DEVELOPMENT OF A LIBRARY MANAGEMENT SYSTEM ON A RASPBERRY PI BASED WIRELESS LOCAL AREA NETWORK

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Abstract
This paper presents the implementation of a Raspberry pi-based Library Management System (LMS). Traditional libraries require students to manually search for books. Librarians also must manually classify and organize books together with other tasks like book managing, lending, and borrowing transactions. The introduction of the LMS streamlines these processes while ensuring a more optimal library management process. The LMS offers librarians a comprehensive set of features, including the ability to add, view, update, and remove books, as well as manage student information. Accessible through a wireless local area network (WLAN), the LMS empowers librarians to modify database records efficiently. The adoption of WLAN facilitates wireless connectivity among devices within a defined geographic area where the wireless network is active. The developed system leveraged on PHP for programming, HTML and CSS for design, and MySQL as the backend database technology. The system is hosted on an Apache 3.21 application server, with a Raspberry Pi 4 serving as the web server. Following deployment, the online library management system becomes accessible to users within proximity to the web server. Access is granted via the system's public IP address. The implementation of the developed LMS provides opportunities for better library management and accessibility.

Introduction
A library is a physical or virtual location where books and other learning resources are made available for users in either hard or digital version (Pomerantz and Marchionini, 2007). It represents the nerve center of modern learning for students and all seekers of knowledge. The traditional library consists of information resources that are mostly in printed form. However, the rapid evolution of the digital age is gradually moving libraries away from the traditional print-based format to something digital or electronic. Also, information technology and artificial intelligence assisted learning are increasingly becoming crucial in knowledge acquisition and training process. As a result of all these, digitizing both library resources as well as the library management process becomes very essential in our current age.

One very efficient way of realizing this objective is by using a digital library management system. The Library Management System (LMS) in this sense is a software application that is designed to manage the operations and services of a library (Ullah *et al*., 2022). The primary goal of a library management system is to help librarians and library staff automate and streamline tasks such as cataloging, circulation, acquisitions, and inventory management (Randhawa, 2013). A database of library resources, which might contain books, journals, multimedia files, and other kinds of information, is also frequently included in the LMS (Sungkur *et al*., 2021). In this study, we implemented a Library Management System with a SQL server on a Raspberry pi 4 microprocessor. The implementation of the LMS requires the library manager to first enter students' and books information into the database, thereafter, the data may be accessed over Library Management System to read, remove, or change the information, thus ensuring a round-the-clock access to the library resources.

The history of Library Management Systems dates far back. In the 1970s and 1980s, the first computer-based library management systems were developed, known as integrated library systems (ILS) (Pratheepan, 2013). These systems were designed to automate many of the routine tasks involved in library management, such as cataloging, circulation, and acquisitions. In the 1990s, web based LMS began to emerge. These systems offered many advantages over traditional ILS, including easier access for users, increased flexibility, and scalability (Singh and Sanaman, 2012).

One example of a popular web based LMS is Koha, which was first released in 1999 and has since been adopted by libraries around the world (Salma and Devi, 2020). In recent years, open-source software has

become popular since no license cost are associated with usage while users are at liberty to adjust and customize the software files at will. Consequently, several open-source library management systems have been developed. These systems are freely available to libraries, allowing them to customize the software to meet their specific needs. Some examples of open-source LMS include Koha, Evergreen, and VuFind (Roy *et al*., 2022). Aside these, there are also cloud based LMS which has further helped to improve the delivery and implementation of the system. These systems are hosted in the cloud and accessed through a web browser, eliminating the need for libraries to maintain their own hardware and software. Examples of cloud based LMS include Alma by Ex Libris and WorldShare Management Services by Online Computer Library Center (OCLC) (Salma and Devi, 2020).

The digital library project management system offers versatility and ease of use. However, effective management of the book catalogue remains essential to optimize productivity for both librarians and library users. The system comprehensively stores information about staff, students, and books. It tracks books distributed to users, as well as those currently available in the library. Additionally, it highlights popular materials among students and assists in locating missing library books. They are also very effective at keeping records of book binders and suppliers.

Several authors have developed different versions of a library management system. In a study conducted by Omeluzor and Madukoma (2012), the authors designed a system using KOHA Open-Source software to update the book and resource database at Bharathidasan University's School of Chemistry Library. They utilized this system to automate the charging and discharging functions in the circulation section, which includes various search options for accessing additional information. Dutta *et al*. (2022) also created a library management system for library patrons and employees. The developed system was useful in finding books online and reserve them. The platform was also used to upload news and read reports. The LMS was integrated with email and short messaging service functionality while providing easy navigation through a user-friendly graphical user interface.

While several studies have investigated the integration of Raspberry Pi in educational settings and IoT applications, limited research focuses explicitly on its application in library management systems. However, the few existing works demonstrate the feasibility and advantages of utilizing Raspberry Pi-based WLANs for enhancing library services. For instance, a Raspberry pi based smart library management system was proposed by Mukund et al. (2021) for anti-theft related library management. The proposed system employed the use of radio frequency identification tags with a raspberry pi to manage books. A similar approach was taken by Bhure (2018). The author also proposed a design that is capable of securing library books while ensuring proper management. Artificial intelligence was further introduced in a system deployed by Jayawardena *et al*. (2022) in managing library stock.

Despite the promising advancements in both LMS and Raspberry Pi-based networking, there remains a notable research gap in the development of comprehensive library management system that leverages the capabilities of Raspberry Pi-based WLANs. Existing studies often focus on proof-of-concept implementations or address specific functionalities rather than offering a holistic solution tailored to the complex requirements of modern libraries.

While several progresses have been made in library management systems design, in our paper, we aim to bridge the gap by proposing the development of a robust and scalable library management system on a Raspberry Pi-based WLAN infrastructure, addressing the issue of high installation, and running costs associated with traditional systems. Our approach integrates essential library functions with wireless networking capabilities to offer libraries a cost-effective, accessible, and adaptable solution. Operating on a Raspberry Pi 4 platform, our system ensures data safety and protection while providing users with convenient access to library resources without the need for active internet service. Through rigorous design, implementation, and evaluation, we seek to demonstrate the feasibility and effectiveness of our system in real-world library environments, thus contributing to the advancement of library technology and digital inclusion initiatives.

The library management system developed in this study was implemented for the Department of Computer Engineering and Electrical Engineering at the Federal University of Technology, Akure with a view to mitigate the difficulty associated with using traditional library management within the university system as well as ensuring students unrestrained and cost-free access to library resources.

This paper is divided into four sections. In section 1, we introduced the research and provide general information on the operation of a library management system. The section also provides a background to the study alongside a comprehensive literature survey on the research topic. In Section 2, we present our study design methodology. The section presented the design class diagram as well as the design implementation. Section 3 provides insight into the results of our design while we conclude on our design and findings in section 4.

.Design Methodology
LMS Design Architecture

The digital library management application consists of two modules which are the User Module and Admin Module. The admin side manages operations like adding and managing categories, authors, catalogues, issued books and so on. The admin also has the role of assigning responsibilities and managing functions on the platform. The architecture of the library management system is as shown in Figure 1. From Figure 1, the various roles of the developed system can be observed. The system allows users to create a new account and pre-registered users can easily sign up into the system with the already provided details. Once the user logs in, he/she has access to the user dashboard which provides details on the books issued and books not returned yet. The user signup page requires that users provide information on the full name, mobile number, email, password, confirm password and verification. The admin side of the system allows the administrator to log into the digital library by entering the username, password, and verification code.

Administrative users would be registered on the admin webpage by a superior admin user and be given login details to log in to the admin dashboard. Once the admin is logged in, an admin dashboard page pops up which provides details on books used, times book issued, times book returned, registered users, authors listed and listed categories

The user signup page requires that users provide information such as full name, mobile number, email address, password. A verification block is also included to ensure the integrity of platform and protect again spams. The system requires the administrator to log into the digital library by entering the username, password, and verification code. Administrative users would be registered on the admin webpage by a superior admin user and be given login details to log in to the admin dashboard. Once the admin is logged in, an admin dashboard page pops up which provides details on books used, times book issued, times book returned, registered users, authors listed and listed categories. The class diagram of the proposed management system is as shown in Figure 2.
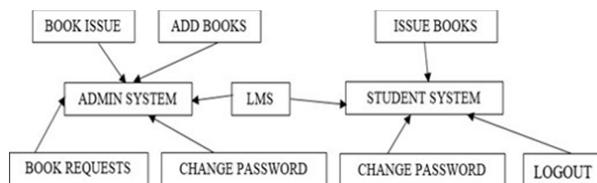

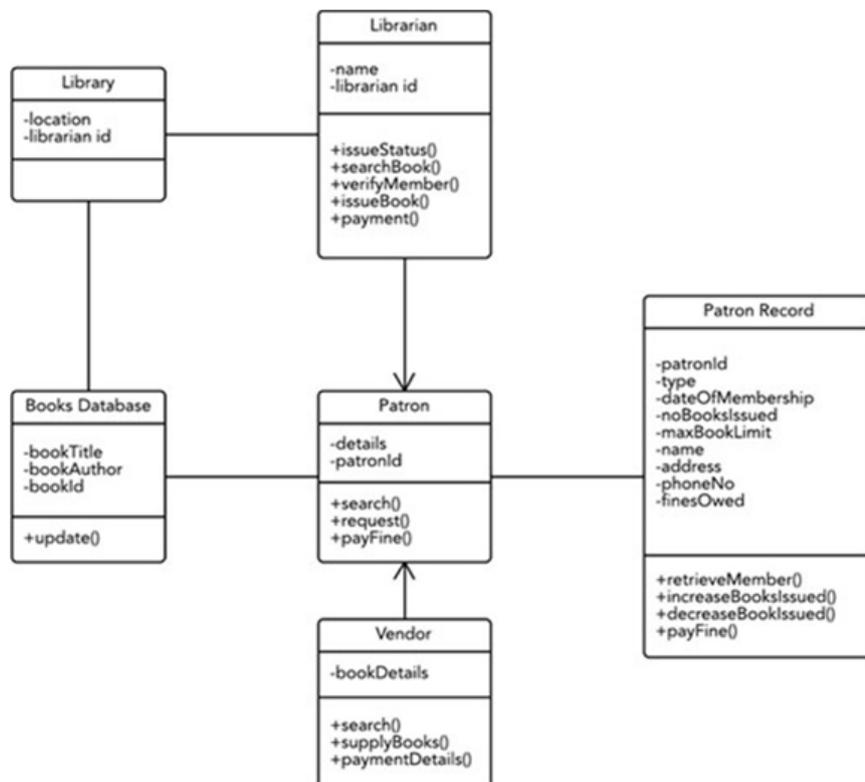Figure 1. Architecture of the library management system

Figure 2. Class diagram of the Library Management System

Software Design of The Proposed LMS
The digital library application front end was developed using HTML5, CSS3 and JavaScript whilst the backend was developed with Apache HTTP Server, PHP, and MySQL. The application was designed using a modular approach. The first and most important component of the design was the landing page. The landing page gives a brief description of what the system does and provides easy navigation to other modules and functionalities of the web application such as user signup page, user login page and admin login page. The most important module on the landing page was the administration module which was designed to manage the user interface. Other critical component on the landing page included admin log in page which can only be accessed by a valid admin. The admin has access to the web application data and monitor all user (student) information. Other modules in the web application include the contact page, terms and conditions page, and footer page.

Another important component of the design is the user registration module. This module comprises of the user signup page. Here the user which in this case is the student is required to provide certain information such as full name, phone number, email, and signup password to create an account on the web application. Once the user signs up to the library system, a student id is automatically generated. The user can then log in into the user login module by providing the email id, password, and verification code. If a user forgets the login credentials, a password recovery module was included in the design. Consequently, for users who do not remember their password, a password reset link is created in the log in modal. The link would redirect them to a page where they would enter the email address, they want the password reset link to be sent. A token is created for each password request made by a user, a time limit of 10 minutes is also attached to the token after which it would expire and be deleted from the database. Users who are not able to reset their password must make another request.

LMS Hardware Implementation
The raspberry pi functions as the major hardware component in this design. In configuring the raspberry pi as the local web server, the raspberry pi OS Full (32-bit) was installed via the raspberry imager into a SD card, the raspberry pi desktop environment was setup after plugging the pi to electric power and connecting with peripherals such as keyboard, mouse and a monitor, installation of Apache, PHP, MySQL and PHPmyAdmin was then carried out from the raspberry pi terminal, the digital library management system code was cloned from its GitHub repository into the raspberry pi and the final process of the design involved connecting the Apache with ngrok which is a cross-platform that enables the locally hosted web server to be exposed to the internet.

Results
Figure 3 shows the landing page for the library management system, it provides the basic page where user and admin can click on to access the library system. The University main gate was used as a background image of the landing page to enhance the user experience and provide users with a sense of identification. The top left corner of the landing page shows the University Logo followed by three links for the admin login page, user signup page for new users and the user login page for returning users. Another signup button was included around the bottom corner of the landing page to enhance the look and feel of the page. One of the most important features of the landing page is the login area which features two text field for users to enter their email address and password. New users who do not have a login credential can also access the sign-up link from this login area as well.

A welcome message "Welcome to a Library management system hosted with Raspberry pi as webserver" was affixed to the page to show that the project is still in the experimental stage. The landing page is accessible to all, as both the admin and the users of the library can access the home page of the library management system as it has been authorized and authenticated for public use.

Figure 4 shows the admin login page. This page can be accessed by clicking the "ADMIN LOGIN" link at the top left corner of the landing page. The admin in this sense is responsible for the overall management of the library management system. His role which includes assigning rights, approval books, adding book catalogue among several others is pivotal to the smooth running of the system. The administrator possesses a unique login credential and will login with it each time the admin panel is to be accessed. Since there could be more than one admin, the login credentials for the admin must already exist in the admin database for entry access to be granted.
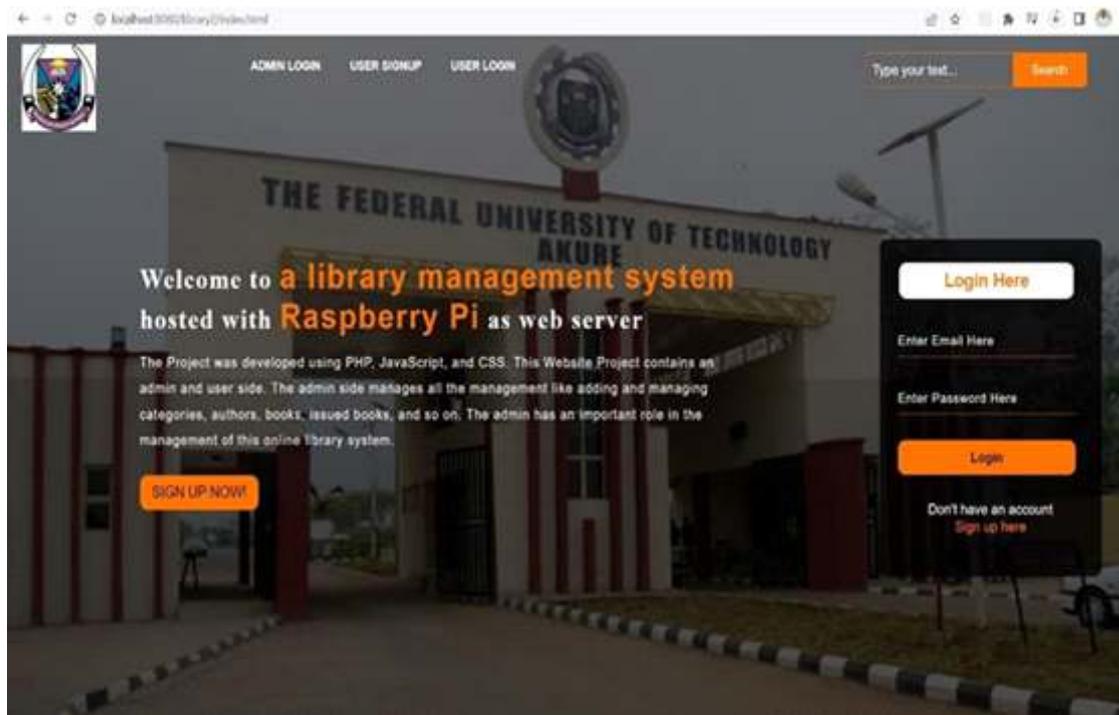
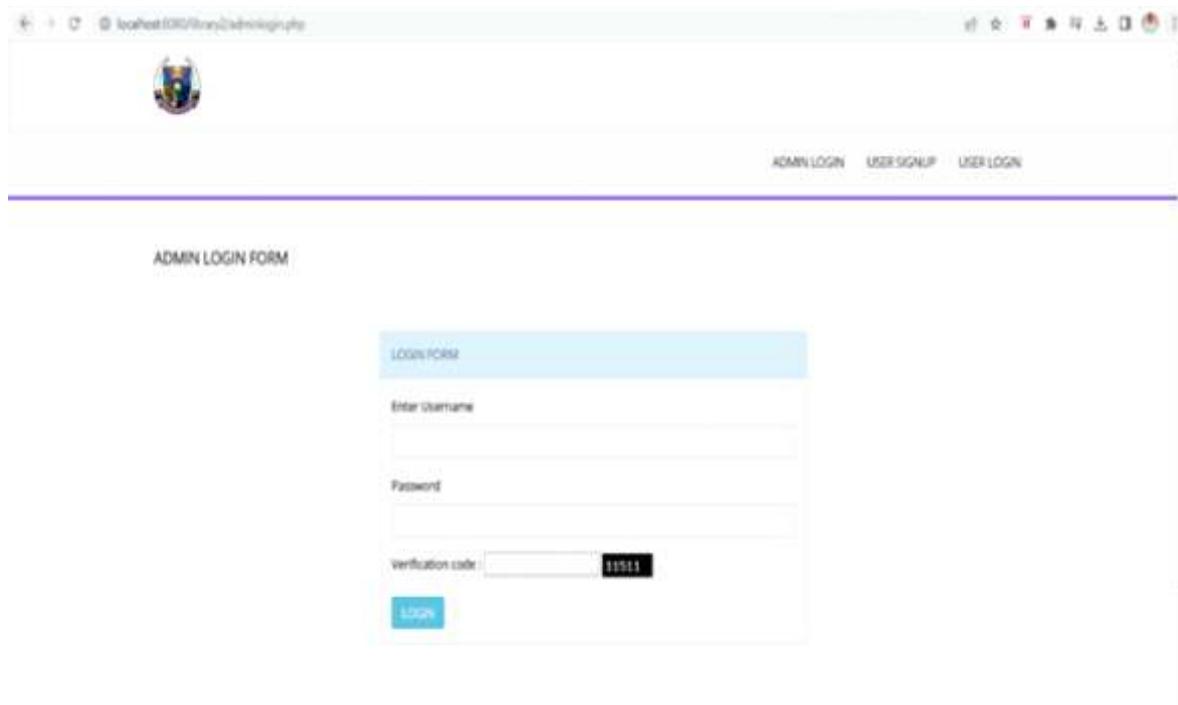Figure 3. Landing page of the digital library web application

Figure 4. Admin login page

The user signup page is shown in Figure 5. The user signup page comprises of spaces provided for intending users to fill in details such as full name, mobile number, email, password, and verification code. After completing the signup, user will receive a user ID with which the user can login with as shown in Figure 6. The registered user can only log in to the system by providing the email ID and password used to register the user account at the user signup stage.
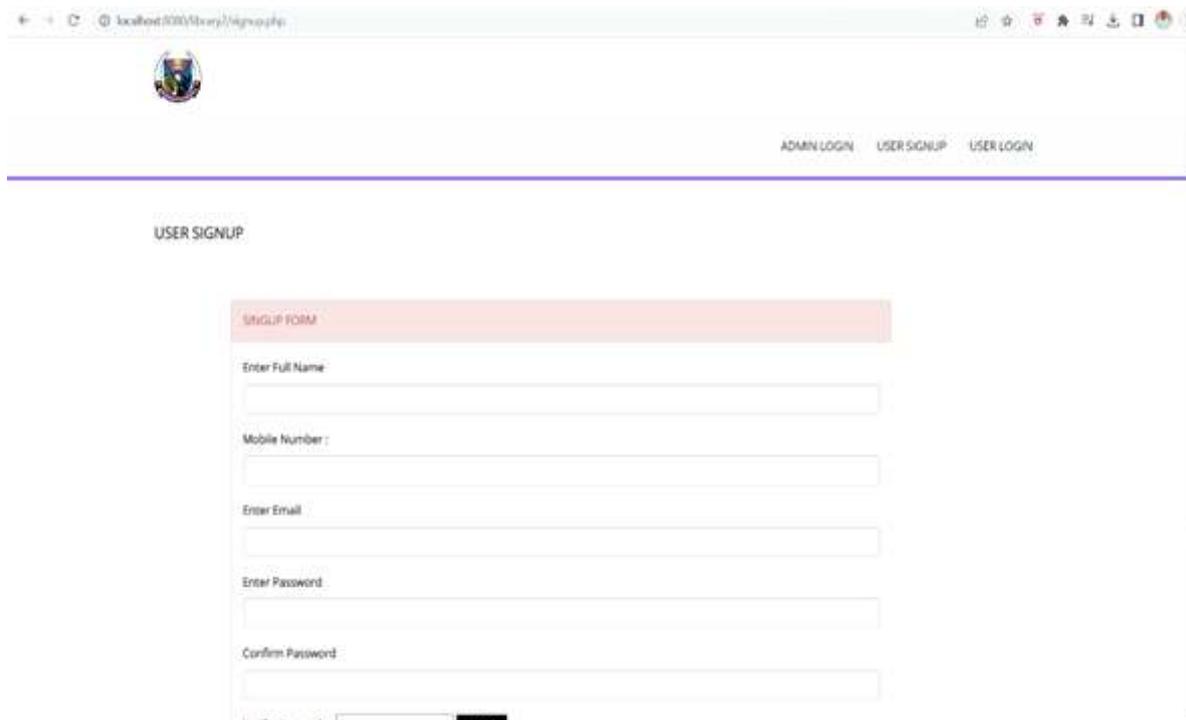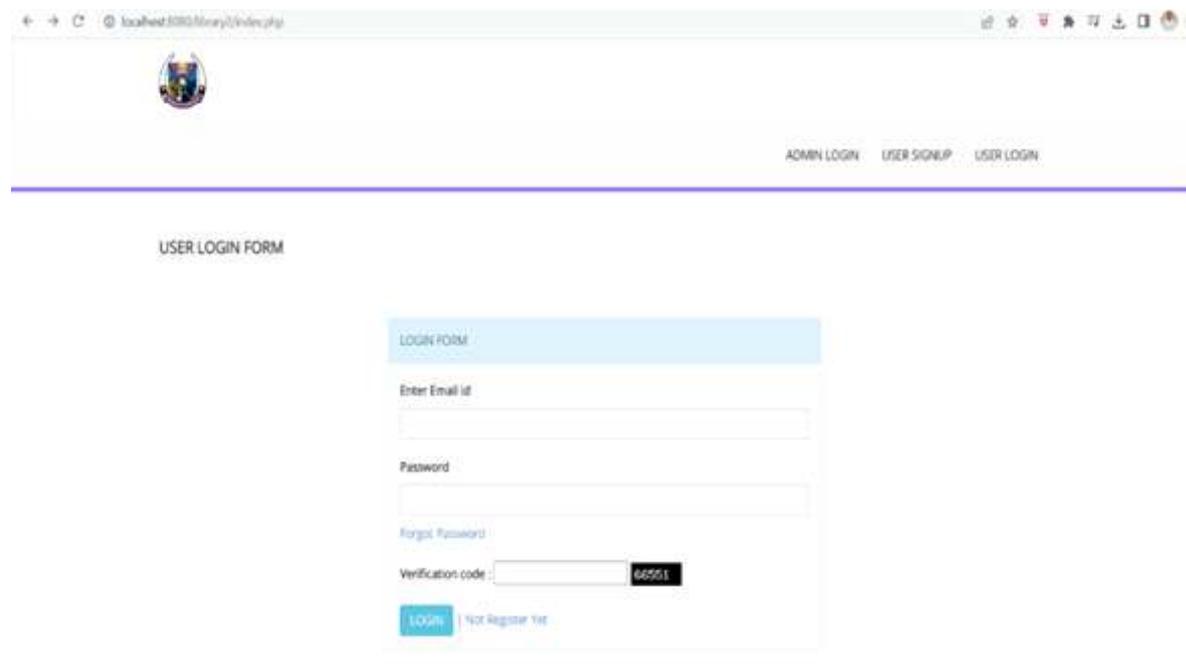
Figure 5: User Signup page

Figure 6: User login page

The library management specific tasks are shown in Figure 7 and 8. Figure 7 shows the administrator dashboard page. The page contains information on the number of books issued, number of times the books were issued, authors listed, listed categories, returned books and total number of registered users on the library management system. Figure 8 is the user dashboard page. This page provides users with the number of title of books borrowed and number of titles returned.
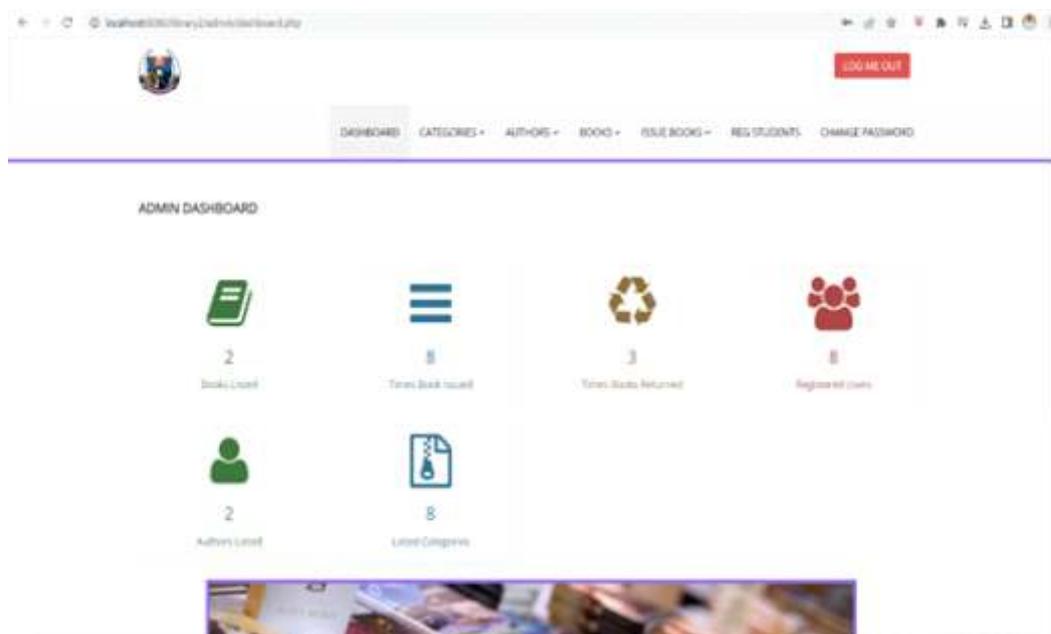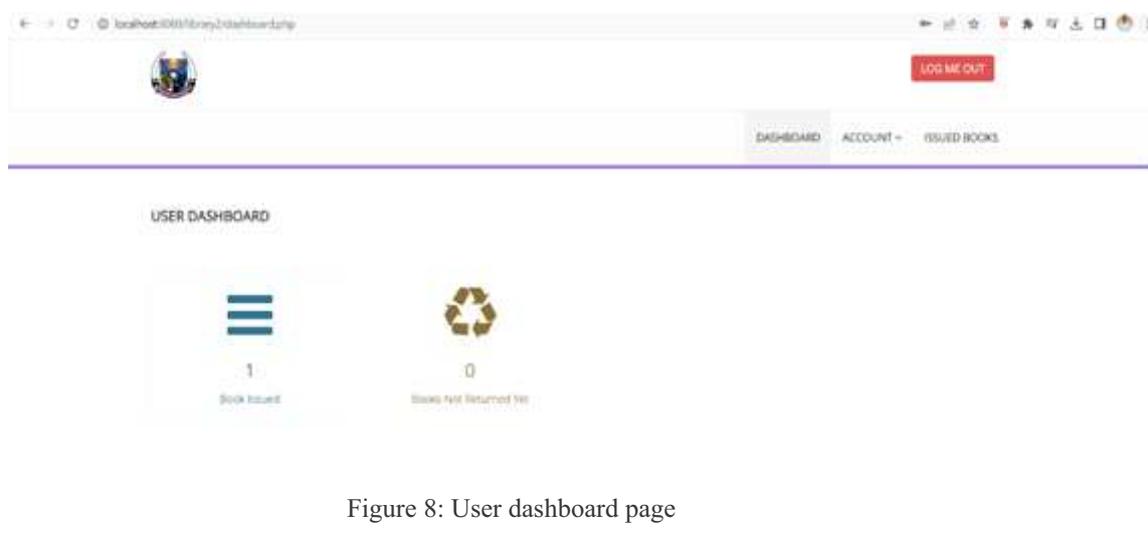
Figure 7: Admin dashboard page

Figure 8: User dashboard page

Conclusions

This paper presents the implementation of a digital library management system based on a wireless local area network. The design represents a significant advancement over the conventional library systems commonly employed in educational institutions today. This innovative approach not only enhances the overall educational experience but also substantially reduces the burden and time associated with the storage, access, and retrieval of materials compared to traditional library methods. The design was implemented on a local area network. The incorporation of a Raspberry Pi 4 as a local web server adds a unique dimension to the design particularly in terms of cost reduction and mobility. The developed LMS consists of every functional block for both users and admins thus facilitating seamless learning for university students and optimizing administrative tasks for library staff.

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