



## Smart Library Automation: Integrating Classification Tree-Based cataloging with XAMPP Server Environment

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**Abstract:** Various sectors, including libraries, have experienced a revolution due to the swift progress of technology. This involves introducing automation and monitoring systems for more efficient operations. Hence the study Smart Library Automation and Monitoring System as an appropriate solution for these technological advancements. The proposed system integrates cutting-edge technologies to create a smart interconnected library ecosystem. Object Oriented Design Methodology was used as the software engineering technique, the proposed system leverages classification tree-based cataloging, a hierarchical organization method that enhances the accessibility and navigability of library collections. JavaScript, PHP, HTML, CSS, and XML technologies are integrated to develop an intuitive and interactive user interface for the library management system, XAMPP was later used as local server environment to utilize the automation. The system boasts various advanced functions, such as automatic lending and returning of books, shelf monitoring, and cataloging for resource accessibility assurance. By integrating these features into a comprehensive library management solution, it enables proficient utilization with intellectuality sustainability on par with the modern digital era standards.

**Keywords:** Smart Library, Web, PHP, Design, Management.

### 1. INTRODUCTION

Digital technologies have brought about significant changes in different spheres of human life, including how people access, save and disseminate information. In the academic field, traditional libraries are gradually being supplemented or even substituted by e-libraries- digital resources that provide a broad range of materials accessible from remote locations without regard to physical limitations like time and space. Therefore, an understanding of their origin is essential if we hope to grasp their relevance in present-day society.

In the mid-1900s, computers revolutionized library services by shifting their focus from simply storing materials to offering information-based assistance. This led to a new type of service that emerged in the 20th century - one which provided electronic accessibility to resources.

Virtual library services refer to services delivered through specific websites accessible on the internet, offering integrated access to various databases. According to Gavit [6], Web Based Library Services are primarily provided through the library portal, which is a unique kind of gateway to web-based library resources. It offers integrated access to the metadata of a library's numerous databases. Virtual Library Services can be referred to as Digital Library Services, Web Based Library Services or Electronic Library services.

According to Araya & Mengteab [3] the physical library frequently encounters obstacles due to poor management practices. Many inaccuracies in record keeping arise from human error, including misplacing or damaging hand-written documentation caused by inefficient handling processes. Virtual library services offer users the convenience of accessing information at their convenience, eliminating the need for physical travel and expanding the options for addressing reference questions. These services are not restricted by traditional opening hours and can be available around the clock.

Web-based services are established for several key reasons: "Ensuring that user needs and accessible information sources are consistently well-matched; Timely and appropriate delivery of information sources to users; Guaranteeing the quality, accuracy, and appropriateness of provided information; Offering assistance to users in interpreting materials, when necessary; Promoting user awareness of emerging services and information sources; Providing personalized guidance and support to help users enhance their information research and application skills." Sangale [15]

In recent times, advancements in digital technology have enabled the digitization and online presentation of materials. People have unlimited information at their fingertips in these modern times because of computers. Today, the importance

that a computer commands has influenced the different activities of businesses, institutions, and governments, as well as individuals for their activities. This will fit the guidelines that will focus out the internet being a necessity especially for education and research. Many educational institutions worldwide have already adopted digital and predominantly web-based libraries.

A prime example of a web application is the World Wide Web library. Web applications have gradually replaced standalone applications due to the advantages they offer. Digital libraries existed long before the internet in the Western world, but the numerous advantages of web-based digital libraries have made them the preferred technology among today's students.

## 2. LITERATURE REVIEW

The origins of virtual libraries can be traced back to the early stages of the internet and the digitalization of library catalogs. In 1971, the Online Computer Library Center (OCLC) introduced the first online catalog, named WorldCat, which allowed users to search for and access bibliographic records from a distance Dewey [5]. This marked the inception of this transformation.

The shift from manual to computerized library systems marked a significant turning point in the libraries' evolution. The previous methods entailed laborious responsibilities, including card cataloging and manually monitoring circulation, leading to restricted accessibility to resources. However, with the introduction of computer technology, these procedures underwent revolutionary changes that considerably increased efficiency while providing enhanced user experience.

Adebayo [1] notes that the automation of library procedures began in the 1980s and 1990s, resulting in an increased adoption of Integrated Library Systems (ILS). These systems enabled librarians to work more efficiently compared to previous methods. In the early 1970s, Online Public Access Catalog (OPAC) genre appeared but its earliest versions were quite limited and served as a complement to circulation modules – which are now ILS' precursor still employed today Nahotko [11].

The development of library management systems has been significantly impacted by technological advancements, and one prominent example of this progress is the Koha Library Management System. The name Koha comes from a Māori term for a gift or donation. Koha represents a significant leap from traditional manual library management practices to sophisticated, technology-driven solutions that redefine the way libraries operate and serve their users Koha [10].

Niranjana, Tolessa & Paul [12], in their study "Implementation of Koha Integrated Library Management System in Wollega University Main Library, Nekemte, Ethiopia" investigate the technical setup, Koha library software installation, customisation process, and data migration process in the Wollega University Library. The library began implementing all of Koha's modules, including cataloging, serial control, OPAC, and others, in May 2017. The Koha version 17.05 was upgraded to Koha 19.05 in September 2019, which incorporated the novel feature of "email notification for users."

Mageto [10] examines how the education industry is evolving due to various factors such as policy changes, innovation, technological advancements in infrastructure and challenges presented by COVID-19 pandemic. In his study titled "Design and Development of E-Library System: COVID-19 Pandemic Challenges", Mageto [10] proposes using Information and Communication Technologies (ICT) integration into library services for improved efficiency, security and quality towards addressing these changes implemented so far. The research aims to address issues with existing library systems by designing and developing a prototype. This prototype will manage various library tasks, including appointments, lending, reserving, returning, payment processing, book record storage, information provision, and invoice processing. To enhance security, the passage mentions encryption and access control measures.

Additionally, it highlights the adaptability of the system to different network conditions. In areas with connectivity issues, high internet costs, or poor infrastructure, the system plans to use offline web services, connecting only when necessary. Finally, the development methodology employed for creating this electronic library system is identified as the "spiral development methodology." This methodology typically involves iterative cycles of development, allowing for continuous refinement and adaptation as the project progresses.

Chiagunye, Nwachukwu-nwokefor, & Udeani [4] created a Web-based Digital Library Management System (DLMS) for their research that allows for the simultaneous creation of an infinite amount of digital information and public accessibility. The system is made to gather research materials for the organisation and then disseminate them to users in faraway locations.

The website also includes the following elements in addition to the home page: Organogram, Uploads, Repository, Online gateway, and Feedback. Java, PHP, and HTML are the design criteria, and MySQL is the database type. It is intended to be a method for managing interactive content. While a content management system handles data entry, validation, and changes, an interactive system engages users in conversation.

Alarape, & Edet [2] explain that an e-library system is a crucial component of modern libraries in the internet age. Without such a system, libraries may face significant challenges, including a lack of adequate user visitation. Their paper presents an e-library system developed using PHP for programming, HTML and CSS for design, and MySQL for the backend database. The system runs on the Apache v3.21 application server and is accessible via the Mozilla Firefox web browser. This e-library system allows users to access multimedia resources and addresses issues prevalent in traditional libraries, such as unavailability of resources, inadequate space, physical constraints, and restricted access.

Gbaje's [7] highlights the negative impact of inadequate information resources on education, research, and development in Nigerian academic libraries. In response to this issue, the government has taken steps towards improvement through

initiatives such as National Virtual Library programs and policies promoting access to current information for teaching and learning. The implementation of a virtual library enables online accessibility to vast amounts of scholarly content while also providing valuable solutions across higher educational institutions.

In her study on cataloging change management, Yusuf [16] identified several strategies for managing changes in cataloging practices. These include outsourcing, purchasing of ICT solutions, employing systems engineers within library staffs, attending workshops and conferences as well as exchanging/attaching staff to reputable libraries. Others are enhancing supervision over non-professional copy catalogue employees and mandating new hires to complete a competency assessment that focuses on cataloging principles. Before starting a digitalization project, careful preparation is absolutely essential. Planning is essential and serves as the road map for successful digitization. The aim will be more easily attained by establishing explicit goal policies and making sure that the necessary resources (both material and manpower) are available for digitalization. Therefore, planning is essential for any new endeavor, and digitization is no exception.

Additionally, the workload and project expenses greatly rely on the resources already available at each library. Costs can be decreased, as demonstrated through cooperative networks. Retrospective conversion projects can be successfully lightened with the use of national and worldwide library collaboration, enabling more rapid and efficient development.

In data mining, data classification algorithms are commonly used to separate data into distinct groups. The goal of machine learning is to teach a computer to learn from a variety of training and testing datasets, determining its own outcomes in each scenario without the need for explicit programming. Decision Trees are one machine learning technique. Decision Tree algorithms are employed in a variety of industries and applications. These algorithms can be utilized in search engines, medical certified fields, text extraction, and replacement statistical techniques to find data. Various decision tree algorithms have been developed based on the accuracy and effectiveness cost.

Patel & Prajapati [13] in their paper, studied and analyze the ID3, C4.5, and CART decision tree algorithms. Classification is defined as the process of assigning objects to groups that have a wide range of potential uses. They concluded that CART executes algorithms in 0.5 seconds, ID3 in 0.02 seconds, and C4.5 in 0.06 seconds. CART has the slowest execution rate, while ID3 has the fastest.

While CART is the slowest algorithm—it takes far longer than the others—it has the best accuracy and produces results that are far more exact than those of ID3 and C4.5. It leads to the conclusion that, after comparing the three algorithms, the CART is the best option.

Priyam, Abhijeet, Anju, & Saurabh [14], in their investigation of three decision tree algorithms that are currently in use (ID3, C4.5, and CART) and applied to educational data in order to forecast exam success. In order to forecast a student's performance on the final exam, all algorithms are applied to the student's internal assessment data. The accuracy and time required to derive the tree can be used to compare the relative efficiency of different decision tree algorithms. The tutor has been able to identify the weaker students and help them do better thanks to the system's forecasts. Of the three methods, C4.5 offers the most accuracy and efficiency, making it the ideal choice for small datasets. When the training data is big, the serial decision tree algorithm's (ID3, C4.5, and CART) primary drawback is its poor classification accuracy. However, all of these are limited to tiny datasets and necessitate the permanent storage of all or part of the dataset in memory. Their use for mining over big databases is thus limited.

### 3. MATERIALS AND METHOD

This paper utilizes object-oriented design (OODM) as the software engineering technique. In line with this system development approach, an information system is made up of a networked group of objects that collaborate to perform tasks. Conceptually speaking, there are no individual processes, data items or files involved. There are elements operating in the system. Anything that can respond to messages in a computer system is referred to as an object. There are two primary categories of OODM:

- i. Object-Oriented Analysis: In software, the aim of analysis exercises is to generate a model that outlines the functional requirements of systems without being limited by implementation restrictions. These models isolate and describe essential entities with their distinct relationships and methods required to resolve issues at hand.
- ii. Object-Oriented Design: The focus lies on constructing a system's object-oriented model that can support the outlined demands. The analyst and programmers should shift their thought process from functions or processes to objects for optimal results.

#### 3.1 Cataloging Library Materials using Classification Tree

The hierarchical arrangement of library materials into subject categories is done through a classification tree. This tool enables cataloguers to allocate accurate classification numbers, which facilitates the organization of books on shelves and in the catalogue system.

To catalogue library materials using a classification tree, the cataloguer first determines the main subject of the material. Once the main subject has been identified, the cataloguer can use the classification tree to find the appropriate subject category. Once the subject category has been found, the cataloguer can assign the material a classification number.

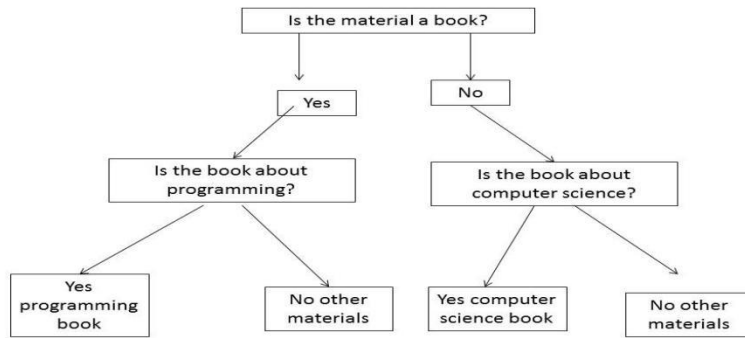


Figure 1: Cataloging library materials using classification tree

### 3.2 Description of the Proposed System

The Smart Library Automation System is an online system proposed to be utilized solely by the library users to up the service capacity level availed through the libraries when offering access to their facilities.

#### 3.2.1 Overview of the programming language to be used

PHP is a programming language utilized for server-side development. Similar to other languages used by developers, PHP enables the manipulation of data sent from web browsers and assists in generating logical website content. Additionally, it boasts multiple extensions that streamline database connections, retrieval of information displayed on pages and inputted by users back into databases.

PHP is comprised of a scripting language and an interpreter. By using PHP, web developers can dictate the desired behavior and logic for their webpage similarly to other script languages. HTML documents with incorporated scripts are served by the web server while the interpreter acts as a module communicating with it in order to translate those scripts into commands that prompt computer actions resulting in outcomes aligned with what was specified in the initial developer's script.

#### 3.2.2 Features of PHP

PHP, also known as Hypertext Preprocessor, is an open-source scripting language extensively utilized for crafting websites. Its popularity stems from the myriad of capabilities that aid in developing dynamic web applications with ease and flexibility. One key reason why it has gained widespread adoption among developers globally is its simplicity compared to other programming languages.

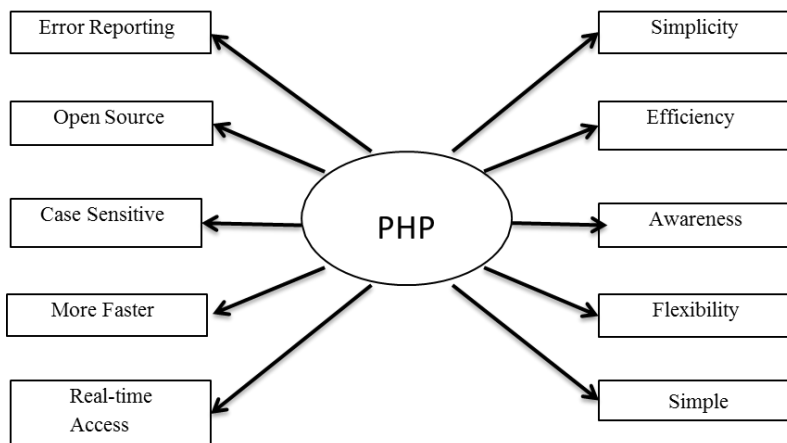


Figure 2: Features of PHP

More detail is given for some of the features of PHP below:

- i. Open Source: PHP is free and open-source, making it available to a sizable development community. As a result, PHP now has access to a vast library of tools, frameworks, and extensions.
- ii. Server-Side Scripting: The most popular server-side scripting language is PHP. The dynamic production of web content is made possible by its execution on the web server and the transmission of the results to the client's web browser.

- iii. Cross-Platform Compatibility: PHP is capable of functioning on a number of OS, including Windows, Linux, macOS, and others. It works with many different web servers, such as Apache, Nginx, and Microsoft IIS.
- iv. Platform Independent: PHP code will be run on every platform, Linux, Unix, Mac OS X, Windows.
- v. Case Sensitive: When declaring variables in PHP, the scripting language is case sensitive. However, it should be noted that keywords (such as if, else, while and echo), classes and functions - including those defined by users - are not case-sensitive within PHP code.
- vi. Support for Web Standards: PHP facilitates the creation of web applications that adhere to a variety of web standards, including HTTP, HTML, XML, and more.
- vii. Extensive Library Support: Support for a wide range of libraries and extensions is provided via Composer and the PHP Extension Community Library (PECL), which also offers a robust standard library. These libraries help developers add functionality rapidly and simplify difficult jobs.
- viii. Ease of Learning: PHP features a plain syntax that is forgiving and simple to learn for developers, especially for those with expertise using C-style languages.
- ix. Large Community: The developer community for PHP is large and vibrant, which means there are a lot of online resources, forums, and groups where developers can get assistance, exchange expertise, and work together.

### 3.2.3 System design

For the system's backend programming language, a scripting language (PHP) was chosen as the best technique, and it was supported by the following technologies: HTML, JavaScript, and Bootstrap. These additional technologies are intended to aid in the creation of a responsive, user-friendly system that accommodates all screen sizes.

Tools used in developing the system

i. MySQL

The database utilized in the creation of the web-based e-library system is MySQL, a relational database management system. When necessary, it stores, retrieves, and manipulates data entries. It is the recommended option for the construction of a system like this because it is open source and has a very strong support community.

ii. JavaScript

Computers benefit from JavaScript's adaptable programming language, frequently utilized on web pages for dynamic page creation and client-side communication with users. Supporting object-oriented programming while interpreted, the technology was initially called LiveScript before being renamed by Netscape as JavaScript – possibly due to Java hype. Browsers such as Internet Explorer have integrated this widely-used core since its 1995 debut in Netscape version two-point-zero.

Advantages of using JavaScript include:

- i. Less interaction with the server since user input may be verified before the page is sent to the server. This reduces server traffic, resulting in less burdens on your server.
  - ii. Providing visitors with immediate feedback: They do not have to wait for a page to reload to see whether they have neglected to enter something.
  - iii. Enhanced interactivity: Increased interactivity can be achieved by creating user interfaces that react to mouse movements or keyboard input from the users.
  - iv. Richer interfaces: To enhance the user experience of your website, incorporating elements such as drag-and-drop components and sliders can be achieved through utilizing JavaScript. This ultimately creates a richer interface for site users.
- iii. XAMPP

Javapoint [9], Apache Friends developed XAMPP, a cross-platform web server solution stack that is both free and open source. It gets its name from the collection of components it includes: "X" stands for cross-platform compatibility while the other letters denote each component in the bundle:

X - Cross-platform: XAMPP is compatible with various operating systems, including Windows, Linux, and macOS.

A - Apache: It includes the Apache HTTP Server, one of the most popular and widely used web servers in the world. Apache serves as the foundation for hosting websites and web applications.

M - MariaDB: XAMPP comes with MariaDB, a community-developed fork of MySQL. MariaDB is an efficient system for managing relational databases, which enables the storage and management of data in web-based applications with robustness.

P - PHP: PHP is a server-side scripting language used for developing dynamic web pages. XAMPP includes PHP to enable the execution of server-side scripts and the creation of dynamic web applications.

P - Perl: Perl is a programming language known for its text processing capabilities. While not as commonly used in web development today, it remains part of the XAMPP stack and can be utilized for various scripting tasks.

Key Features and Components of XAMPP includes;

Easy Installation: XAMPP is designed to be easy to install and configure, making it suitable for developers, students, and hobbyists who need a local development environment.

Local Server Environment: XAMPP provides a complete local server environment, allowing users to develop and test web applications on their own machine before deploying them to a live server.

Development Tools: In addition to Apache, MariaDB, PHP, and Perl, XAMPP includes other tools and libraries such as phpMyAdmin (for database management), FileZilla (FTP server), and Mercury Mail (email server).

Versatility: XAMPP is versatile and can be used for various web development projects, including content management systems (CMS), e-commerce platforms, and custom web applications.

Open Source: Being open source, XAMPP encourages collaboration and community contributions. Developers can modify and extend the stack to meet their specific needs.

### 3.3 Software Requirements

- i. Operating system (Android, windows, MAC)
- ii. Web browser (chrome or Firefox Mozilla etc)

### 3.4 Hardware Requirements

- i. 2.00 GB RAM or higher
- ii. 2.13GHz dual core or higher processor
- iii. 3G/EDGE/Wi-Fi internet connectivity
- iv. PC's, smart phones and other web compatible devices.

### 3.5 Database Schema

A database schema is a plan or visual representation of the logical and physical arrangement of a database. It determines how information is structured, stored, and retrieved in a database management system (DBMS). The schema contains details about tables, columns, connections between tables, limitations, and other essential components for defining and administering the database. The diagrams below represent the logical schema of the smart library.

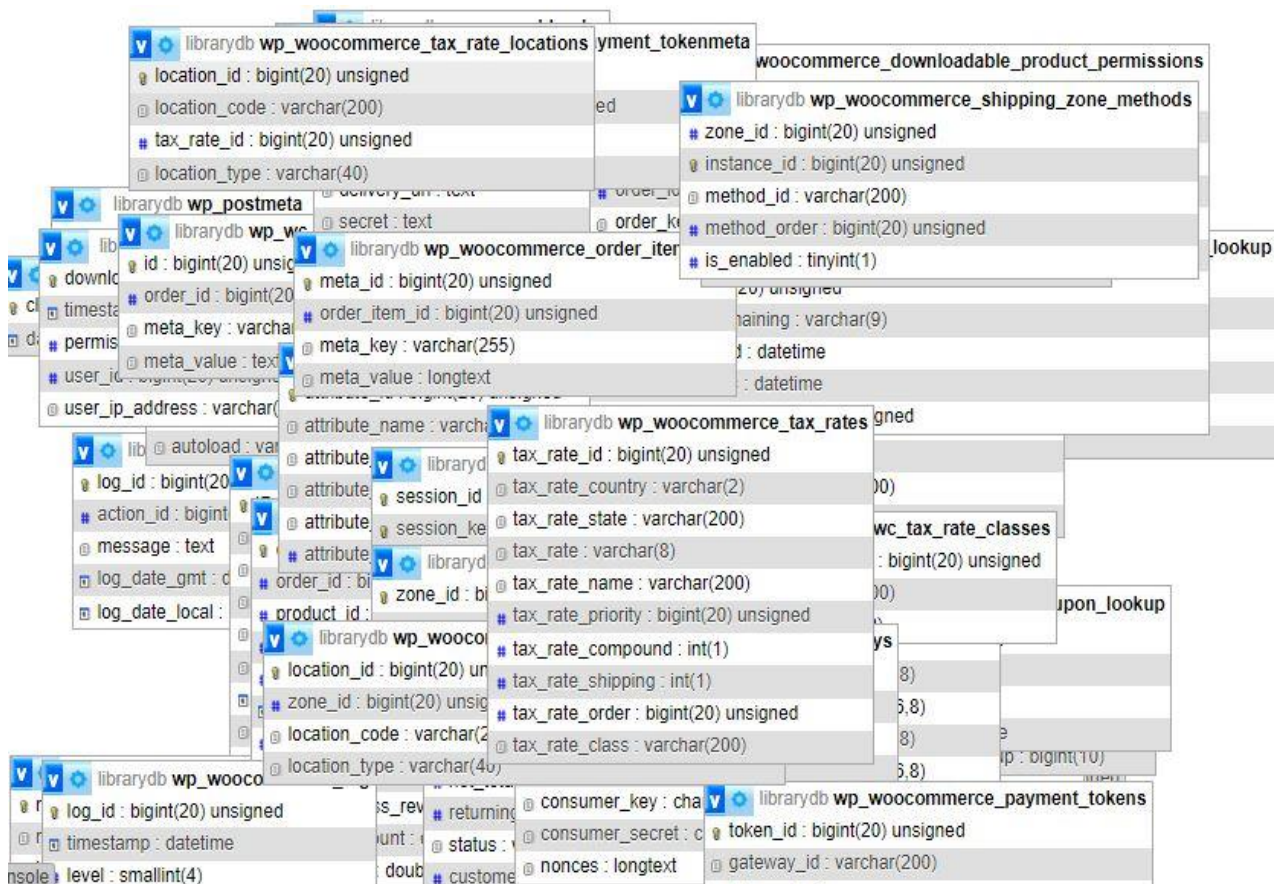


Figure 3: Smart library database schema

### 3.6 System Architecture

The smart library system will offer a comprehensive set of functionalities to cater to the needs of different user groups, including librarians, students, faculty, and administrative staff. The architecture of these functionalities can be organized into several modules or components:

- i. User Management :
  - User registration and authentication
  - Role-based access control (RBAC)
  - User profile management
- ii. Collection Management:
  - Book/resource cataloging
  - Acquisition and collection
- iii. Circulation Module:
  - Book checkout and check-in processes
  - Due date tracking and fine calculations
- iv. Search and Discovery:
  - Advanced search capabilities
  - Recommendation engine (based on user preferences, borrowing history, etc.)
  - Virtual browsing and shelf browsing
- v. Digital Library Module:
  - Access to digital collections (e-books, journals, multimedia)
  - Content management system for digitized resources
- vi. Administrative Module:
  - Library policies and rules management
  - System configuration and settings
- vii. User Dashboard and Personalization:
  - Personalized user dashboard with customizable views and preferences
  - Reading lists and bookmarking functionality
  - Subscription management for alerts and notification

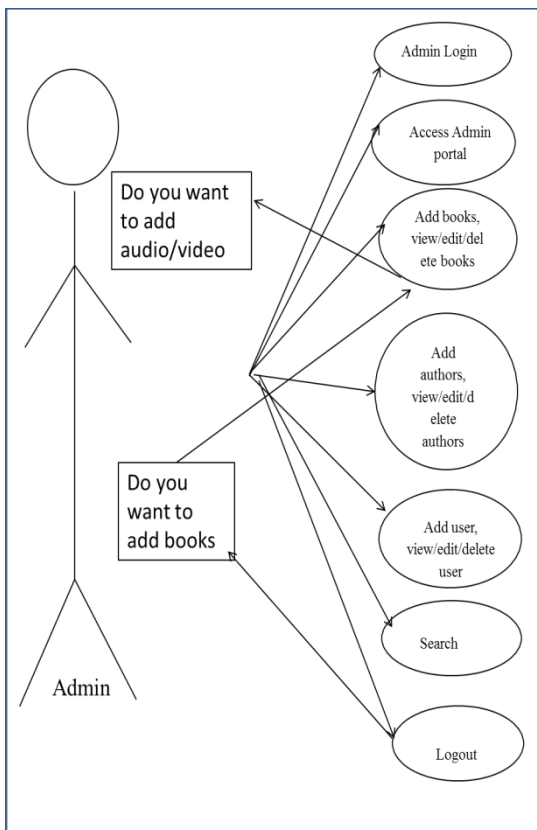


Figure 4: System architecture (Admin)

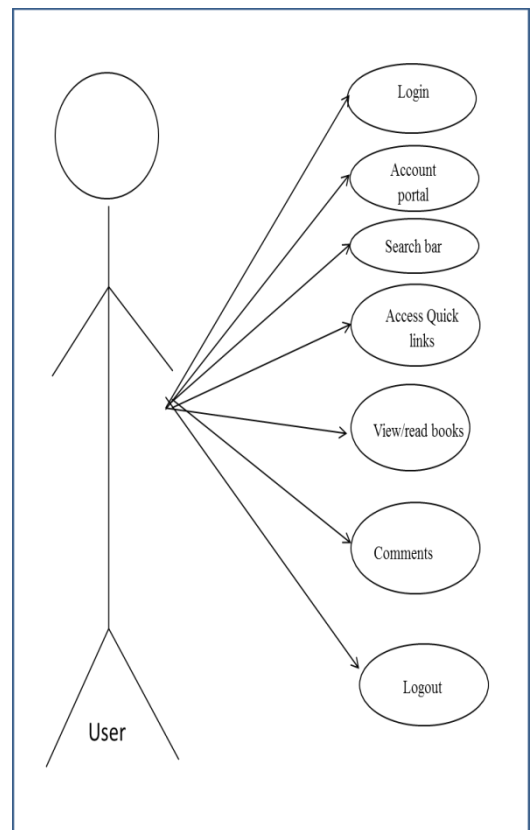


Figure 5: System architecture (User)

#### 4. RESULTS AND DISCUSSION

The result of the analyzed work/ data collected is analyzed quantitatively and qualitatively. It deals with how the designed system interacts with the systems user interface and their various functions.

##### 4.1 Programming Environment/System Testing Procedure

PHP, considered to be one of the most widely used scripting languages, is utilized to enhance web pages. It enables

users to generate usernames and passwords for login/logout sessions, scrutinize form details, create forums and picture galleries along with surveys among many other features. This is sometimes embedded in an HTML file.

#### 4.1.1 The monitoring system

Using SQL statements, the tables in the database were connected to establish a relationship. To prevent duplication, primary keys are used to accurately identify all entries while foreign keys link various tables and improve referential integrity. At this level of programming, data manipulation such as inserting or deleting information along with retrieving search results is conducted seamlessly for enhanced efficiency.

The operating system selected for the system was Windows. MySQL and PHP scripting were employed in developing the database due to their high processing speed, particularly with internet access.

#### 4.1.2 Scripting

The use of scripting empowers web pages to become dynamic, enabling developers to manipulate various elements dynamically based on users' browsing activities. PHP and JavaScript serve the purpose of making these pages more interactive. JavaScript is an object-oriented scripting language used in web pages along with markup language HTML (mostly embedded in HTML). The database is searched using users' supplied clues in a predetermined format as specified by the written codes.

#### 4.2 Output and Input Designs of the System

The output to be extracted from the proposed system are as shown below.

- i. **Home Page:** When the Uniform Resource Locator (URL) is typed into the address bar, the initial page to load onto the web browser is referred to as the Home page. This serves as a gateway for both users and administrators of an online library system who need access. The primary page features essential sections such as About Us, Library Services, Contact Information and Cart that make up part of our developed system's interface. Additionally, present are My Account section allowing patrons manage their accounts settings much capacity Loan Books element where borrowers can borrow books online hassle-free.

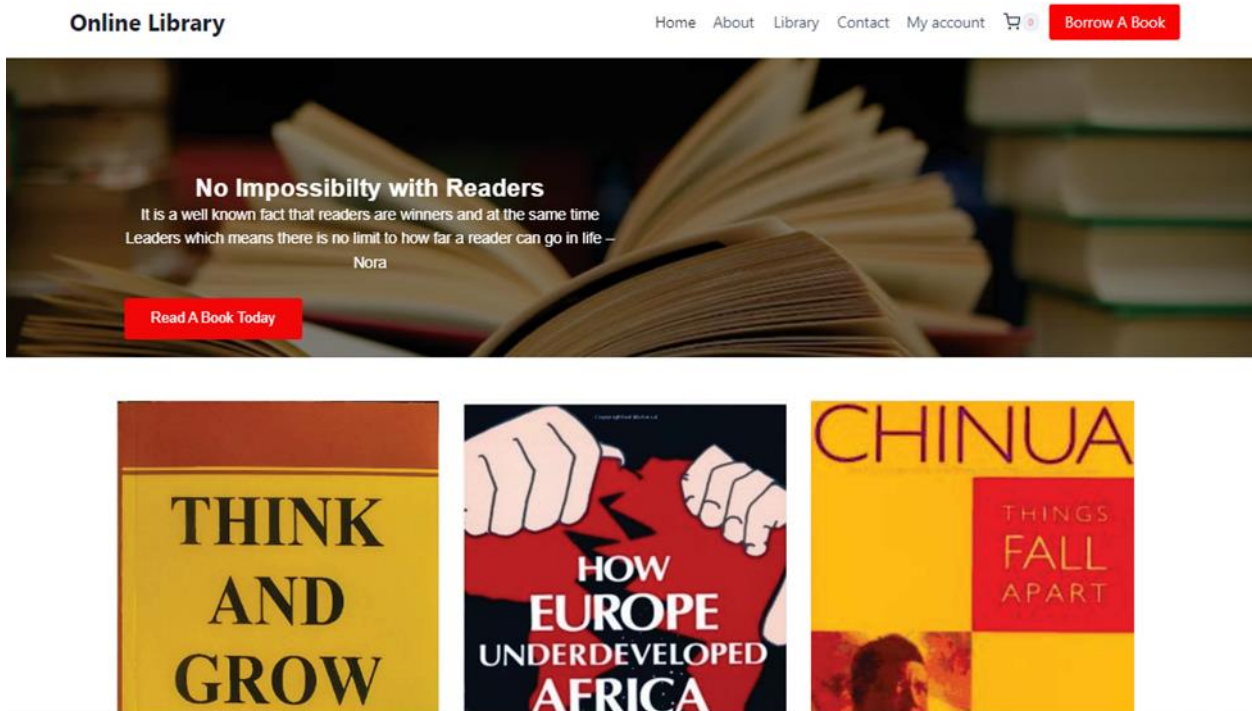


Figure 6: Screen shot for homepage

- ii. **User login/add user:** Before gaining access to the library's username and password, users are required to be registered by an administrator during their login. It is solely up to the admin of the library to register any user who wishes to utilize its resources. The administrator has the ability to enroll a new library user by collecting their necessary information. The registration process includes gathering data like the individual's name, address, email and preferred password in addition to selecting their user status as an admin, author or regular member. Upon being granted user access, the individual will receive login credentials in the form of a designated username and password which can be used to enter the library system.



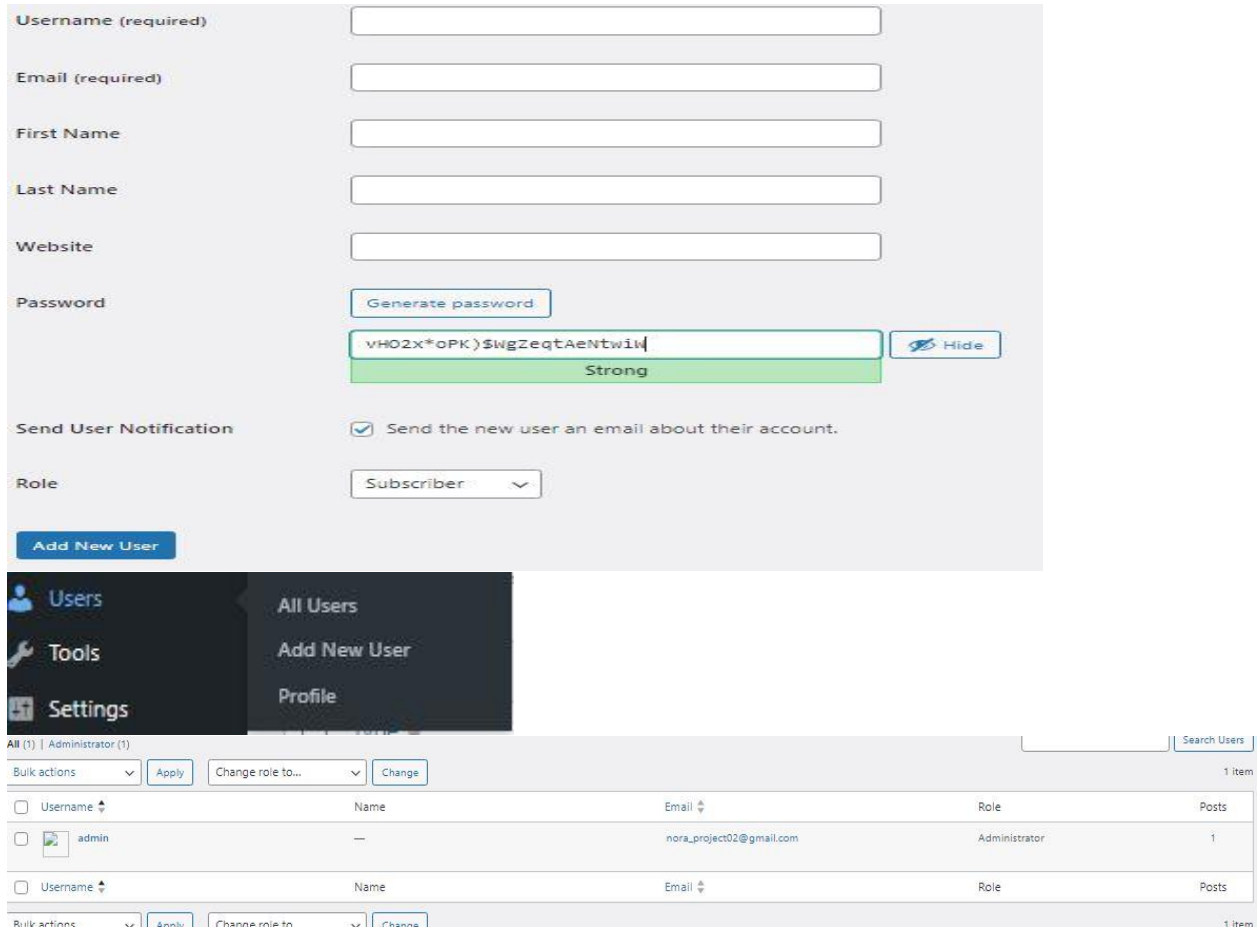


Figure 7: Add user into the system

iii. **Add book:** This is where an admin adds materials/book/media file/journals.

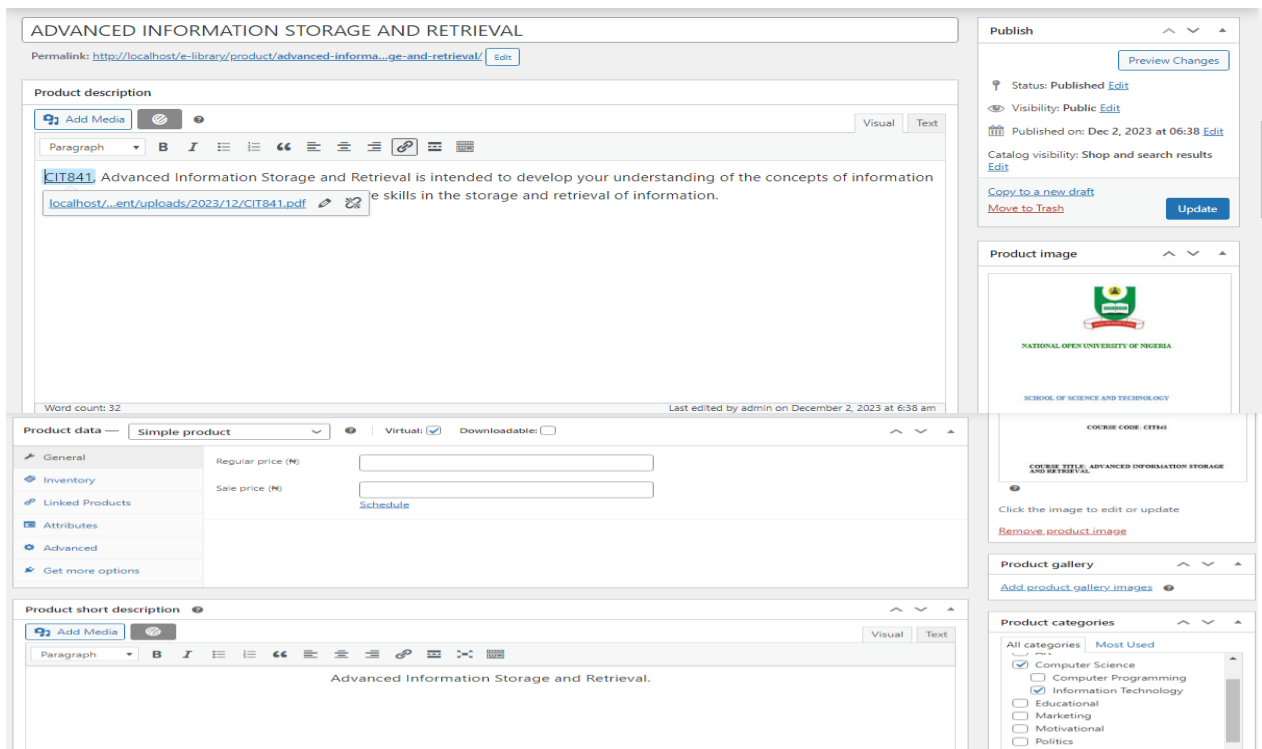


Figure 8: Add books/Categories

- iv. **Add Category:** This module helps librarians and users navigate through the vast collection of books, journals, and other materials. Various criteria, including title, author, keywords and subject can be used by users when searching for materials. Accurate and relevant results are guaranteed through the use of the categorization module.

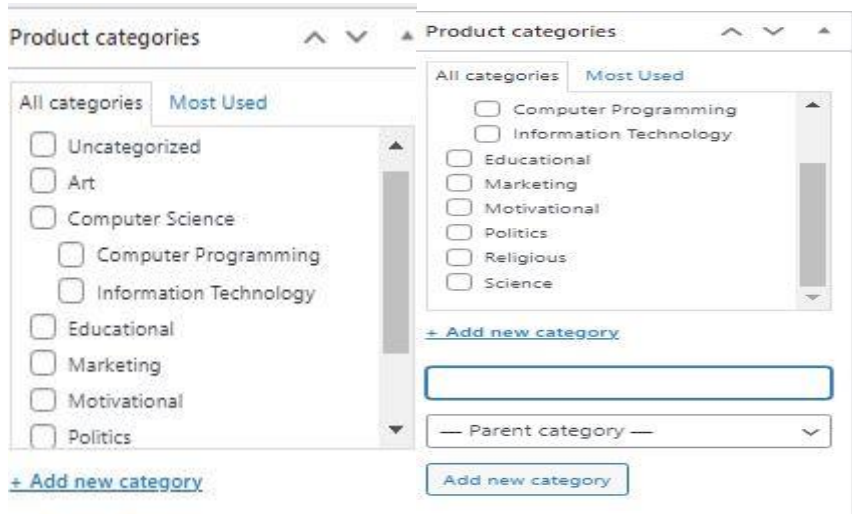
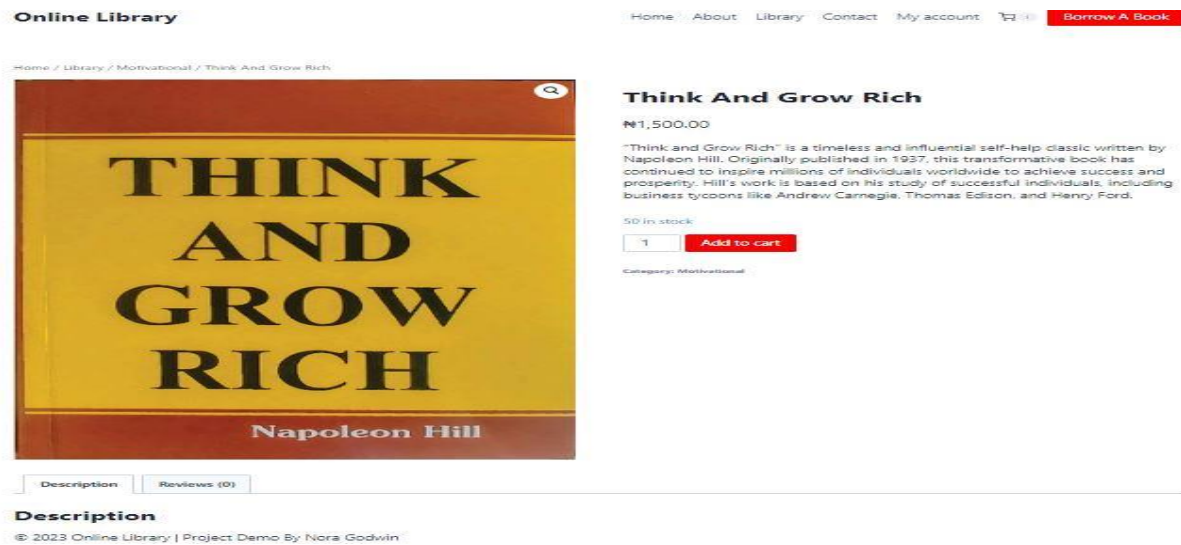


Figure 9: Add books/Categories

- v. **Borrow/download a book:** Here, the user can borrow a book, if its virtual i.e. readable; he can read or either download



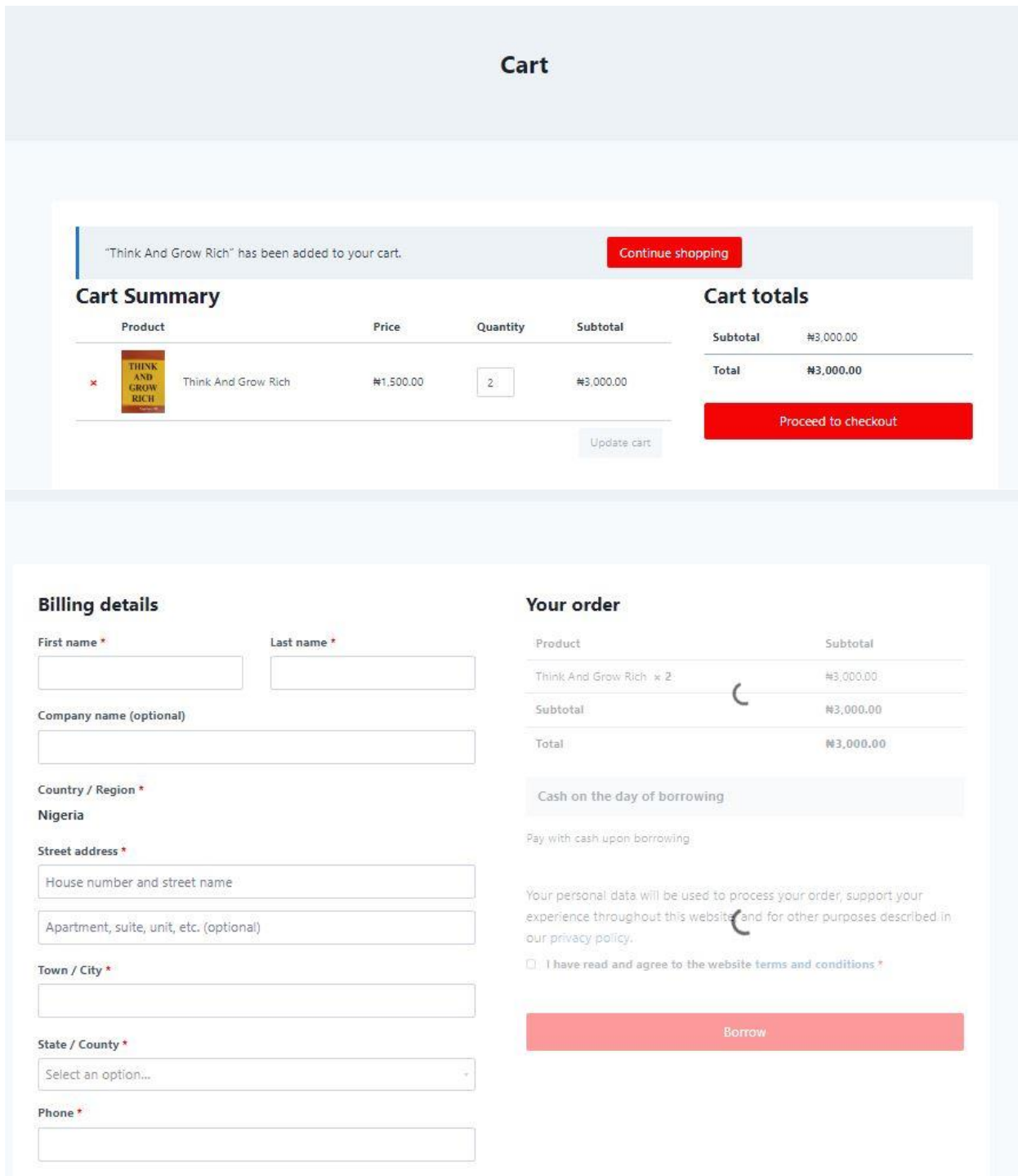


Figure 10: Borrow/Download a book

## 5. CONCLUSION

### 5.1 Conclusion

The research successfully designed and implemented a "Smart Library Automation and Monitoring System", emphasizing the importance of web-based virtual libraries. The system addresses challenges associated with traditional libraries, such as limited physical space, high costs, and accessibility issues. By creating a user-friendly interface and leveraging digital technology, the study contributes to enhancing information access for students and staff. The significance of the study lies in its potential to revolutionize library operations, making them more efficient, cost-effective, and globally accessible.

Consider expanding the system to cover additional departments and institutions, promoting widespread adoption and accessibility. Regularly update the system to incorporate new features, technologies, and user feedback, ensuring its relevance and effectiveness over time.

Provide training sessions to users to maximize their utilization of the virtual library system and raise awareness of its benefits. Collaborate with other institutions to share resources and enhance the digital library's collection, fostering a collaborative academic environment. Optimize the virtual library system for mobile devices; ensuring users can access information conveniently on various platforms.

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