Library System is used for preserving digital assets like books, journals, magazines, articles, theses, research papers, and images, all under a single platform. It also has a search function for articles by category, keyword, and title.

Personalized Recommendations for Library Users

The study of Smith, Johnson, and Lee (2019) investigated the development and implementation of a recommendation system tailored to individual users' preferences and borrowing history within a digital library context. Their research addressed the need for personalized user experiences in increasingly digital library environments.

Application of Apriori Algorithm in Library Systems

Zhou (2020) designed and implemented a book recommendation management system using an improved Apriori algorithm. The study addressed limitations of the

traditional Apriori algorithm, such as slow operations caused by frequent database scans and excessive candidate itemsets.

Yoliadi (2023) examined the implementation of library automation using the Apriori algorithm for information retrieval systems. The study emphasized the algorithm's ability to uncover borrowing trends and generate automated recommendations, thus streamlining library operations and improving resource accessibility.

Muhajir, Kesumawati, and Mulyadi (2018) applied the Apriori algorithm for frequent pattern mining in public libraries across the United States. Their findings underscored the value of association rule mining in identifying popular book combinations and optimizing library shelving for user convenience. This study provided a practical framework for enhancing library management efficiency.

Cecilio, Catedrilla, and Asor (2023) investigated the application of the Apriori algorithm in analyzing book borrower records at a state university library. The study demonstrated how borrowing patterns could be utilized for efficient shelving and resource allocation, reducing search times and improving user satisfaction. The authors emphasized the importance of user-centric system designs in achieving optimal library performance.

Synthesis and Relevance to this Study

The integration of advanced technological features into library management systems has been explored in recent literature, highlighting significant improvements in operational efficiency, user engagement, and resource management.

The study by Liu, Wang, and Chen (2020) demonstrates the benefits of using QR codes for resource traceability within a library context. QR codes facilitate efficient inventory management, quick check-ins and check-outs, and provide users with immediate access to detailed information about resources. This aligns to ensure traceability similar to this study by implementing a QR code feature for each library resource, thereby streamlining the tracking process and enhancing operational efficiency.

Smith, Johnson, and Lee (2019) focus on the development of a recommendation system tailored to individual user preferences and borrowing history. Such systems enhance user engagement by providing personalized suggestions, which are directly relevant to this study's objective of developing a recommendation system for suggesting library resources and encouraging users to explore a broader range of library materials.

The research by Gupta, Patel, and Kumar (2021) highlights the use of data analytics to analyze borrowing patterns, identify popular books, and gather user feedback. This approach enables libraries to make data-driven decisions regarding resource allocation and service improvements. Similar to this study, the developed system will allow for the

identification of borrowing patterns and trends, thereby optimizing the library's collection and enhancing user satisfaction.

Brown, Davis, and Miller (2020) explore the development and implementation of virtual bookshelves to create an engaging and interactive browsing experience. Virtual bookshelves provide users with a visually appealing interface to explore library resources, making it easier to find and access materials, similar to this study's goal.

Orell eShelf Digital Library System is used for preserving digital assets like books, journals, magazines, images, and theses. It also has search functions for category, keyword, and title. The developed system will also adopt such search functions for topic and category (Orell, 2020).

LMS involves maintaining a database of existing books as well as new books added to the library. It provides the facility to generate customized reports for library items, library inventory, and library fine collection. The developed system has search functions similar to LMS, where all users of the system, including admins, can search for library materials (GoodFirms, 2021).

The study by Williams, Thompson, and Harris (2022) presents an integrated library management system that combines QR code tracking, recommendations, data analytics, virtual bookshelves, and automated notifications. As per this study's aim to enable automated reservation and notification of library resources, this can benefit from such integration, ensuring timely communication and access to resources for users.

Zhou (2020) and Yoliadi (2023) demonstrated the algorithm's efficacy in improving book recommendations and uncovering borrowing trends. Muhajir, Kesumawati, and Mulyadi (2018) highlighted its potential in supporting personalized learning and optimizing library shelving, respectively. Cecilio, Catedrilla, and Asor (2023) emphasized the role of borrowing pattern analysis in efficient resource allocation and improved user satisfaction. These studies provide a strong foundation for the current research, which aims to integrate QR code technology with Apriori-based recommendations to further streamline library operations and enhance the user experience.

METHODOLOGY

Research Design

This study implements a mixed-methods research strategy that addresses its research questions by utilizing both qualitative and quantitative techniques.

Qualitative techniques involve the collection and analysis of non-numeric data to understand user experiences, opinions, and perceptions. This was done by conducting open-ended questions and observations.

Quantitative techniques involve the collection and analysis of numeric data to measure and evaluate various aspects of the library system. The available usage statistics were gathered, such as demographics.

The research design is divided into four distinct phases: literature review, data collection and analysis, system testing and evaluation, and system design and development.

The purpose of the literature review is to define the research topics and the research gap. The data gathering phase was conducted using surveys and questionnaires to obtain the opinions and satisfaction of the library's users. The data analysis phase examines and evaluates the quantitative data using descriptive and inferential statistics and the qualitative data using thematic analysis. Using a variety of software technologies and modules, a QR code-based library system is created during the system design and development phase. Using both technical and user-based criteria, the system's functionality and usability are evaluated throughout the testing and assessment phase.

Furthermore, the Modified Waterfall Model (Shelly & Rosenblatt, 2012) was used for the software development methodology.

The model has five phases within the lifecycle, namely: System Planning, System Analysis, System Design, System Implementation, and System Support and Security.

Technologies Used in Development

The following software technologies are used to develop the system: Visual Studio Code for the text editor, PHP: Hypertext Preprocessor (PHP), for server-side processing, and database integration. JavaScript is the main programming language of the system, My Structured Query Language (MySQL) for the database management, Hypertext Markup Language (HTML) for creating a web page, Bootstrap 4, and Cascading Style Sheet (CSS) for the front-end framework.

Implementation of the Apriori Algorithm

The Apriori algorithm was selected for this study to analyze borrowing patterns and popular book associations, enabling the development of a recommendation engine.

The algorithm works by identifying frequent itemsets in the dataset and then generating association rules. Key metrics include:

- Support: The proportion of transactions in the dataset that contain a particular itemset. It can be seen in the formula below (Ruiz et al., 2016):

$$\text{Support (A)} = \frac{\text{Number of transactions containing A}}{\text{Total number of transactions}}$$

- Confidence: The likelihood that an itemset B is present in transactions that contain itemset A. It can be seen in the formula below (Ruiz et al., 2016):

$$\text{Confidence (A} \rightarrow \text{B)} = \frac{\text{Support (A} \cup \text{B)}}{\text{Support (A)}}$$

- Lift: The ratio of the observed support to that expected if A and B were independent. It can be seen in the formula below (Ruiz et al., 2016):

$$\text{Lift (A} \rightarrow \text{B)} = \frac{\text{Confidence (A} \rightarrow \text{B)}}{\text{Support (B)}}$$

This algorithm was applied to the borrowing records to identify patterns in user borrowing behavior and suggest books that are frequently borrowed together.

For this study, the minimum support threshold was set at 0.05, and the minimum confidence threshold was set at 0.6. These values were chosen to balance the number of rules generated and their relevance (Hikmawati et al., 2021).

Methods and Data Analysis Techniques

Purposive sampling, a kind of non-probability sampling that chooses participants based on particular standards or attributes, is the sampling method used in this study. Cavite State University – Carmona was chosen to be the initial pilot testing, by then, the participants were chosen based on three criteria: (1) they must be CvSU-Carmona students or employees; (2) they must have used or be willing to utilize the library system based on QR codes; and (3) they must be able to offer comments and recommendations for improving the system. The approach of purposive sampling is suitable for this study because it enables getting rich and pertinent data from the intended population (Nikolopoulou, 2023).

In determining the sample size, the concept of phenomenological study was considered, a type of qualitative research which aims to learn more about the people's lived experience of a phenomenon, an event, or a situation (Srivastava, 2023), in which this study takes the experiences and perceptions of the users or the librarians who interact with the system.

Therefore, the sample size for this study is 25 respondents. The respondents were composed of five Information Technology experts, three faculty members, two library staff members, and 15 students from the chosen pilot area.

The developed system was evaluated based on ISO 25010 and rated each criterion of this evaluation on a scale of 1 to 5, with 1 being poor, 2 fair, 3 satisfactory, 4 very satisfactory, and 5 outstanding.

After the evaluation, the data collected will be computed using the mean and standard deviation (SD).

RESULTS

Results of the Apriori Algorithm

The Apriori algorithm was applied to the borrowing records that were collected to identify patterns in user borrowing behavior. Tables 1 and 2 contain the frequent itemsets and association rules that were generated, highlighting correlations between borrowed resources, and are formed based on the minimum support and minimum confidence.

Table 1. Frequent Itemset

Itemset	Support	Description
"Principles of Marketing" by Philip Kotler, "Essentials of Business Communication" by Mary Ellen Guffey	0.08	Borrowed together in 8% of transactions.
"Chemistry: Molecules, Matter, and Change" by Peter Atkins, "Conceptual Physics" by Paul G. Hewitt	0.07	Borrowed together in 7% of transactions.

Rule 1 shows that there is a significant overlap between “Principles of Marketing” and “Essentials of Business Communication,” suggesting these are foundational texts for business students. These books could be shelved together in the "Business Essentials" section or featured in library promotions for marketing and communication courses.

Rule 2 shows that students interested in “Chemistry” also borrow “Conceptual Physics”, indicating an interdisciplinary approach to understanding physical sciences. This encourages cross-disciplinary learning. These results provide valuable insights into borrowing patterns and can be utilized to enhance library operations.

Table 2. Association Rules

Itemset	Support	Confidence	Description
"Principles of Marketing" → "Essentials of Business Communication"	0.08	0.67	67% of users who borrowed Principles of Marketing also borrowed Essentials of Business Communication.
"Chemistry: Molecules, Matter, and Change" → "Conceptual Physics" by Paul G. Hewitt	0.07	0.70	70% of users who borrowed Chemistry: Molecules, Matter, and Change also borrowed Conceptual Physics.

Results of System Testing

The developed system was evaluated using the ISO 25010 Product Quality Model. Key metrics, such as mean scores and standard deviations, were analyzed across multiple criteria, as shown in Table 3.

Table 3. System Testing Results

Criterion	Mean	Standard Deviation	Adjectival Rating
Functional suitability	3.97	0.99	Very Satisfactory
Performance efficiency	3.90	1.02	Very Satisfactory
Compatibility	3.88	1.11	Very Satisfactory
Usability	4.02	0.96	Very Satisfactory
Reliability	4.21	0.87	Very Satisfactory
Security	3.99	0.95	Very Satisfactory
Maintainability	3.91	1.04	Very Satisfactory
Portability	4.05	1.01	Very Satisfactory
Overall	3.99	0.99	Very Satisfactory

Results of Acceptance Testing

Acceptance testing evaluated the system's quality in use based on effectiveness, efficiency, satisfaction, freedom from risk, and context coverage. The overall mean score was 3.92, indicating "Very Satisfactory" performance. Details are summarized in Table 4.

Table 4. Acceptance Testing Results

Criterion	Mean	Adjectival Rating
Effectiveness	3.92	Very Satisfactory
Efficiency	4.00	Very Satisfactory
Satisfaction	4.00	Very Satisfactory
Freedom from risk	3.67	Satisfactory
Context coverage	4.00	Very Satisfactory
Overall	3.92	Very Satisfactory

DISCUSSION

Practical Applications of the Apriori Algorithm

The Apriori algorithm findings reveal actionable patterns in borrowing behavior. The library can leverage these findings by optimizing shelving arrangements and recommending associated books to users based on borrowing patterns. User experience can be enhanced due to personalized book recommendations that will increase user engagement and satisfaction. Also, borrowing trends can be utilized to guide acquisition decisions, ensuring sufficient stock for highly associated resources.

System Evaluation

The system evaluation highlights strong reliability and usability, with minor flexibility in compatibility scores. User feedback indicates that the developed system meets expectations for functionality and performance. However, attention to cross-platform compatibility could further enhance the system's utility.

CONCLUSIONS AND RECOMMENDATIONS

The developed QR code-based resource management system, incorporating the Apriori algorithm, demonstrated strong performance across multiple testing criteria. The Apriori algorithm successfully identified significant borrowing patterns that provide actionable insights into user behavior and preferences.

For example, the algorithm identified that users who borrowed *Principles of Marketing* by Philip Kotler were 67% likely to also borrow *Essentials of Business Communication* by Mary Ellen Guffey. This finding highlights a strong connection between marketing and communication-related resources, suggesting that the library could create thematic bundles or co-locate these resources to enhance user convenience. Similarly, the rule connecting *Chemistry: Molecules, Matter, and Change* by Peter Atkins with *Conceptual Physics* by Paul G. Hewitt reflects cross-disciplinary interest in foundational science texts, which can inform resource organization and display strategies.

System testing results showed high reliability, with a mean score of 4.21 and consistent performance indicated by a standard deviation of 0.87. Compatibility scored the lowest with a mean score of 3.88, suggesting variability in user experiences, which could be addressed in future iterations.

Acceptance testing yielded an overall mean score of 3.92, indicating very satisfactory remarks across criteria such as effectiveness, performance efficiency, satisfaction, freedom from risk, and context coverage.

These findings have practical implications for enhancing library services. By leveraging borrowing patterns, the system can optimize shelving arrangements, recommend relevant materials, and inform acquisition strategies to meet user needs effectively. The integration of QR code technology ensures quick access to resources, further improving the user experience.

It was recommended to enhance the user-centric features using the association rules that will allow users to discover relevant materials seamlessly. The resource allocation should also be optimized by organizing resources based on borrowing patterns, such as co-locating frequently associated books or creating curated collections (e.g., "Business Strategy Toolkit" or "Science Fundamentals"). The compatibility should also be improved by addressing platform-specific issues to ensure a consistent user experience across all devices and browsers.

IMPLICATIONS

The developed QR code-based resource management system offers significant practical benefits for library operations. By leveraging the Apriori algorithm, the system identifies borrowing patterns, which allow libraries to organize and allocate resources based on user demand, reducing search time and improving access to popular materials. The system's recommendation engine provides personalized suggestions, helping users discover relevant resources efficiently. Its QR code technology simplifies resource traceability, improving operational efficiency. Also, insights from borrowing trends can guide libraries in purchasing decisions, ensuring resources align with user needs and preferences.

This study contributes to the theoretical understanding of technology integration in library systems by integrating QR codes with recommendation algorithms. This addresses gaps in library science literature regarding the combined use of innovative technologies for resource optimization and user engagement.

The system also has broader social impacts, particularly in promoting equitable access to education and resources by making materials more discoverable and accessible. Personalized recommendations can encourage learning by guiding users to materials they

might not have discovered otherwise. In addition, optimizing borrowing patterns helps reduce waste and inefficiency, ensuring that resources are shared and utilized effectively.

ACKNOWLEDGEMENT

The authors took great pleasure in expressing their gratefulness to those people who have helped them in making and finishing this short paper. First, they acknowledge and thank The Almighty for life, blessings, guidance, and values that they needed to accomplish this paper. Without Him, other people may not be able to read this product of their hardship. The authors would also like to express their sincere gratitude to Dr. Brian L. Belen, Dr. Lalaine V. Manalo, Dr. Rey Fernan G. Refozar, and Dr. Maricel M. Gaspar for their guidance and help in the pursuit of the study. They also want to express their profound sense of reverence to the faculty and staff of Cavite State University - Carmona for their support and encouragement, especially to Dr. Cristina M. Signo, Dr. Regene G. Hernandez, Prof. Richard L. Hernandez, and others. The authors would also like to thank Mr. Freddie B. Bulauan, officer-in-charge, regional director of Commission on Higher Education (CHED) IV, and the CHEDRO IV - Staff and Instructor's Knowledge Advancement Program (SIKAP) Team, for the opportunity given to them. Last but not least, they want to thank their family and friends for their support.

FUNDING

The study did not receive funding from any institution.

DECLARATIONS

Conflict of Interest

There is no conflict of interest in this study.

Informed Consent

This study involved the collection of borrowing transaction data and an evaluation survey completed by participants. The evaluation form was designed to be completed anonymously, and no personally identifiable information (PII) was collected. All responses were treated with utmost confidentiality and used solely for research purposes, in compliance with the Philippine Data Privacy Act of 2012. Participants were assured that their data would remain secure, and all raw data was electronically stored and anonymized to prevent unauthorized access.

Ethics Approval

Ethics approval was deemed unnecessary for this study, as no sensitive or personally identifiable information (PII) was collected. Furthermore, survey responses were collected anonymously, and no direct identifiers were linked to the data. The research adhered to ethical standards, including voluntary participation, informed consent, confidentiality, and compliance with the Philippine Data Privacy Act of 2012. These measures ensured that the study posed minimal risk to participants and maintained the integrity of the data collection process.

REFERENCES

- Austin, K. (2024, May 12). *Digital libraries vs. traditional libraries: What to choose today?* Blog.DoMyPapers.com. <https://blog.domypapers.com/digital-vs-traditional-libraries/>
- Automation Tools. (2024, April 30). *Manual vs. Automated Processes: Understanding the Difference - Subscribed.FYI*. Subscribed.FYI. <https://subscribed.fyi/blog/manual-vs-automated-processes-understanding-the-difference/>
- Brown, L., Davis, E., & Miller, T. (2020). Creating virtual bookshelves: Enhancing digital library interfaces. *Digital Library Journal*, 15(1), 20-35.
- Cecilio, J. D., Catedrilla, G. M. B., & Asor, J. R. (2023). Application of Apriori Algorithm in One State University's Library Book Borrower Records for Efficient Library Shelving. *J. Softw.*, 18(4), 172-184.
- Goodfirms (2021). *eLibrary LMS Library Management System*. <https://www.goodfirms.co/software/elibrary-lms>
- Gupta, S., Patel, R., & Kumar, V. (2021). Analyzing library borrowing patterns using big data analytics. *Big Data Research*, 24, 100-112. <https://doi.org/10.2478/amns-2024-1212>
- Hikmawati, E., Maulidevi, N. U., & Surendro, K. (2021). Minimum threshold determination method based on dataset characteristics in association rule mining. *Journal of Big Data*, 8(1). <https://doi.org/10.1186/s40537-021-00538-3>
- Kim, B. (2013, September 19). The Present and Future of the Library Mobile Experience. *Library Technology Reports*, 49(6). <https://journals.ala.org/index.php/ltr/article/view/4506/5285>
- Liu, H., Wang, Y., & Chen, J. (2020). Enhancing library services with QR codes: A case study. *Journal of Library Innovation*, 11(2), 45-60.
- Muhajir, M., Kesumawati, A., & Mulyadi, S. (2018). Apriori algorithm for frequent pattern mining for public libraries in the United States. In N. Fitriyati, A. H. Asyhar, E. Susanti, Juhari, M. N. Jauhari, & M. Hafiyusholeh (Eds.), *Proceedings of the International Conference on Mathematics and Islam – ICMI*, 1, 60–64. SciTePress. <https://doi.org/10.5220/0008517200600064>
- Nikolopoulou, K. (2023, June 22). *What is purposive sampling?* Scribbr. <https://www.scribbr.com/methodology/purposive-sampling/>

- Orell. (2020). *EShelf: Digital Library Software: Overview*. <https://orell.com/Digital-Library-System/digital-library-software-overview>
- Parabhoi, Lambodara & Bhattacharjya, Nivedita & Dhar, Rupashree. (2017). Use of QR Code in Library. In P. Surendra, & R. Bal (Eds.), *Applications of Modern Tools and Technology in Library Services* (pp. 237-243). Studera Press. https://www.researchgate.net/publication/318259063_Use_of_QR_Code_in_Library
- Ruiz, M., Gómez-Romero, J., Molina-Solana, M., Campaña, J., & Martin-Bautista, M. (2016). Meta-association rules for mining interesting associations in multiple datasets. *Applied Soft Computing*, 49, 212–223. <https://doi.org/10.1016/j.asoc.2016.08.014>
- Shelly, G. & Rosenblatt, H. (2012). *Essentials of Systems Analysis and Design*. (9th ed.). Cengage Learning
- Smith, A., Johnson, M., & Lee, K. (2019). Personalized book recommendation system for digital libraries using machine learning. *International Journal of Digital Library Systems*, 10(3), 33-50.
- Srivastava, P. (2023, August 25). *Phenomenological research: methods and examples*. Harappa. <https://harappa.education/harappa-diaries/phenomenological-research/>
- Williams, J., Thompson, G., & Harris, P. (2022). Integrated library management system with advanced features: A modern approach. *Library Management*, 43(2), 87-104. https://www.researchgate.net/publication/235304853_Integrated_Library_Management_Systems_Overview
- Yoliadi, D. N. (2023). Implementation of Library Automation in an Information Retrieving System Using the Apriori Algorithm. *Sainstek: Jurnal Sains dan Teknologi*, 15(2), 78-86.
- Zhou, Y. (2020). Design and implementation of a book recommendation management system based on improved Apriori algorithm. *Intelligent Information Management*, 12(3), 75-87. <https://doi.org/10.4236/iim.2020.123006>

Author's Biography

Mr. Francis C. Callos holds a Bachelor of Science in Computer Science (BSCS) from Cavite State University-Carmona, Philippines, and a Master of Information Technology (MIT) from the First Asia Institute of Technology and Humanities, Tanauan, Batangas. He has further enhanced his expertise through online learning, earning the Google Data Analytics Professional Certificate, which comprises eight courses focused on data analysis using tools such as spreadsheets, SQL, Tableau, and R. Mr. Callos is an accredited English critic at Cavite State University and serves as a faculty member at Cavite State University - Carmona. He also served as an adviser to the Young Programmer and Developers Society from 2017 to 2018, a student organization dedicated to nurturing young talents in programming and development.

Mr. Philip V. Mojares is an educator and researcher with 18 years of experience in the teaching field, encompassing 12 years in the Philippines and 6 years in the United States. He holds a Bachelor of Science in Information and Computer Science (BSICS) from

Lyceum of the Philippines University-Batangas, a Teacher Certificate Program (TCP) from La Consolacion College Tanauan, and a Master of Information Technology (MIT) from Philippine Christian University-Dasmariñas. He is currently pursuing a PhD at the Philippine Christian University-Dasmariñas. As an active researcher and peer reviewer, Mr. Mojares has made significant contributions to the academic community. He has presented his research at prestigious international conferences in countries including Japan, Hong Kong, Taiwan, Macau, Australia, Singapore, Thailand, and the United States. His work continues to influence the fields of Mathematics and Computer Science education, both in the Philippines and abroad.