Design and Implementation of a Mobile App for BLDE (Deemed to be University) Library: A User- Focused Study

Thesis submitted to BLDE (Deemed to be University) for the Partial Fulfilment for the award of the degree of

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By

Mr. Shridhar Biradar

Reg.No: 23STMLIB06

Department of Library and Information Science

School of Applied Science & Technology

Supervisor

Dr. Prasanna Kumar B.M

Department of Library and Information Science

School of Applied Science & Technology

BLDE (Deemed to be University)

Vijayapura – 586103, Karnataka

2024-2025

BLDE (Deemed to be University)

School of Applied Science and Technology Vijayapura, Karnataka

DECLARATION BY THE CANDIDATE

This is to certify that the thesis entitled ***"Design and Implementation of a Mobile App for BLDE (Deemed to be University) Library: A User- Focused Study"*** submitted by **Mr. Shridhar Biradar** (Reg. No.: 23STMLIB06) for the award of the degree of Post-Graduation to the BLDE (Deemed to be University), Vijayapura, is a record of bonafide research work carried out by his under the supervision and guidance of **Dr. Prasanna Kumar B.M** Assistant Professor and University Librarian Department of Library and Information Science at BLDE (Deemed to be University) Vijayapura, Karnataka.

Date: **Signature of the Student**

Place: Vijayapura

Mr. Shridhar Biradar

Reg.No: 23STMLIB06

Post Graduate

Department of Library and Information Science

School of Applied Science and Technology,

BLDE (Deemed to be University)

Vijayapura, Karnataka

BLDE (Deemed to be University)

School of Applied Science and Technology Vijayapura, Karnataka

CERTIFICATE FROM THE SUPERVISOR

This is to certify that the thesis entitled ***"Design and Implementation of a Mobile App for BLDE (Deemed to be University) Library: A User- Focused Study"*** submitted by **Mr. Shridhar Biradar** (Reg. No.: 23STMLIB06) for the award of the degree of Post-Graduation to the BLDE (DU), Vijayapura, is a record of bonafide research work carried out by his under the supervision and guidance of **Dr.Prasanna Kumar B.M** Assistant Professor and University Librarian Department of Library and Information Science at BLDE (Deemed to be University) Vijayapura. I consider that the thesis has reached the standards and fulfilling the requirements of the rules and regulations relating to the nature of the degree. The contents embodied in the thesis have not been submitted for the award of any othis degree or diploma in this or any this university.

Date: **Signature of the Supervisor**

Place: Vijayapura

Dr. Prasanna Kumar, B.M
Assistant Professor and University Librarian
Department of Library and Information Science
School of Applied Science and Technology
BLDE (Deemed to be University)
Vijayapura, Karnataka

BLDE (Deemed to be University)

School of Applied Science and Technology Vijayapura, Karnataka

ENDORSEMENT BY THE HEAD OF DEPARTMENT

This is to certify that the thesis entitled ***"Design and Implementation of a Mobile App for BLDE (Deemed to be University) Library: A User- Focused Study"*** submitted by **Mr. Shridhar Biradar** (Reg. No.: 23STMLIB06) for the award of the degree of Post-Graduation to the BLDE (DU), Vijayapura, is a record of bonafide research work carried out by his under the supervision and guidance of **Dr.Prasanna Kumar B.M** University Librarian Department of Library and Information Science at BLDE (Deemed to be University) Vijayapura This work has been carried out by his in the School of Applied Science & Technology BLDE (Deemed to be University) Vijayapura, Karnataka.

Date: **Signature of the HOD**

Place: Vijayapura

Dr. Prasanna Kumar, B.M
Assistant Professor and University Librarian
Department of Library and Information Science
School of Applied Science and Technology
BLDE (Deemed to be University)
Vijayapura, Karnataka

BLDE (Deemed to be University)

School of Applied Science and Technology Vijayapura, Karnataka

ENDORSEMENT BY THE DEAN

This is to certify that the thesis entitled ***"Design and Implementation of a Mobile App for BLDE (Deemed to be University) Library: A User- Focused Study"*** submitted by **Mr. Shridhar Biradar** (Reg. No.: 23STMLIB06) for the award of the degree of Post-Graduation to the BLDE (DU), Vijayapura, is a record of bonafide research work carried out by his under the supervision and guidance of **Dr.Prasanna Kumar B.M** University Librarian Department of Library and Information Science at BLDE (Deemed to be University) Vijayapura This work has been carried out by his in the School of Applied Science & Technology BLDE (Deemed to be University) Vijayapura, Karnataka.

Date: **Signature of the Dean**

Place: Vijayapura

Dr. S.V. PATIL

Dean School of Applied and Technology

BLDE (Deemed to be University)

Vijayapura, Karnataka

BLDE (Deemed to be University)

School of Applied Science and Technology Vijayapura, Karnataka

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Date: **Signature of the Student**

Place: Vijayapura

Mr. Shridhar Biradar

Reg.No: 23STMLIB06

Post Graduate

Department of Library and Information Science

School of Applied Science and Technology,

BLDE (Deemed to be University)

Vijayapura, Karnataka

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ABBREVATION

Abbreviation	Full Form
AI	Artificial Intelligence
API	Application Programming Interface
ALMS	Automated Library Management System
DB	Database
GUI	Graphical User Interface
HTML	Hypertext Markup Language
ILS	Integrated Library System
IoT	Internet of Things
IRB	Institutional Review Board
LMS	Library Management System
MIT	Massachusetts Institute of Technology
OAI-PMH	Open Archives Initiative Protocol for Metadata Harvesting
OPAC	Online Public Access Catalogue
QR	Quick Response
RDBMS	Relational Database Management System
SSO	Single Sign-On
SPSS	Statistical Package for the Social Sciences
UI	User Interface
UAT	User Acceptance Testing
URL	Uniform Resource Locator
UX	User Experience
WCAG	Web Content Accessibility Guidelines

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ABSTRACT

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Background

Digital libraries and mobile access have transformed academic information services by enabling anytime–anywhere discovery, personalized access to e-resources, and streamlined communication between users and library staff. The BLDE Central Library requires a user-centered mobile solution to improve access, engagement and operational efficiency.

Aim & Objectives

To design, implement and evaluate a user-centered Android mobile application for the BLDE library that integrates OPAC, e-resource access, borrowing/renewal, notifications and feedback; and to assess usability and user satisfaction through a mixed-methods pilot. Key objectives include needs assessment, rapid prototyping, real-time integration, and evaluation.

Methodology

A mixed-methods, user-centered approach: surveys, focus groups, personas and iterative usability testing informed feature priorities. Prototyping and implementation used MIT App Inventor (blocks visual programming) with Firebase Real-time Database for backend storage/syncing; analytics and in-app surveys captured quantitative and qualitative usage metrics during pilot deployment. Ethical safeguards and informed consent were observed.

System Design & Implementation

Modular client-server architecture: mobile client (MIT App Inventor) + Firebase backend (Users, Books, Requests nodes in JSON/NoSQL schema). Integration used App Inventor's Firebase component (store/get, data-change listeners) and optional Google Sheets for lightweight admin tasks. Core modules: Authentication, OPAC search, E-resource gateway, Reservation/Renewal, Notifications, Feedback.

Results & Key Findings

Pilot testing demonstrated strong adoption among students, improved discoverability of resources and streamlined communications. Limitations included MIT App Inventor's dynamic data constraints, offline capability restrictions and Android-only deployment. Iterative feedback led to UX refinements and validated low-code feasibility for institutional apps.

Conclusions & Contributions

The study shows a practical, user-centered path to deliver library services via a low-code mobile app; it documents implementation patterns (App Inventor ↔ Firebase), usability outcomes, and recommendations for scalability, security rules and future enhancements (AI recommendations, iOS support). The prototype advances BLDE's digital transformation and provides a reproducible model for similar academic libraries.

Keywords: Mobile library app; MIT App Inventor; Firebase Real-time Database; OPAC; user-centered design; BLDE University.

Chapter 1: INTRODUCTION

1.1. Background of the Study

Digital library services have greatly altered the information management field in the past several decades. Libraries were traditionally understood to be physical places, storing books and similar materials, to which people have to go to have access. Digital libraries developed, through rapid advancements in information and communication technologies, as an extension of and improvement to traditional libraries. Digital libraries allow users to access, arrange, and preserve knowledge, working well beyond the limits of physical boundaries. Digital technologies have improved access, but also the efficiency and interactivity of information services (Muduli et al., 2021).

Digital libraries have historical roots in the age-old efforts of humans collecting and organizing knowledge. Libraries in antiquity were primarily stewards of physical manuscripts. When the printing press was invented in the fifteenth century, it marked a significant change in increased access to books, and the democratization of access to knowledge, ultimately leading to the establishment of the first public libraries (Muduli et al., 2021). In the nineteenth century, greater attempts were made to widespread (or free) access to books, to foster reading in all classes of society, supported by powerful philanthropist efforts in building thousands of libraries (Muduli et al., 2021).

In the 20th century, new technologies brought about notable changes to libraries, including both more recent mechanical technologies and early digital technologies which advanced cataloguing, storage, and retrieval systems. Classification schemes provided ways for autonomy and search strategies, as did automation efforts that ultimately became Online Public Access Catalogues (OPAC) (Wikipedia, 2025). Towards the end of the 20th century, advances in digital infrastructures have started to promote the idea of completely digital libraries, more recently the digital libraries we see today, to support searching and access to electronic texts, database and multimedia contents via computer networks (Mintbook, 2024).

Digital libraries today have emerged from practical applications via multifaceted services which offer not only digitized books and journals but interactivity with reference, institutional repositories, and access integrated with the educational system, providing anytime-anywhere access (Muduli et al., 2021). Digital libraries use standardized metadata for organizing resources and searching actions, improved

search and retrieval features, and adopted growing use of artificial intelligence for personalized resource discovery (Muduli et al., 2021; Mintbook, 2024).

Digital library services have significant value in a variety of ways. First, these services democratize access to information, creating equal opportunities for education, regardless of geographical, economic, or social barriers. (Mintbook, 2024) Digital libraries also empower researchers and learners, increasing their research productivity, by providing rapid access to multiple repositories of organized knowledge, as well as collaboration opportunities to create knowledge (AllPurposeGuru, 2021).

Digital repositories are also very important in preserving our cultural heritage and the intellectual output of academia, by creating digital objects or surrogates of documents and materials that may be subject to degradation if handled and stored incorrectly (Muduli et al., 2021). Lastly, digital libraries allow for flexible learning spaces that are necessary for ongoing education and distance learning, meeting the changing expectations of many individuals who are increasingly engaged through mobile and distance formats or channels (Mintbook, 2024).

1.2. Historical Context and Evolution

Libraries have long been central to progress in education, culture, and science. They initially existed as physical keepers of collections, restricting access through geographical, temporal, and social barriers. The conventional model restricted library uses to designated places and times and frequently by large parts of the population (Muduli et al., 2021). The invention of the printing press during the 15th century marked a sea change in library history. With the rise of the printing press, anything written could be replicated; libraries evolved from storing texts for elites to becoming centers of higher learning accessible to anyone. This new trend led to the proliferation of public libraries in the 19th century, making knowledge available and encouraging reading for all (Muduli et al., 2021).

In the 20th century, advances in technology played a more significant role still. Thelibrary operations and services were made more efficient by use of technology such as the telephone, typewriter, early computer hardware (Muduli et al., 2021). Standardized card formats and access points provided more uniform access to the collections; these reduced transcription effort as bibliographic information was not re-written (albeit at some cost in terms of record legibility). Cataloguing external services such as interlibrary loan were also developed during this time following

systems. The most revolutionary change came in the late 20th century with computers and networked information systems. Online Public Access Catalogues (OPACs), which began to appear in the 1980s, revolutionized library catalogues as patrons were given the opportunity to search for a document electronically and autonomously, thus democratizing access to library collections (Wikipedia, 2025).

The first digital libraries built on this foundation with networked technologies to make scholarly materials freely available. One such repository was arXiv and a similar one was the Education Resources Information Centre (ERIC). ArXiv was set up in 1991 as a preprint archive that allowed free access to scientific papers in areas like physics and mathematics, a local institutional repository model which global institutional repositories have followed (AllPurposeGuru, 2021). The Education Resources Information Centre, initially opened in 1964 and made available online in 1969, was a huge database of educational resources. These projects showed how powerful networked, digital collections were in terms of giving access to information in a democratizing way and making scholarly communication faster.

In 1994, the United States Department of Defence, and the National Science Foundation, jointly supported the Digital Library Initiative (DLI) a program that was the main driver for rapid library development and research in the digital domain. The DLI aimed at creating scalable digital libraries that could house various content types such as multimedia material which could be maps, photographs, satellite images, and videos apart from research articles (AllPurposeGuru, 2021). The program has driven the new models and the new technology that are the foundation for the present digital library systems not only to be accessed but also with the advanced features like content structuring, metadata standards, and federated searching across collections (AllPurposeGuru, 2021).

1.3 Defining the Digital Library

A digital library is a fundamental change from traditional libraries that covers a wide range of digital content and uses advanced technology infrastructure for the organization, access, and engagement of users. It is not just digitizing the physical content; it stands for a structured, organized, and curated collection consisting of the text, pictures, sounds, video, and even complicated datasets that facilitate the user's ease in discovering and retrieving without being limited to any geographical or physical region (Borgman, 1993 as quoted by IJIRT, 2022; Wikipedia, 2025).

The modern digital libraries offer a variety of resources such as books, journal articles, theses and dissertations, rare manuscripts, photographs, and multimedia content that are generally presented in several languages and society forms to meet the diverse needs of academic, research, and general communities (Muduli et al., 2021). Apart from the general content base, digital libraries are also enabling new models of content management, which include, acquisition, preservation, discovery, and sharing. For instance, they use standard metadata to uniformly structure the information, thus, they enable the functionalities such as federated search which allows users to search across the aggregated databases coming from different sources, and institutional repositories which digitally hold an organization's scholarly output.

1.4 Core Functions and Services

Digital library services significantly extend traditional library functions through an effective use of digital technology in providing an extensive, user-focused experience. These services comprise a variety of significant functionalities that contemporary knowledge access and management demand.

Firstly, digital libraries maintain huge digital collections and archives which allow access to diverse ranges of digitized documents—books, journals, manuscripts, images, audio, and video—thus, users are enabled to explore extensive multimedia content beyond the limits of traditional libraries (Muduli et al., 2021; Wikipedia, 2025). Moreover, these collections are usually supplemented by institutional repositories that contain unique scholarly work such as theses and dissertations; thus, they become instrumental in scholarly research and heritage conservation.

Second, search and retrieval tools are essential source components of a computer library. Sophisticated databases and cataloguing systems make it possible for users to locate the required resource in a very short time by using a keyword, topic, author, or metadata. All of them have very advanced features of filtering, indexing, and federated searching which improve findability and research optimization (Muduli et al., 2021).

Remote and mobile access is another very important service which is made possible by cloud-based platforms that do not restrict geographically and let users access the resources from any place and at any time. Such portability helps different users like remote learners, experts, and international researchers to become empowered by easy and inclusive access to information (Mintbook, 2024).

1.5 Educational and Societal Impact

1. Democratization of Knowledge

   Digital library services remove the barriers of space and money, thus allowing top-notch educational materials to reach all social groups, even the most remote and disadvantaged communities (Mintbook, 2024; Muduli et al., 2021). Such a leveling of the playing field is in line with the ideals of public libraries but at a scale and extent that are beyond the physical world.

2. Enhanced Research and Collaboration

   Researchers and students are provided with the opportunity of instant, round-the-clock access to the most recent sources of information. They also have the possibility of cross-searching resources from different disciplines and can involve themselves in worldwide collaborations— all these being facilitated by metadata standards and open-access repositories (AllPurposeGuru, 2021).

3. Preservation and Sustainability

   One of the major roles of digital libraries is to conserve the ecological, cultural, and academic heritage through the process of creating long-lasting digital versions of rare, fragile, or even unsafe materials (Wikipedia, 2025; Muduli et al., 2021). In a way, these libraries become the defenders against the loss of knowledge due to disasters, decay, or even aging. By continuing to provide up-to-date research and historical materials, they guarantee academic longevity of the present and also become the base for future academic inquiries.

4. Flexible and Inclusive Access

   Digital libraries, which are cloud-based and mobile-compatible, can flexibly support learning through different user groups, such as part-time students, remote learners, and people with disabilities. By means of accessible and adaptable digital resources, these platforms help inclusive education to grow and become a bridge over the gap existing in traditional learning environments (Mintbook, 2024; Muduli et al., 2021).

5. Cost and Resource Efficiency

   By moving to cloud-based or collaborative digital library models, the dependence on physical infrastructure and manpower can be substantially lessened. Besides the benefit of institutions lowering their operational costs, this change also leads to better access speed and makes it possible for service delivery to be scaled as per the user's demand (Mintbook, 2024).

1.6 Ongoing Challenges

Even with these advantages, digital libraries are not free from various types of problems such as technical, ethical, and organizational issues:

- Digital Divide: Differences in digital literacy, internet connectivity, and the availability of devices still cause that access to digital resources inequities continue to exist (Muduli et al., 2021).
- Copyright and Licensing: Limitations on the usage of intellectual property rights may cause that few digital contents libraries provide are accessible to users (IJIRT, 2022).
- Sustainability and Technology: The institution that is responsible for technological obsolescence, uptime, data security, and resource investment will be there in a very few years, although it is a constant concern (Mintbook, 2024).
- Quality and Information Overload: Proper organization, curation, and user education are the main instruments that help to prevent information overload and guarantee the trustworthiness of resources (Muduli et al., 2021).

1.7 Overview of BLDE (Deemed to be University) Library and its current systems

Since 1986, the BLDE (Deemed to be University) library has been a central academic and research facility for faculty, students, and researchers. The library occupies an area of 2400 square meters with a seating capacity of 750 and has a central library plus 25 departmental libraries, providing exclusive reading rooms for undergraduate and post-graduate students, and for staff members, respectively. The library is fully air-conditioned, with a plethora of fast-growing collection of more than 20,000 books, 2,500 journals, 210,000 theses and dissertation, and all types of audio-visual materials, covering a broad range of subjects. The services offered in the library include circulation, document delivery services, literature searches, reprography, interlibrary loan services through DELNET, plagiarism detection services, and services for differently-abled users. Additionally, the policies concerning how the library is used, means of feedback, and outreach programs for user education and awareness also contribute to an enriching experience.

The library has a strong digital infrastructure with a 56-machine digital library having 1 Gbps internet connectivity, both on-campus and off-campus. It offers access to a

wide range of e-resources such as e-journals, e-books, databases such as ProQuest Health Complete, and institutional repositories. The library has an additional e-library in the hospital block to facilitate specialty research. The computerized library management system employs OPAC for resource monitoring and RFID for self-checkout and surveillance. Open 24/7 for reading and 8 AM to 10 PM for circulation and reference, the library places a focus on ongoing access to learning. The BLDE Library is an example of a modern, research-oriented academic library that meets the educational needs of the 21st century by including such channels as Swayam Prabha and having a lively collection updated by the professional staff..

The library possesses an extremely robust digital infrastructure, including a 56-computer digital library with 1 Gbps internet facility, both campus and off-campus. It provides access to various e-resources, including e-journals, e-books, ProQuest Health Complete – and database for can be accessed by using institutional repositories of department. An e-library in the hospital block supports and enhances current research. The library has a computerized management system where they use OPAC (Online Public Access Catalog) for resource tracking and RFID (Radio Frequency Identification Technology) allows for self-checkout and continuous monitoring. The library is open for reading purposes 24/7 and the library is available for circulation and reference from 8 AM -10 PM. The library ethos emphasizes learning without borders and making learning available. The central library at BLDE has all the features and facilities of a modern academic library system. As a centre of learning and research, it provides open access areas, a specially designed newsstand area, and an e-learning zone with the latest infrastructure. The library offers different learning environments and carries an active, well-selected collection which is taken care of by the professionally trained library staff and updated regularly to meet the requirements of the academic community. Being in line with the norms of a modern academic library, the BLDE Library is a source of support for research and learning that is in harmony with the standards of higher education institutions of the 21st century.

1.8 Relevance of mobile apps in academic libraries

By 2025, mobile apps have turned into necessary instruments for academic libraries, basically changing the way library users obtain information, utilize resources, and communicate with library services.

Anywhere, Anytime Access

The mobile apps are not restricted by time or place in any way. In any location library users are able to look through the library catalogs, get e-books and journals, take care of accounts, book study rooms, and be informed about due dates or new acquisitions through the notifications in real-time. The continuous availability is a considerable step forward from access via a desktop only or physically going to the library, especially remote learners and researchers in the field are thus supported (Mucla Research Paper, 2025).

Enhanced User Engagement and Personalization

Library apps provide a tailored user experience through individually designed menus, suggested readings, and user-friendly interfaces. Alerts, reminders, and interaction feature like chat with a librarian's that are quick and easy to use, help to increase user satisfaction and consequently, user engagement. These apps are designed to meet the demands of a digitally native user community, who are mobile-first in their mode of interaction (Mucla Research Paper, 2025).

Support for Learning and Research

Educational mobile applications merge with digital instruments and learning platforms to enable the students to study remotely, take part in interactive learning, and do their research efficiently. These apps serve as links to endless digital libraries, institutional repositories, and third-party resources, which in turn, enhance the academic content delivered and make scholarship better (Nandbox, 2025). On top of that, features such as embedded citation tools, research alerts, and collaborative workspaces give more power to students and faculty.

Operational Benefits for Library Staff

Mobile applications, besides being beneficial to the users, also have a positive impact on library operations by giving the opportunity to staff to do key tasks on their mobile devices. Activities such as barcode scanning, inventory management, cataloguing, and updating of metadata can be performed remotely, thus, library staff are able to increase their productivity and the quality of services they offer. Consequently, mobile applications become a means for library staff to have more work hour flexibility and efficient resource management (Softlink IC, 2025).

Cost-Effectiveness and Scalability

Through mobile applications, which are by nature digital-first access and service enablers, academic libraries are able to lessen their reliance on physical infrastructures and print collections thus, they save money. On the other hand, mobile platforms can be scaled up to cover more users and new service demands without the need for a corresponding increase in resources (Nandbox, 2025).

Future-Proofing and Innovation

With mobile applications, a library can easily implement new technologies like artificial intelligence, augmented reality, and voice assistants. In fact, this flexibility gives libraries the opportunity to be always current and able to respond to changes in user behavior as well as to technological developments (Mucla Research Paper, 2025).

1.9 Statement of the problem

The problem statement for the project is: "Design and Implementation of a Mobile App for BLDE (Deemed to be University) Library: A User-Focused Study."

1.10 Research objectives

a) For gathering accurate information regarding the collection, staff, and various services of the BLDE (Deemed to be University) Library.
b) To give extensive instructions on how to design a mobile app and to discuss the functionalities of MIT App Inventor for the development of apps.
c) To create and implement a mobile app for BLDE (Deemed to be University) Library in APK format that has e-resources, OPAC, and access to the institutional repository.
d) To provide access to the mobile app, enabling mobile users to access e- journals, e-books, and indexing databases seamlessly and centrally for anytime, anywhere access.
e) In order to allow users to download and install the mobile app freely and integrate the app with search engines or app stores to make it more discoverable and accessible.

1.11 Scope and limitations

The scope of this study focuses on designing and implementing a mobile application for the

BLDE (Deemed to be University) Central Library, aimed at enhancing access to library resources and services for students, faculty, and staff. The app will feature functionalities such as book searches, real-time availability tracking, borrowing history, overdue notifications, event updates, and user feedback. Developed using MIT App Inventor, the app is tailored for Android devices, ensuring a user-friendly and efficient interface. However, the study is limited to the university's library system and Android platform, excluding cross- platform compatibility, integration with existing library databases, and advanced features such as AI-based recommendations due to time and resource constraints. The study's geographical boundary is confined to the university, and its findings are applicable within this specific context.

1.12 Significance of Using MIT App Inventor – Detailed Explanation

MIT App Inventor is an online visual programming tool that enables anyone, particularly beginners and non-programmers, to design fully working mobile applications for Android and iOS smartphones. Created by the Massachusetts Institute of Technology (MIT), the application makes app building democratic through an easy-to-use drag-and-drop interface that lowers the barriers of coding. (Abelson, Schiller, and Google Inc., 2023).

1. Educational Value MIT App Inventor is an educational tool that can be very effective in a computer science curriculum. It brings to light core programming concepts such as variables, loops, conditionals, and event handling in a manner that is easy and understandable even for beginners. The creation of real-world applications by students makes the abstract computational concepts more understandable to them as they get to learn by doing.
2. Accessibility and Inclusivity Among the most notable features of MIT App Inventor is its accessibility. There is absolutely no need for a user to have any programming knowledge before, and it can be done from a web browser. In this way, it becomes a perfect tool for students, teachers, and hobbyists

anywhere in the world, even those in remote areas, who may not have access to the latest phones. Such openness helps lessen the disparities in technology access and thus gives more people the chance to learn tech.

3. Rapid Prototyping and Creativity Inventor makes work easier for creative people by giving them the tool to quickly draft, test, and check out the changes in their mobile app ideas. The platform serves well the concept of prototyping for educational, social, and business purposes and even it is done by people without much technical knowledge. The main benefit, therefore, is that the user is free from technical constraints and therefore able to rapidly turn the creative ideas into working mobile apps.
4. Cross-disciplinary Applications In addition to computer science, the MIT App Inventor is still useful in such subjects as math, science, and social studies. Teachers and students can develop apps that help the classroom learning process. They could be tools for easier data collection, language practice, or even simulations, making lessons more interactive, engaging, and practical.
5. Community and Open-Source Development The platform has the support of a lively community made up of people from across the globe, and it is also open to contributions by the community. This communal atmosphere attracts the sharing of resources, the exchanging of good practices, and, furthermore, it leads to the rise of digital literacy in different parts of the world.
6. Empowerment through Creation: MIT App Inventor enables people to solve real-world problems by making their own mobile applications. Such a direct method of learning significantly develops the learner's confidence, logical thinking, and problem-solving abilities, which are the core skills of the 21st- century education. It is a tool specifically designed for Android, thus providing an easily accessible and efficient interface. The research has been confined to the library system of the university and the Android platform only, thus not taking into account the cross-platform compatibility, compatibility with current library databases, and features such as AI-based recommendations due to the limitation of time and resources. The geographical scope of the study is limited to the university, and its findings can only be utilized within this restricted area.

CHAPTER 2: LITERATURE REVIEW

Existing research on mobile application development through MIT App Inventor illustrates its efficiency as a cost-effective tool for novice coders and instructors globally. One of the studies emphasized the employment of MIT App Inventor 2 as an alternative approach to developing Android mobile apps, specifically focusing on Education 4.0 where technological integration raises the quality of the learning environment. The research employed descriptive research techniques and discovered that 90% of the student participants were highly satisfied with learning and employing the platform. Students were able to successfully build personal, academic, and Internet of Things (IoT) mobile applications, such as incorporating hardware such as Arduino microcontrollers into their applications. This study advised incorporating MIT App Inventor into K-12 education to enhance programming among students with no prior coding background (International Journal of Computing Sciences Research, 2024).

A second research thread investigates the novel application of AI with App Inventor to further democratize application building. For example, the launch of Aptly, which enables natural language input with App Inventor's block programming, enables users—particularly young students—to build apps by specifying their functionality in plain words. Early user studies indicated that such AI-enhanced tools have the potential to reduce entry barriers in programming, improve creativity, and raise student engagement regardless of their experience in coding (Patton et al., 2024). In the same vein, researchers have reported the application of MIT App Inventor in workshops focused on the effective teaching of computational thinking and generative AI principles to a wide cross-section of international students, showing greater confidence and motivation to use programming skills in practical settings (Kim, Zhou, Sudo, & Takano, 2024).

Quantitative studies of app projects developed using MIT App Inventor indicate a diverse range of functionalities that were realized by users, ranging from safety applications that deter text messaging while driving to applications that facilitate community outreach activities. The ability and ease of use of the platform were demonstrated to be affected by properly designed tutorials that enable users incrementally to realize the system's extensive scope. Most of the users of App Inventor interact with the environment on their own, using online independent

tutorials and guides to develop applications that address daily issues (Xie, Shabir, & Abelson, 2024).

Existing Library Management Systems (LMS) have rapidly advanced to meet the demands of diverse libraries, including academic, public, and special collections. They offer a variety of features that focus on cataloguing, circulation, digital resource management, analytics, and user services to make library operations more efficient and user-friendly (DevOpsSchool, 2025; GeeksforGeeks, 2024). Most contemporary LMS systems are either web-based or cloud-enabled, thus facilitating automation, providing easy access, and allowing seamless integration of the system with larger institutional platforms to which the LMS belongs (Octal Software, 2025).

LMS are intended to automate the essential library operations that have been traditionally carried out manually such as book catalogue management, issue and return transactions, acquisition, membership, and fee management. By making this change, the library reduces the chances of errors made by staff and the workload of the administrative staff, at the same time, the user experience is enhanced by such means as real-time book availability, self-check modules, and online public access catalogs (OPAC) (GeeksforGeeks, 2024; IJSAT, 2025). The primary features are generally considered to be catalog management, a feature that facilitates complete resource tracking by title, author, and subject, and circulation/inventory management, which can perform the tasks of lending, returning, and calculating fines automatically thus achieving the best control of the inventory. User management makes it possible to have detailed records of members and strong authentication while acquisition modules take care of procurement and vendor record-keeping thus facilitating up-to-date collections (IJSAT, 2025; Octal Software, 2025).

Leading library management software (LMS) of today such as Koha, Libsys, Alma (Ex Libris), and SirsiDynix Symphony have different strategies in handling their operations. For instance, Koha is an open-source platform and flexible to changes but usually, it is necessary to have a technically skilled person to carry out the installation. Libsys is recognized for its complete automation and reporting features but a little institution may find it expensive. On the other hand, Alma has a robust cloud-based integration with powerful analytics feature for academic libraries and at the same time, it is a bit complicated to be deployed. Lastly, SirsiDynix Symphony is a library system that can grow with a user base but a small library may face the problem of being too costly (DevOpsSchool, 2025).

Most recent changes are cantered on cloud engineering for better scalability and robustness, automated notification via email or SMS, access based on smart cards, and mobile apps to improve user experience. Besides, being open to third-party systems, using artificial intelligence for the individualized suggestions of sources and having detailed analytics for making data-driven decisions have already become standard features (Octal Software, 2025; IJSAT, 2025). Nevertheless, there are still some difficulties that the required upfront investment, staff training, and technical skills—especially in the case of open-source or highly customizable platforms—are among them. In addition, difficulties in integrating legacy systems and operating during peak hours are also mentioned (DevOpsSchool, 2025; IJSAT, 2025).

The coming times will see AI driving smarter search and recommendations, the rise of mobile interfaces, deeper integration with academic repositories, and real-time analytics as the core features of the next-generation LMS. Moreover, more efficient support for multiple libraries and better security measures will be the focus of the upcoming library software (Simple Little Library System, 2024; GeeksforGeeks, 2024).

User-centric design principles are the keystone of the mobile app development process that guarantees it to be effective and engaging; after all, users are the ones who need it, want it, and use it (Interaction Design Foundation, 2025). At the heart of user-centered (or user-centred) design is user understanding through research—using methods like interviews, surveys, and the creation of user personas—to make sure the app finally comes to address the actual needs and problems (Damco Group, 2023). By constantly showing real user feedback and behavioral insights throughout the whole design and iteration process, developers can create mobile experiences that are not just intuitive, but also relevant and accepted (Damco Group, 2023; Xojo, 2025).

Simple and intuitive interface is a must! Users must be able to use the application without any difficulties and by the way of familiar design patterns and established conventions. The most important actions and features should be visible at once; thus, users' mental effort would be reduced, and frustration's occurrence would be prevented (Xojo, 2025; Think.Design, 2024). On the other hand, the navigation has to be smooth with an interface organizing the content logically, using clear step flows, and cutting off unnecessary interactions, so the user journey is made easier (Damco Group, 2023).

Pay-off in user's recognition and trust is through consistency of the interface design, which covers the colour schemes, iconography, typography, and layout. If the apps have the same visual and interactive style, they will be creating a recognizable and expectable environment that will also help to build the user's confidence and comfort, thus increasing user satisfaction and brand loyalty (Damco Group, 2023). Personalization of mobile applications is yet another essential principle that can allow users to have the content, dashboards, and recommendations adjusted according to their preferences, which leads to higher engagement and loyalty (Damco Group, 2023).Accessibility is non-negotiable in user-centric mobile design, ensuring app usability for people with diverse abilities by implementing features such as high-contrast modes, readable fonts, screen reader compatibility, and alternative text for images (Damco Group, 2023; Think.Design, 2024). This not only widens the app's user base but also aligns with legal standards and ethical responsibilities.

Involved in the entire process of creating a product from scratch, getting user opinions regularly is the best way to improve the product continuously. The developers can implement such features or make minor changes that would perfectly match the user's needs as their expectations change gradually by collecting user opinions through surveys, analytics, and usability testing (Damco Group, 2023; Interaction Design Foundation, 2025). To sum up, performance enhancement is very important because mobile applications have to be fast and efficient; otherwise, the users' patience may run out. Consequently, they might give up using the application that has not been optimized for performance (Damco Group, 2023).

MIT App Inventor is a web-based platform that is not only free but also developed by the Massachusetts Institute of Technology (MIT). It allows, among others, the creation of mobile applications for Android and iOS devices, particularly for the young beginners, with or without programming skills. It works with a visual, blocks-based programming language, in which you create app functionalities by dragging and connecting code blocks, thus the whole process of app development is made easier and is also open to everybody (MIT App Inventor, 2024). The user interfaces of the apps can be designed by the users with the aid of a very easy drag-and-drop interface referred to as the 'Designer', where different components such as buttons, images, sliders, and sensors can be placed and customized.

The most remarkable feature of MIT App Inventor is the real-time app testing. Thanks to the App Inventor Companion app, the developers can live test their apps on

a connected phone or tablet, thus there is instant feedback and faster iteration during development (YouTube tutorial, 2022). The platform has the potential to cover various app functionalities such as multimedia, GPS, text-to-speech, and connectivity sensors thus it allows the development of applications from simple ones like games or utilities to more complex ones like education tools.

MIT App Inventor is a platform that lets you easily develop mobile applications using drag-and-drop features. This is one of the reasons why it has become very popular among teachers and schools as a way to introduce students to coding and mobile app development (MIT App Inventor Tutorials, 2024). Since the applications are made in the cloud, it is easy to work in teams and share projects as everything is done online, and thus you can access it from any computer with the internet.

Old studies on the mobile application development using MIT App Inventor have testified its effectiveness as a user-friendly platform for both novice and teacher programmers worldwide. One research project reported on the usage of MIT App Inventor 2 as an alternative treatment for Android mobile app development with the focus on Education 4.0, where technology adoption makes a difference in the learning environment. The study used quantitative research methods and found out that 90% of the students in the survey were very happy with learning and using the platform. The students were able to develop various types of mobile applications for personal use, education, and Internet of Things (IoT), and they were even able to incorporate hardware like Arduino microcontrollers as part of their projects. The paper proposed the adoption of MIT App Inventor in K–12 education to prepare non-coders students for the future programming skill requirement (International Journal of Computing Sciences Research, 2024).

Another line of research delves into the application of artificial intelligence with App Inventor in a creative way to further democratize the app-making process. For instance, the integration of aptly, which provides natural language input coupled with App Inventor's block programming, allows users, especially kids, to create apps just by stating their functions in everyday language. The first user feedbacks...

The projects made with MIT App Inventor were studied quantitatively, and the different activities of the users were found to be really numerous: safety apps which discourage texting while driving, community participation and so forth. The platform's usability and power were dependent on the good organization of the tutorials that helped the users explore the system slowly but surely. The majority of

App Inventor users are working independently along with the environment, relying on internet-based self-directed tutorials and resources to build apps that tackle everyday problems (Xie, Shabir, & Abelson, 2024). Moreover, MIT App Inventor has been a common choice in educational establishments for the teaching of mobile app design basics. It has been reported that the online workshops and graduate courses in which it is used provide a practical, hands-on introduction to app development and mobile design thinking. Feedback from such courses has been that App Inventor's block-based method lessens the learning curve, thereby making app design reachable for students from diverse academic backgrounds (Boise State University, 2011). Besides, the studies in library science have demonstrated that MIT App Inventor does help library professionals to create customized mobile applications that are not only library service-oriented but also the ones for better user engagement and effective operations (RRI Digital Repository, 2023).

The studies on mobile app development using MIT App Inventor have achieved a lot, but still there are gaps that need to be refilled with further research. To mention one of the gaps, lack of studies dealing with offline capabilities and access to the technology for users in low-resource or limited-connectivity areas is the major one. Most of the past research has been done assuming the condition of stable internet access which in turn narrowed down the platforms.

Additionally, little research has examined the social and cultural dimension of mobile app creation with App Inventor, such as inclusion, diversity, and equity in access, especially among marginalized or underrepresented groups. More work is needed to understand barriers learners face and how to tailor curricula and tools to foster greater participation and relevance (Dunand, 2021).

Finally, while App Inventor excels in enabling the creation of functional apps, studies on usability, user experience, and app quality control in productions developed by novices remain sparse. There is an opportunity to better integrate user-cantered design principles and iterative feedback loops into the learning workflows, to elevate the quality and impact of student-created applications (Xie, Shabir, & Abelson, 2024).

Most studies point to the central position occupied by mobile apps in changing and improving library services. For example, Bhoj (2020) points out the early resistance of Indian research libraries to embrace mobile-based services despite a worldwide movement toward mobile integration based on the need for instant and seamless access to information. In the same way, (Jakati and Kumar 2022) illustrate how

mobile apps support far-end access and effective information supply, a paradigm shifts from the traditional library service to mobile learning spaces.

The mobile library application's efficiency largely depends on the technological tools and the frameworks of development that are selected. The Flutter open-source mobile development framework, which was created by Google, is very effective in the creation of applications that have native-like features and can be used without any hitches on both the Android and iOS platforms. Among the other notable tools like React Native, and Xamarin, which besides being mobile application development tools also provide backend management, cloud integration, and data security support through Firebase and AWS Amplify, are referred to in the same paper (Sharma & Sahoo, 2024).

Moreover, the like of (Saxena and Yadav 2013) and (Sharma and Sahoo 2024) studies come up with the role of mobile technologies in improving library services. The user experience is greatly enriched by the mentioned aspects plus the advanced search functions, suggesting by individual tastes, e-resources access, and account management.

Research has generally portrayed the use of digital libraries in educational environments as a significant and positive factor on the learning outcomes. Scientists have come up with the conclusion that the easy and quick access to a wide variety of scholarly materials has been a great contributor to the enhancement of learning through digital libraries. For instance, according to (Smith and Johnson 2018), the institutions that have successfully incorporated the digital library systems have not only increased the involvement of students but also research productivity. Moreover, digital libraries are the connection between academic theory and practical applications. As (Brown et al. 2020) mentioned, such libraries offer various multimedia resources—videos, simulations, and interactive content—that are suitable for different learning styles and make hard concepts easier to understand.

Mobile libraries, backed by mobile technologies, have a critical role to play in providing library services for our mobile-oriented society. Reading patterns have inclined more toward fragmented forms due to mobile usage (Zhao et al., 2016). Today, the basic characteristics of mobile libraries are well-defined. A study by (Ma and Dong 2020) revealed that most universities provide mobile library facilities, with 22 universities utilizing Wireless Application Protocol (WAP) and 35 using mobile apps for this service. With advancing technology, users are able to access information

with ease at any time or place. Digital libraries mainly concentrate on delivering extensive collections of e-books and heterogeneous electronic resources (Huang et al., 2015; Ye et al., 2020). Earlier research has mostly centered on the development of special resource databases, operational modes of digital libraries, extension of service models, and assessment standards (Wang, 2013; Xu & Du, 2018; Li & Liu, 2019). (Zhao et al., 2022)

(Kroski 2008) in a report entitled "On the move with the mobile web: libraries and mobile technologies" examined the features of mobile sites used by numerous university libraries and proposed that library mobile websites could provide diverse services based on users' individual needs. In order to efficiently meet the needs of large numbers of undergraduates, libraries may have to give more importance to services like reference assistance, minimal search capabilities, and products that involve the new technologies. (Bridges, Rempel, and Griggs 2010) offered effective data and information for libraries looking to activate their sites, which proved to be a useful guide for suggesting mobile library sites and recognizing the existing trends in mobile technologies. Li (2013) noted that many academic libraries in China employed mobile technology-based interfaces for helping distant users browse scholarly databases for electronic materials. In addition, (Singh and Singh 2015) noted the importance of mobile information services in academic libraries, introducing the "BHU Library Mobile" website developed by Sayaji Rao Gaekwad Central Library at Banaras Hindu University with the purpose of providing improved mobile services to their users. Their work also highlighted the limitations of mobile usage by Indian libraries, such as inadequate Wi-Fi provision, limited screen size, narrow bandwidth, and low storage capacity. •\t(Ballard and Blaine 2012) outlined an extensive mobile phone application that allows users to search catalogues, access reserve modules, renew their books, and seek information such as library hours and events.

(Nalluri and Gaddam 2016) examined Duke University's "Duke Mobile" app that assists student’s on- and off-campus in gaining access to the library resources such as e-books, e-journals, and digital multimedia collections through their mobile devices. It is easy to download this app so users are able to access library collections and databases regardless of where they are located. (Wani 2019) analyzed mobile library apps, emphasizing their characteristics, advantages, and shortcomings and concluded that the use of mobile libraries is vital in order to offer users quick, accessible, and suitable information services.

Mobile libraries are taking a step ahead with the integration of smart services such as QR code utilization (Zhao et al., 2015) and WeChat-based services (Liu, 2021) along with the mobile internet growth. Nevertheless, the basic functions are not sufficient to meet the escalating expectations of the users who get more acquainted with these applications. Thus, the developers are now giving priority to user experience (UX) enhancements even beyond the essential functions. The research conducted on the UX of mobile libraries has centered on users' views concerning technological usage and aesthetic design elements (Lai et al., 2014; Ke & Su, 2018; Wang et al., 2018; Xu & Guo, 2018). Such studies usually asses UX through the quality of the functions provided (system, information, and service), visual design (structure, elements, and color), and infrastructure factors (wireless networks and IoT), stressing the practical and objective facets. In contrast, the emotional journeys of mobile library users are still insufficiently explored. Some researchers have treated emotional factors as a part of the overall UX evaluation (Qiao, 2017; Chen, 2020), but there are only a few who have investigated the impact of interactive IT features on users' emotional responses. This research is different from the previous ones in that it looks into the influence of interactive technology features on users' emotional experiences by assessing feelings right after the mobile library app use. (Revathi, 2023)

Library Management Systems (LMS) have undergone a terrific change, from an entirely manual, paper-based system to modern web-enabled advanced automated systems. They are the backbone of the management of the library's resources, the interactions with the users and the administrative procedures thus increasing the overall efficiency of the library functions (Singh & Kaur, 2019; Sharma, 2021). This review highlights different stages of LMS evolution by focusing on the technological. The first Automated Library Management Systems (ALMS) were implemented in the 1970s and 1980s, where computer databases were used to substitute traditional card catalogues. The early systems merged bibliographic data, which made it possible to catalogue and search by title, author, or subject more rapidly. Even so, the systems were mostly very expensive, technically challenging and had poor user interfaces (Gorib et al., 2017; Kumar, 2018).

The introduction of web technology brought about a wholesale shift, as libraries began to provide online access to their catalogs, services, and databases. Web-enabled LMS made it possible for users to be in contact with the libraries at a distance, thus making the services to reach beyond the physical locations (Patel & Desai, 2020). The

development of such systems also necessitated the use of server languages such as PHP or Python along with HTML, CSS, and JavaScript to provide engaging and user-friendly interfaces (Reddy, 2019). Their core functions include searching, user booking and monitoring of circulation as well as administrative tasks such as management of resources, monitoring of users, and production of reports which can all be done from an area connected to the internet (Ali & Rehman, 2021).

To sum up, the advancement of LMS has been a significant factor in making library services more accessible and efficient. The existing web-based systems are not only capable of doing away with manual work but also improve the users' experience and speed up the work (Shukla & Mehta, 2022). However, problems such as integration with other systems, scalability, and migration of data are yet to be tackled (Das, 2020). When it comes to the future, further tech development is expected to mean more extensive blending of digital resources, mobile services and using state-of-the-art technologies such as artificial intelligence and cloud computing to make the system.

The review synthesizes scholarly articles related to the adoption and usage of mobile technologies in academic libraries. It includes a study conducted by (Kari 2020) which highlighted the fact that librarians and library users in Nigeria were not only aware of but also very much ready to accept mobile technologies in library operations. Moreover, the paper summarizes the work of (Ashiq et al.2023), who investigated the procurement and use of mobile phones in the learning process of LIS students, and pointed out the critical need for mobile access on the part of the academic library in order to make good use of its resources. In addition, a study by (Acheampong and Agyemang 2021) that improved tolerance for mobile furbishing of academic library services in distance learning appraisals has been mentioned as well.23

The literature review critically assesses the service provision area where mobile technology was most effective and broke down the good libraries thus benefiting from their implementation. This is (Al-Droubi's 2018) work whose finding indicated a strong correlation between the application of mobile technologies and the quality of information delivered to users. The review also includes work by (Izuchukwu et al.4 2021) on employing mobile tools and technologies for library outreach service to prison inmates, showing how mobile technologies can expand library services beyond the normal settings. Overall, the literature review presents the situation of mobile

technology adoption in academic libraries as a factor that enhances service delivery to various contexts. (Kolawole et al., n.d.)

Throughout the years, one of the major and common themes in library and information science research was the issue of information access and its dissemination. One of the major ways that early studies proved their significance was by exposing the library services connection with the user's specific information needs. For instance, O'Neill (2001) suggested that library services would be made relevant to researchers' needs if users were individually profiled with keywords and themes. Similarly, Horne and Kristensen (2004) introduced a service for table of contents at Cornell University Library, which aimed to facilitate information delivery and strengthen scholarly communication as its primary goal. Also, Hossain and Islam (2012) pointed out the existence of both electronic and traditional means of dissemination and stated that both activities are crucial in guaranteeing really easy access to academic information resources.

Furthermore, others have focused on the development of technology to displace the barriers in accessing information. For instance, De Giusti et al. (2010) presented an ontology-based system for user-context detection, which allows them to create librarian profiles that are more thorough than what the user provides. In a parallel way, Porcel et al. (2012) proposed the utilization of fuzzy logic techniques to access research materials, which in turn could lead to the discovery of better supporting material recommendations. Collectively, these pieces of research indicate a gradual transition of library services from traditional methods of information dissemination to dynamic, personalized, and context-dependent systems.

The papers have a common theme, which is that developing countries faced a specific set of problems while accepting the new ways of spreading information. Witten et al. (2001, 2006) pointed out that developing countries were almost always struggling with very little access to personal computers, very poor technology infrastructure, and very restrictive information policies, all of which were against the digitizing of libraries. Iran is an example of a country that, despite having a relatively good communication infrastructure, is crippled by an overt reliance on an internal internet network and widespread censorship that prevents access to global scholarly knowledge (Anderson, 2012; Wulf et al., 2022). These conditions have resulted in a number of libraries adopting old technologies, such as card catalogues, instead of moving on to advanced digital tools (Saeidnia et al., 2022).

Mobile technology is now recognized as a major force in reshaping academic library services, as it offers flexibility and accessibility that are not limited by physical location. Bomhold (2014) emphasized that mobile services are integral to the satisfaction of changing user communities, while Lippincott (2010) pointed out their role in giving access to materials that is both on-demand and independent of location. User-centred design and personalization have been the driving forces behind this transition. O'Neill (2001) had pointed out the importance of selective dissemination of information (SDI) tailored to fit researchers' profiles, and De Giusti et al. (2010) continued this tradition with ontology-based systems that put users' needs in context. Porcel et al. (2012) applied fuzzy logic techniques to improve access to expert resources, thereby demonstrating that intelligent systems can help academic information services.

Despite advances in technology, libraries in developing countries still face infrastructural and policy obstacles that prevent them from going digital. According to Witten et al. (2001) and Witten (2006), a lack of proper technological infrastructure and limited access to computers are some of the factors that hinder the acceptance of digital libraries. The situation in Iran is an example of this as the reliance on local internet networks that are censored limits the country's access to worldwide scholarly content (Anderson, 2012; Wulf et al., 2022). Therefore, libraries today are still using traditional methods like card index systems (Saeidnia & Hasanzadeh, 2022). Still, research highlights the redemptive potential of mobile apps in bridging such divides. Wong (2006) and Michael (2010) were of the view that libraries in poor countries could step up human development by providing free access to major information on health, agriculture, and education, which is still there in many nations. Thus, mobile applications can be seen as a solution that is not only economical but also very easily accessible and user-friendly for expanding information access and improving the academic research environments (Canuel & Crichton, 2011; Saeidnia et al., 2023).

In the past twenty years, mobile technology being integrated into library services has become a significant topic in scholarly discussions. The study done by Karim, Darus, and Hussin in 2006, which showed the mobile phone and wireless applications like SMS notifications, academic timetables, and library alerts as the major facilitators of education in academic libraries, was one of the earliest and tracts in this direction. In fact, Herman (2007) also investigated SMS reference services and came up with

similar conclusions that they helped students get access to information that was fast and convenient. Hahn (2008) gave a broader context by introducing mobile learning (M-learning) and declaring it as an unplanned yet transformational change in both education and librarianship. All these researchers are in agreement that cell phones are not only communication gadgets but primary mediums for the dissemination of library services.

In addition, researchers have also looked at the mobile technology in libraries as a source of user interaction and innovation. Maxymuk (2009) argued that libraries sending messages through text kept them in the front and made them interesting to young people even if there were some limitations like message size. Walsh (2009) and Fox (2010) went so far as to state that the mobile-based services are in line with the needs of distance learners and the growing demand for mobile access to learning materials. Cummings, Merrill, and Borrelli (2010) showed that academic library users were ready to use OPACs on their handhelds thus they pointed out the role of mobile devices in information retrieval. Parsons (2010) supported this by presenting the scenario of distance learners who are increasingly reliant on mobile phones for their information needs, which means that libraries will have to adapt in order to stay relevant with their target users

CHAPTER 3: METHODOLOGY

3.1 Research Design

Below is a structure suitable for two pages that encapsulates a thorough, user-centric research design for the development and execution of a mobile application for the BLDE (Deemed to be University) Library. This design synthesizes global best practices and the recommendations of peer-reviewed studies while pinpointing user needs, app development through iterations, and thorough testing as its key aspects.

The rapid advancement of mobile technology has altered the picture of information access, and mobile applications have become a necessary means of academic libraries to offer their services more efficiently. The library of BLDE (Deemed to be University) is planning to develop a mobile app with the objective of providing better access to information, resource discovery, and improved user experience in the academic environment. A user-focused research approach ensures that the final product not only satisfies the needs of the users but also meets the expectations of current library services.

2. Research Objectives

- To design a user-centric mobile library app grounded in the specific needs of students, faculty, and staff at BLDE (Deemed to be University).
- To systematically evaluate user requirements, app usability, and the impact on library service satisfaction.
- To provide actionable recommendations for the continuous improvement of digital library offerings.

3. Research Methodology

Mixed-Methods Approach This research is conducted through a mixed-methods approach, which means the whole methodology is grounded on a combination of the quantitative and qualitative methods for determining app effectiveness and user expectations that will eventually lead to overall understanding.

Phase I: Needs Assessment

- **Surveys:** Library patrons will be the main sources of getting the required information through the use of standardized surveys. The questionnaires will contain very specific questions on the most used digital amenities. The library

users will be asked about their intentions to use the Online Public Access Catalogue (OPAC), their inclinations towards online book renewals and reservation facilities as potential services. The survey might also include the automated reminders like due date reminders into inquiry. The query may also include the library's preference of usage of e-resources through the digital portals.

- **Focus Groups/ Interviews:** Focus groups and interviews will be conducted with mixed library users also. These user interactions will focus on exploring user experience and expectations while also allowing participants to talk about shared experiences with challenges, and helpful pain points. These discussions will provide information about user preferences and in evaluating the users' varying level of digital literacy. This information will be combined to help the library design and define the technical services based on user preferences and evaluate services/models to meet user needs and expectations.
- **Literature Review:** There will be a literature review guided by ideas of systematic literature reviews to assess national and international case studies with an emphasis on electronic library systems and emerging practices. This would include, for instance, examination of peer-reviewed articles, policy documents, and best practices, to understand key features such as mobile OPAC, push notifications, online ordering of items, and integrated e-resource gateways that have been implemented elsewhere. This would also promote a better understanding of common impediments to implementation such as technical challenges, resistance, lack of infrastructure, as well as digital equity issues to justify features in the local context. Further, this aspect of the literature review will inform regulatory, infrastructure, and cultural considerations for any system proposed to assist in evaluating it against, or allowing for future adaptations. The benefits of the literature review will also help establish a framework/tabulation for effective justification of feature choice, as well as mitigate challenges to potential or existing change. The literature review will be an important element of the initial planning and development of a user-centred, effective, and scalable library system.

Phase II: Design and Prototyping of an App

- **User-cantered design principles:** The design and prototyping of the library system will be guided by user-cantered design principles to effectively meet the needs and expectations of users in the real world. Features will be prioritized based on feedback generated from surveys, focus groups, and interviews, to ensure that only the most relevant features are included. The design of the prototype will promote accessibility and universal design standards to enable use by people of all abilities. The interface design will be very user-friendly and at the same time very much revised for ease of navigation and reduction of the learning curve, while also incorporating the possibility of multi-language support in order to attract the widest possible variety of users and to offer them the best possible experience. User testing will be a continuous activity and will take the largest part in the system beeing developed this way, resulting in a more inclusive, efficient, user-centered library experience.
- **Development platform:** MIT App Inventor is set as the development platform for the library system prototype, and its block-based visual programming environment can support rapid prototyping with almost no programming skills. It is thus considered to be a very efficient platform for the rapid and user-required development of features that stem from user research such as OPAC access, renewing books and notifications. The platform provides easy testing and deployment to Android devices, and thus developers are able to get instant, in-the-moment feedback, and also easily and quickly iterate on that feedback so the prototype will be modified to fit the user's needs. This is a way to a flexible, user-oriented development process that dominates functionality, accessibility, and extra development.
- **Usability Testing:** The testing of usability will involve performing observational sessions during which users will be in direct contact with the library system prototype under perfect conditions. The behaviors, problems, and comments of the participants during these sessions will be tracked and processed to discover usability issues, which may be related to navigation, confusion with certain library system features, or problems with accessibility and mobile usability. Volunteers will be asked to give extra suggestions along

with their comments, which will serve as helpful feedback on the ways to lessen the usability issues that affect the overall user experience. The information that will be collected will directly influence the design process, which will be measured by the ease of use, functionality, marketability, and friendliness to the user of the final product. The whole usability process is expected to result in a library system that is not only helpful but also delightful to a diverse group of users.

Phase III: Implementation

- **Pilot Launch:** The pilot launch will include an application that is launched to a limited number of users in order to determine its functionality and viability in a live setting. A part of this phase will provide detailed user manuals and training materials so that users have a way of interacting with the app and carrying out its functions. The findings from the pilot launch will be instrumental in spotting possible improvements in the future. Real usage and user feedback indicate changes that can be made prior to the full rollout. The pilot launch represents a significant milestone in checking the performance, usability, and enjoyment of the app from the perspective of the intended concept.
- **Data Gathering**: The relevant metrics for the app usage will be constantly tracked throughout the process, and amongst them will be downloads, active sessions, and the use of specific features. With the help of quantitative data, we will be able to identify the patterns of the users' interaction with the app, the most and the least used features as well. Besides, we are going to run an in-app survey simultaneously, which will give us qualitative, open-ended user feedback regarding their experience with the app, encompassing what they like, dislike, and find difficult. The combination of these data sources will assist in determining the level of user engagement and satisfaction, which in turn will lead to continuous improvement—ultimately providing a service that is responsive to the users' needs

4. Ethical Considerations

Before the study begins, participation from each person will not be done without getting their informed consent. They will be enlightened about the aim, methodology, and possible hazards of the study. Apart from that, the participants will be told openly

and honestly about the instruments of their data usage, storage, and confidentiality protection to ensure non-disclosure. They will be informed about the safe-keeping of their information, the voluntary nature of their participation, the right to withdraw anytime at no cost, and no blame. Such methods will not only ensure but also create trust through the research process as well as uphold ethical standards.

Throughout the survey and usability data collection and management, the privacy of the participants will be safeguarded actively in compliance with the university and research ethics policies. Autos of the participants will be made unidentifiable or eliminated completely so that the information can be kept secret and all data will be locked up in a safe place with limited access. Every action or operation concerning the participants' data will strictly adhere to the data protection laws to guarantee that unauthorized access or disclosure is avoided. Through conducting our research in this way, we will not only gain but also secure the trust of the participants and the integrity of the research.

5. Potential Outcomes

The project’s goal is to come up with a strong mobile application that will meet the specific needs of users of the BLDE (Deemed to be University) Library. One of the features the app will offer is the users' access to OPAC, renewal, and reservation. It will notify users in due time, and they will also have hassle-free instant access to e-sources. The app will be created following principles of user-centered design that include accessibility, simplicity, usability, and multilingualism to accommodate the difference of academic institutions. Library user experience will get better through regular user input and the continuous upgrading and changing of the app. The project, to sum up, will smoothen the process of discovery and resource management and at the same time making it more convenient for the different kinds of library users.

The conclusion of the mobile app will be that more users have gained the library’s digital resources, as users will have the possibility to easily browse, request holds and renew items from their devices. The library's user experience will improve so much that it will be evident through the user surveys, usability tests, and app reviews that the app's user-friendly features and functionalities are being acknowledged. Users will, furthermore, drop the library resources mostly through more and more regular sessions, active use of features, and attending events supported by the library through the app. All these factors will together prove the app's importance in fulfilling user

needs and in the university's mission to promote learning and research that would be enforced by the app's availability.

3.2 Method – User-Centred Design

A user-centred design method for the BLDE (Deemed to be University) Library mobile app entails a multi-step, iterative process which prioritizes consistency of users' goals, behaviours, and satisfaction in all stages of development. This section identifies and presents the core concepts, practical steps and established principles that underpin a user-centred process that can be presented as content for up to two academic pages.

What Is User-Centric Design

User-cantered design is design that focuses on real users, rather than the assumptions of the organization. User-cantered design is based on the explicit knowledge of users, user context, and the tasks users want to perform in [insert digital library]. The goal of user-cantered design includes a focus on usability (i.e. how easy or efficient is it to complete a task), completing tasks, and all users enjoying or finding value in the experience, regardless of their background or abilities.

Key Principles

User-Cantered Understanding

The initial step will be to study user demographics, contexts, and behaviours using surveys, interviews, and observations. The multi-point study allows for the accumulation of rich qualitative information regarding who the users are, how they utilize library services, and obstacles that hinder them when accessing digital services. Such user-cantered understanding of elements will yield a robust foundation to perspective that is attuned to users' and contexts' needs of the library's user group. This user-neutral, research-centred analysis will set up the standard for impacts—usability and participation encouraging features and functions.

The library's understanding of the users and their needs will be continually in flux over time. The library will always be adjusting its research methods to include surveys, spontaneous feedback collections, plus user observance, to keep track of changes in user preferences, the needs of users, user-created barriers, and new technology that is attracting audiences. This type of user-centred, research-free investigation will ensure that library services are ever in some state of being relevant

and trustworthy. This assumption is made to ensure that user, or patron, involvement is both continuous and to current need.

Inclusive and Accessible Design

The design will prioritize universal accessibility, ensuring that the interfaces work at their best no matter the users' skills and their devices. Support for the screen reader, keyboard-only navigation, text size control, and good visual contrast will all be part of the functions. The app will also be made very user-friendly across different devices such as smartphones, tablets, and desktops, thus providing a friendly experience for all, regardless of the device used or the physical capability of the user.

The accessibility of the app will be a major concern and this will be achieved through the use of large fonts, high-contrast modes, and other means that promote clear and readable text for users with visual impairments. The library community's language needs will be supported as much as possible by providing multilingual access—thus, the visual impairments will not be the only factor to be considered when it comes to languages. All these app features will facilitate users' successful access and usage of the app, hence, welcoming and inclusive experiences and equitable access to library resources will be supported.

Iterative User Involvement

The users will be engaged at all levels of the design process: from the start, via brainstorming and prototyping, usability testing and usability feedback. User data experiences will drive our decision-making so that the output reacts to users' needs and desires. Adopting a collaborative methodology to design promotes user-centred design and finally makes library systems more satisfactory, usable, and effective overall.

Ongoing and direct interaction with users will prevent bad design decisions (and development drift) through ongoing alignment with actual needs and expectations. Through shared work in design work or feedback, users will become co-creators and discover value and commitment to the work. The outcome will be more intuitive and relevant library systems, most likely to be embraced by users, and ultimately improving the user experience.

Easy-to-Use, Common-Sense Interfaces

To reduce user effort and minimize the learning curve, the app will be presented with visible navigation, rational organization, and uniform, standard labels across the

interface. The consistency enables users to quickly determine what actions they must take through the process and locate what they are seeking without becoming disoriented. Designers reduce a user's burden by applying directness and consistency, which allows placing a cognitively less demanding task in an environment of suitable meaning, which can lead to proclivity to interact and task effectiveness.

In addition, the application will develop the main library functions (such as searching for items in the catalogue, renewing of a book, and access to a resource) intentionally and noticeably central and available. Making central services centrally available makes the most significant and useful parts of library use easily accessible without excessive navigation effort. This practice makes the user experience more efficient by making the app's assistance available and effective in carrying out simple and daily library functions.

Holistic Consideration of the User Experience

The application will be limited to the needs of the whole user experience: library discovery and resource use, and account administration and support for users. The wide range of services involved will make it possible for the users to have a unified experience all over the library from searching the library for information, finding the resources, managing their accounts (renewals, reservations, etc.), and shipping out the support quickly if needed. The whole user experience consideration will bring about a consistent, satisfying experience that will prompt the user to use the library's services more and more. Its design will not only focus on the immediate user experience but also on what is likely to the future needs by creating useful guides and providing support channels that are easy to access and highly responsive. As a result, the users will be able to get help without becoming frustrated either during the use of the application or when the problem is being solved. The clear announcement of easy and user-friendly directions is one way of promoting a good user experience when seeking help, and it ultimately contributes to the overall experience of the user in accessing the library's services.

Uniformity and trust

The user experience of an application is trusted, confident, and efficient built on a common look and a reliable operation. Trust comes from a design and interaction language that is easy to understand and predictable, which gives users the comfort of moving around the system and taking advantage of its features. Users' understanding

of the system is no longer a barrier; they can do their tasks with less time spent and the whole experience is that of a professional, well-designed institution, which in turn reinforces their trust in the library.

The app's design will be totally in line with the university's brand standards in order to create a harmonious and recognized user experience. Users will not only be shown but will also feel the familiarity when the colours, fonts, logos, and the whole visual style of the app will be the same as that of the institution's broader branding. Such a strong visual similarity not only supports the branding of the institution but also communicates that the app is part of the campus community, thus improving the users' trust and their relation with the institution.

Sustainable and Responsive

Feedback loops will be kept always open, with in-app surveys, user discussions, and user analytics as tools for uninterrupted communication from users. These will consist of a combination of member response which can be quantified and also gathering qualitative data which will listen to the users who might want to see some areas improved and what their needs are. By the continuous use of this feedback system in the development cycle, the app will not only be progressive in terms of its development but also to the community, so that the app will always be relevant, easy to use, and eco-friendly in its services forever. The app's maintenance and updates; as new features are developed will be done with consideration of university-specific resource commitments, where applicable, in order to secure usage sustainability for a long time. The resources may cover; budget allocation, technical support, and staffing level assignment for conducting regular maintenance revisions (such as updates or bug fixes), and handling features that arise with changing needs requests and existing or new trends in mobile apps. By making the planning and allocation consider the university's capacity and priorities we will guarantee there will be ongoing app improvements such as updates and responsiveness to the campus community.

The User-Cantered Design incorporated into the following stages:

Stage 1: Needs Assessment

The BLDE community comprising students, staff, and faculty will be first surveyed through baseline research as a means to collect a well-rounded picture of their experiences and the library's requirements. It entails the collection of both quantitative information via surveys and qualitative information via focus groups. This way, the

user's major activities such as book searching, book renewing, and database access will be marked out along with the difficulties faced by the users. User high-priority needs will, thus, be mapped and the information will help in the library app's design and development as it will make sure that the app caters to the user's most important needs.

Stage 2: Persona and Journey Mapping

The library will very clearly and explicitly create personas to highlight the main user groups of the library and to describe their visit motivations and impeding factors as well as the information needs for utilizing the library's services. The personas will help design team members to recognize different user types, and to modify app functionality for the corresponding users. Furthermore, library app user journeys for the personas will pinpoint and document the gaps and friction points for the entire user experience. Ultimately, this would help the team in tuning user interaction flow and improving navigation efficiently. The hope is that these user interface updates will, in the end, make navigation as well as the information-seeking process, more user-friendly and thus, lead to higher overall satisfaction with the library's application.

Step 3: Prototyping and Feedback

The application will be rapidly prototyped with the help of MIT App Inventor. The technique offers the option of quick and easy feature and layout changes according to user feedback. The users would be able to participate in the design process live while the designers would be testing the ideas and would find out what the users like. Usability testing workshops will be periodically conducted where the prototype would be used by all participants and designers would be witnessing the struggles or suggestions from the users very close. The results from the workshops would guide the iterations that would ultimately lead to a more intuitive, usable, and relevant app in the long run.

Step 4: Implementation of Accessibility

Features that are easy to use will be developed with full adherence to digital accessibility standards such as WCAG and Section 508, thereby allowing the app to be used by users with disabilities. Besides, support for multiple languages will facilitate different languages spoken by the university's user community. Moreover, the app will not be restricted to a single type of device (e.g., smartphone, tablet,

desktop) thus guaranteeing accessibility depending on the technology preferred by the users.

Step 5: Evaluation and Enhancement

User interaction, feature usage performance measures, and trends will all be monitored through in-app analysis providing substantial numerical values related to the app's interface. In addition to these, in-app questionnaires and subsequent conversations with users will help to get the customer's needs, level of satisfaction, and feedback area, which can be classified as the main source of data. These quantitative and qualitative approaches in general will provide a user experience scenario for further development and library community's needs responsiveness which will be inevitable.

Step 6: Iterative Process

Analytical data from the app combined with user feedback to support continuous improvement in an iterative manner will be the main routine cycles for review. The expectation of project improvement through a careful approach will ensure that the following rounds of improvement are based on data and user needs as outlined by their feedback. Trust and active user participation in the project will also be increased by recognizing user feedback and showing how changing user behaviour on good suggestions will lead to good results. Giving users a say in such matters creates trust and motivates them to keep engaging with the app and the community as a whole by sharing their opinions and suggestions for improvement.

Benefits and Impact

- Significantly enhanced user satisfaction, trust, and engagement with library resources.
- Reduced barriers and streamlined tasks created a more efficient opportunity for library resource usage and discovery.
- The library has the ability to transform and evolve over time and in response to ongoing feedback and user behaviours beyond initial launch.
- An approach that calibrated to users will allow this library app to transform, not remain static, an academic library experience that evolves with new behaviours and technologies, hence will always improve the overall academic library experience for all.

3.3 Tools and Technologies Employed

This section explains the tools and technologies that were utilized for developing the BLDE (Deemed to be University) Library mobile app. In particular, emphasis will be placed on the use of MIT App Inventor for the front-end design and implementation, Firebase/Google Sheets for the database to store data, and the APIs and integration components. This section is organized to fill approximately four pages.

Technology and Tools Utilized

1. MIT App Inventor

MIT App Inventor is the principal development tool for the BLDE Library mobile application. It is a visual programming environment based in the cloud that allows users to build android applications through an intuitive, drag-and-drop method and without any advanced programming knowledge. MIT App Inventor has a number of important benefits:

- Visual Blocks - Application behaviour is built using blocks that connect together like puzzle pieces and contain logic to generate code that allows for prototyping rapidly and making modifications easily.
- Cross-Platform - It can be accessed on Windows, MacOS, and Linux, from any modern browser, with Google account credentials.
- Real-Time Testing - Live apps can be tested on Android devices, or emulators, as the developer or user is able to view changes when they are made.
- Extensible Components - MIT App Inventor is made up of built-in components that can be utilized to create user interface elements, use sensors, create and read databases, media, and connectivity (Bluetooth, WI-FI).
- Extensions Support - MIT App Inventor supports the addition of extensions, either from a community or a custom experience, which adds functionality to the app, including to remote databases.

2. Firebase as Backend Database

Google Firebase was deployed as the backend real-time database service to use with MIT App Inventor for the purposes of managing data storage, retention and synchronization across users and devices.

- Real-time Database: Firebase enables a NoSQL cloud database to store data in JSON format while synchronizing in real-time to all connected clients.
- Data Storage: App interactions such as book searches, reservations, renewals or feedback were stored in a secure manner with live updates.
- Scalability: Firebase is capable of managing thousands of concurrent users while introducing minimal latency, making it an ideal application for a university-wide library app.
- Security Rules: A configurable database security system enables access and modification of data only by authorized users.
- Cloud Functions and Authentication: Firebase offers authentication features including email, Google sign-in and custom user management, to introduce secure user sessions in the app;

Integration between MIT App Inventor and Firebase Utilizing

The Real-time Database API in Firebase, it is possible to connect the MIT App Inventor with Firebase and have data exchanged between them and synchronized. Setup for Firebase

- Creating a Firebase Project: At the Firebase Console, developers can create a Firebase project (which will ultimately allow them to use Firebase's Real-time Database feature).
- Configuring the Database: A structured JSON database schema is designed based on the application's data needs (example types of data presented in JSON: user profiles, book records, transaction logs).
- Security Rules: While developing, the rules for the database might be set to public; however, in production, you would need to have much stricter read/write rules.
- Grabbing Credentials: A Firebase URL and a database secret (token) is generated and used in MIT App Inventor to connect with Firebase.

Integrating Firebase in MIT App Inventor

- Firebase Database Component: An experimental component in App Inventor designed to support real-time fetching, storing, and updating of data with firebase.
- Storing Data: When users perform certain operations, blocks will trigger the Store Value functions to write data to firebase with a specific tags or keys.
- Retrieving Data: The Get Value function will get data from firebase and triggers a handler to process the data and update the app to reflect the data.
- Data Change Listener: When the event Data Changed happens, it detects that there have been changes in the database and will notify the app to update.
- Dealing with Data Structure: Data structures can be dealt with using nested json objects with pre-defined tags to enable updating and querying of the data.
- This enables the app to become responsive, connected, and data driven, enabling updates to both user interactions and library service updates.

Using Google Sheets (Another Database Option)

- Google Sheets can serve as a lightweight database alternative or adjunct data source, particularly for non-concurrent use cases or administrative datasets, although Firebase is the preferred option for more robust capabilities (e.g., real-time capabilities).
- Operation: Google Sheets operates as a cloud-based spreadsheet that can be utilized via API calls.
- Web API Integration: App Inventor can be integrated with Google Sheets using the "Web" component, which sends and receives data via the Google Sheets API or Google Apps Script web apps.
- Use Cases: It can be an excellent option for storing static or semi-static data types, such as book catalogue metadata, user feedback logs, or admin-type records, with the understanding that real-time is not important.
- Limitations: Google Sheets is not as efficient for heavy duty read-write operations or multi-user concurrency, as compared to Firebase.

APIs and External Integrations

The BLDE Library app can integrate multiple external APIs to enhance functionality:

- Library OPAC API: integrates to the university's Online Public Access Catalogue (OPAC) to allow the real-time searching and checking of availability of physical and electronic resources.
- Barcode Scanning API: allows users to scan ISBN or QR codes for quickly looking up information on books. MIT App Inventor supports camera components and extensions to enable a Barcode Scanning API.
- Notification APIs: Firebase Cloud Messaging (FCM) allows for push notifications for due dates, hold status, new arrivals, or to alert users about an upcoming event.
- Authentication APIs: Firebase Authentication or university single sign-on (SSO) systems can aid a secure user login protocol for logging in and obtaining a personalized experience.
- Analytics APIs: Google Analytics or Firebase Analytics can be added to track how users use the app, which features users favour, and user engagement to drive ongoing improvement and development of the app.
- All API integrations rely on RESTful web services or components hosted in SDKs or libraries, and easily adapt to flexible and modular feature integrations while maintaining seamless implementation for MIT App Inventor's block-based interface.

3.4. Data Collection Techniques for User-Focused Mobile App Development

Data collection is essential for the development of a mobile library application that is designed for users. The primary methods used in the study of the BLDE Library app were surveys, interviews, and observations, each providing invaluable information regarding user behaviour, user preferences, and user-related challenges.

Surveys

Surveys are designed questionnaires that facilitate the collection of quantitative and qualitative data from a large user population efficiently. Surveys will be used to collect important information from users, including demographics, digital usage, desirable features, and satisfaction with mobile library services. Surveys in the context of the BLDE Library mobile app study will be used to assess common user

needs, rank library app features, and learn about users' attitudes towards the library's mobile offerings in general. The surveys will be developed to include closed-ended questions such as Likert items to rate the importance of library app features, as well as open-ended questions to allow users to offer descriptive feedback. Surveys will reach a variety of people, including students, faculty, and staff by email lists, university online portals, and through social media platforms, to gather a diverse, representative population. Benefits of surveys include allowing users to provide statistically significant data; enabling easy comparisons across groups for each survey question and to cover large populations in a quick manner. However, surveys may miss some complexity related to user frustrations or usability issues. Examples of survey areas of inquiry may include: when they use mobile devices (for academic purposes), features they would like to see in any library app (e.g. catalogue searching, e-resource access, etc.), and satisfaction levels with any digital library service.

Interviews

Interviews serve as an important augment to surveys and provide in-depth qualitative understanding of user experiences, motivations, and unmet needs. The aim of interviews is to probe the specific reasoning behind behaviours apparent in surveys, e.g., to explore why users engage in particular behaviours and the emotive experiences they have along the way. Semi structured interviews are best in this research because they allow interviewer guided questions, yet also allow users to elaborate on their thoughts and responses. Core user groups were purposefully selected to participate in an interview; students, faculty, and researchers with various levels of digital literacy. Interviews will occur either in person or over a video-conferencing platform, to allow for a more comfortable and natural environment for open discussion. Contextually rich data will help to identify subtle needs and opportunities for improving mobile access and usability. While interviews are useful in generating evidential insights, they also take considerable time and are less generalizable due to small sample sizes. The topics of interviews usually contained queries about user experiences with current digital library services, challenges of using the app to search, or reserve resources, and problems with the app, as well as possible suggestions for improvement. All recorded interviews were transcribed and thematically coded to allow researchers to identify common themes in alignment with user centred design principles.

Observation

Observation is a direct data collection method that allows for the documentation of behaviours of users in a context, unimpeded. It aims to obtain first-hand accounts of user interactions with library services, to uncover real-time barriers, workarounds, or inefficiency that may reside outside of participants' articulation in surveys or interviews. There are two main types of observation: non-participant observation, when researchers observe users and note how they navigate the physical or digital library in silence and participant observation, where the researcher interacts with users throughout their activity to note behaviours and responses. Observations generally occur in both the physical library spaces and during the usability testing of prototypes of mobile applications. These approaches will often document users' true behaviours alongside the role of contextual factors, and environmental aspects in user interactions. Users' behaviours may, however, be biased by the presence of an observer (referred to as Hawthorne effects) and analysis of observation requires owning a careful analysis of the behaviours objectively. Observations typically include noting observations on the time required to locate digital catalogues or specific resources, as well as the steps taken in search, borrowing or renewing materials, maiing conditioning around common usability errors and hesitations while interacting with an app. Field notes and videos acquired during observation will also be used to analyse observation data for patterns, bottlenecks, and challenges around usability, to offer meaningful information to inform adjustments in the iterative design process.

3.5 Sample and Respondents

- The groups included in the sample population for the study of the BLDE (Deemed to be University) Library mobile application comprise three key groups of respondents: students, faculty, and library staff. They represent the major stakeholders impacted by the use of library services and resource management.
- Students: Students are grouped since they represent the largest user population. The participants are those undergraduate and postgraduate student learners within a variety of disciplines. Students' diverse needs and patterns of use are important feedback on the app’s usability and function as it relates to features on the app.

- Faculty: Faculty members utilize the library for research, teaching, and accessing academic resources. Faculty provide feedback on the influence of advanced resources on teaching, how these resources fit with their workflow, and app usefulness from a scholarly perspective.
- Library Staff: Staff's experiences are important for operational feedback on impacts on workflow, data management workflows, and technical feasibility. Staff feedback helps ensure the app adds value to processes that library staff value within their library user experience.
- The sample population groups were selected based on stratified sampling methods with representation from each of the groups proportional to their populations at the university. An example of this selection is for student participants, where students were stratified by groups such as year in program, and faculty of study to obtain a variety of perspectives about the app experience.
- Simple random sampling took place within meaningful strata of students to eliminate the bias of sampling from the population and increase potential for generalization. The purposeful sampling method of selection will be utilized when interviewing library staff members and select faculty member subject matter experts for a qualitative, focused, contextual response related to their experience with the library app.

3.6 Data Analysis Techniques

- The procedures for analysing the data draws on a mixture of quantitative and qualitative methods derived directly from the data collection methods:
- Quantitative Analysis: The survey data will be analyzed using statistical software (SPSS or Excel) and coded into responses. The means, frequencies, and percentages will be computed to briefly describe the use of and preferences for the different features. Cross-tabulation will assess the connections existing between the variable’s demographic and attitudes towards app use. The results will be shown in charts and graphs for easier understanding and accessibility.
- Qualitative Analysis: The analysis of the interview transcripts and open-ended survey responses will be done applying the thematic method. The researchers

will go through the transcripts and open-ended survey responses to identify the common themes, feelings, and issues related to the user experience with the app and will do the coding of the text to categorize the meanings of the responses. We will make use of the NVivo software for the coding that will help in the easier recognition of patterns and in the provision of a rich narrative analysis, all based on the user-cantered design principles.

- Triangulation: One of the ways to ensure the reliability of the research is through the correlation between the quantitative trends and qualitative themes. The data captured through observations also verify the self-reporting measures by confirming the user's actual usage and at the same time indicating the gap between intention and actual use.

3.7 Ethical Considerations

Research conducted in an academic environment must conform to rigorous ethical standards:

- Informed Consent: The participants will be informed about the purpose of the study, the process they would be involved in, confidentiality measures, their option to participate in the study, and their right to leave the study at any time without any negative impact on them.
- Confidentiality and Anonymity: No identifying individual information is present in the data and reports as all individual identifiers have been removed and all information has been anonymized. The data is kept in a secure place and only the members of the research team will be granted access to the data storage.
- Data Use Transparency: Participants will also be informed as to the ways that the data will be used in the future, which will include scholarly dissemination (e.g., a journal publication, conferences, etc.) as well as an advisory capacity in the development of future applications.
- Reduction of Risk: The research will not contain sensitive questions or questions that could be viewed as invasive. If participants experience discomfort or duress during research, support will be available to participants. Ethical clearance will be obtained through the university's Institutional Review Board (IRB) or equivalent board prior to the data collection.

3.8 Limitations of the Methodology

Although the research design aspires toward comprehensive understanding there will be limitations acknowledged:

- Sampling Limitations: Though the design included an element of stratified sampling, it is possible that there may be an under-represented user subgroup due to lack of response or difficulty accessing certain populations, which may bias findings.
- Self-Report Bias: The surveys and interviews included in this study rely on the participant's memory, honesty, and truthfulness, which may elicit recall bias and/or social desirability bias, possibly resulting in inaccurate reporting of behaviour.
- Observer Effect: During interaction observations, the presence of researchers may alter user behaviours. This phenomenon known as the Hawthorne effect makes judging genuine individual interaction additionally difficult.
- Time and Resource Limitations: The time and personnel available for conducting an observation, and interviewing a user, can result in difficulties in framing depth (of questioning and interviewing) or breadth (observational behaviours).
- Technological Barriers: Participants may have varied levels of digital literacy and differing approaches to interacting with the application prototype and responding to questions during usability testing, which can create variability in responses and user feedback.

  Acknowledging the limitations gives the reader context for interpreting the results of the study and advises possible recommendations for future study or iterative improvement of the application

CHAPTER 4: SYSTEM ANALYSIS AND DESIGN

4.1 System Requirements

The BLDE (Deemed to be University) Library mobile app system requirements include functional and non-functional requirements that influence how the application is designed, developed, and deployed. Functional requirements specify what behaviours or operations the system needs to achieve user requirements. Examples of functional requirements include the ability to search the library catalogue by title, author, and key terms; allow users to reserve and renew books; provide a real-time notification of due dates and new arrivals; allow users to register and authenticate; and access digital resources. The mobile app also needs to provide to manage user profiles, see borrowing history and provide feedback. These functions enable an efficient and seamless way for users to engage with the library's services to improve the user experience and library operations (Eke, 2021; GeeksforGeeks, 2024).

The functional requirements

The functional requirements of the BLDE (Deemed to be University) Library Mobile App delineate the core activities and services that the system must support in order to provide effective library management and delivery of user service. This includes user management capabilities like registration, login, and role-based access for students, faculty, and staff. The app facilitates complete catalogue management by allowing users to search for books and resources by title, author, or keywords and filter and sort results. There are circulation management capabilities related to borrowing, returning, and renewing items or placing requests for holds or reservations. The system tracks the status and inventory of library resources on a real-time basis, ensuring accurate information on items ready to use. Reporting and analytics capabilities provide analysis on usage and demand for resources allowing library managers to make informed decisions. Integration abilities allow for easy interaction with external systems such as online public access catalogs (OPACs) and digital repositories aligning operational activity and overall user experience (Library Management System Project, 2024; Functional requirements of library management system, 2025).

Non-functional requirements

Non-functional requirements specify the quality attributes the mobile application must exhibit to ensure acceptable performance and user satisfaction. Usability is a primary

requirement with the app designed and developed with a user interface that is easy to learn and use for technical-skilled users as well as non-technical skilled users in a user-friendly way, which includes accessibility options. Reliability and availability are essential; the app must provide a reliable service 24 hours a day and 365 days a year with minimum downtime, as well as a fast search function, and fast transaction processing. Security requirements include multiple authentication checks, data encryption while in transit, and controls that limit access to sensitive user data, and to maintain the integrity of the system. Compatibility is required for many Android devices and Android operating system versions to provide the widest access possible. The system should also support scalability for users' database growth and resource growth efficiently, in addition to maintainability of ease of software updates, as libraries needs change over time as a resource (GeeksforGeeks, 2024; Library Management System Project, 2024).

4.2 Use Case Diagrams

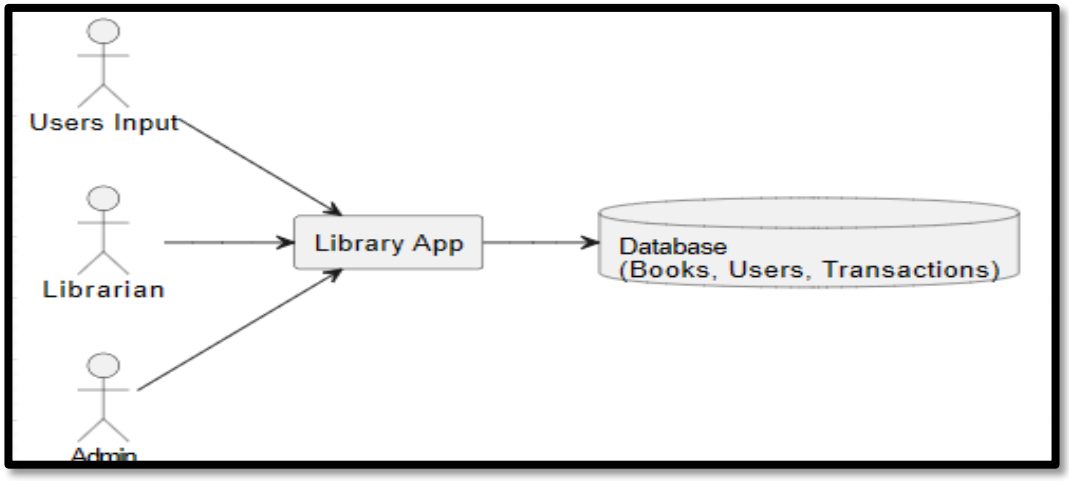


Figure 4.2 Use Case Diagrams

Use Case Diagrams provide a visual depiction of user interaction (actors) with functionality (use cases) in systems. The common actors of the BLDE Library mobile app are Students, Faculty, and Library Staff. Students and Faculty have similar usage cases, which include searching the catalogue, requesting of reserving books, renewing books, and accessing e-resources. Library Staff engage with use cases with respect to managing the catalogue; lending and returning items; cataloguing e-resources; and posting notifications. The diagram diagrammatically depicts these actors and their corresponding interactions with the system design to show how the actors achieve experiences/goals through the mobile interface. This diagram aids in system analysis

and design and provides a clear visual of functional requirements from the users' perspective (EdrawMax, 2025; GeeksforGeeks, 2024).

4.3 Data Flow Diagrams

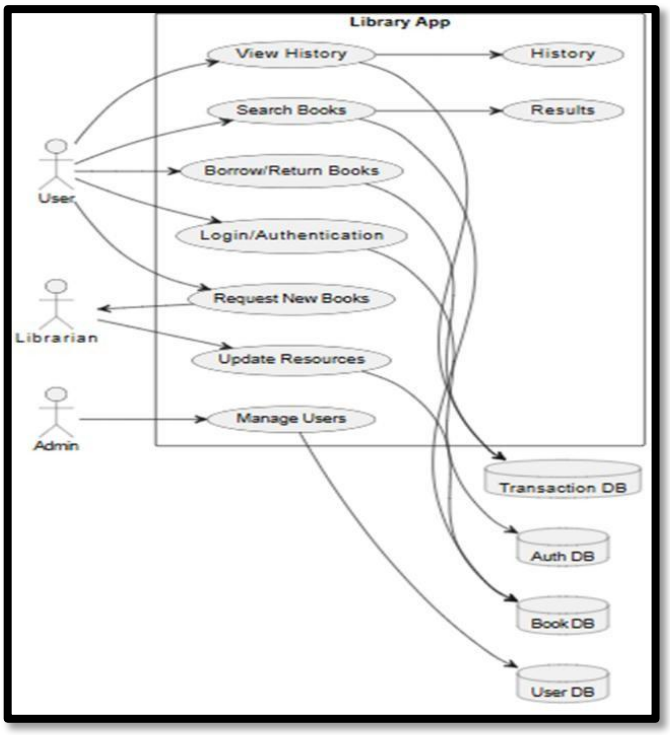


Figure 4.3 Data Flow Diagrams

Data Flow Diagrams illustrate the flow of data between system components, outside entities, and data storage. The context level DFD shown for the library mobile app identifies primary data sources including users (students, faculty), OPAC and digital databases external to the app, and administrative services internal to the institution. The more detailed level DFDs trace the processing steps such as authenticating the user, querying books, handling reservations, and generating notifications for each of these processing steps or data interfaces and the related data storage such as user profiles, lending records, and book inventories. DFDs can be helpful in understanding the flow of data within the system, identifying processing steps and data interfaces. DFDs can also identify potential bottlenecks in work processes, improve data integrity, and enhance efficiencies within the app (Library Management System Documentation, 2024).

4.4 Entity-Relationship (ER) Diagrams

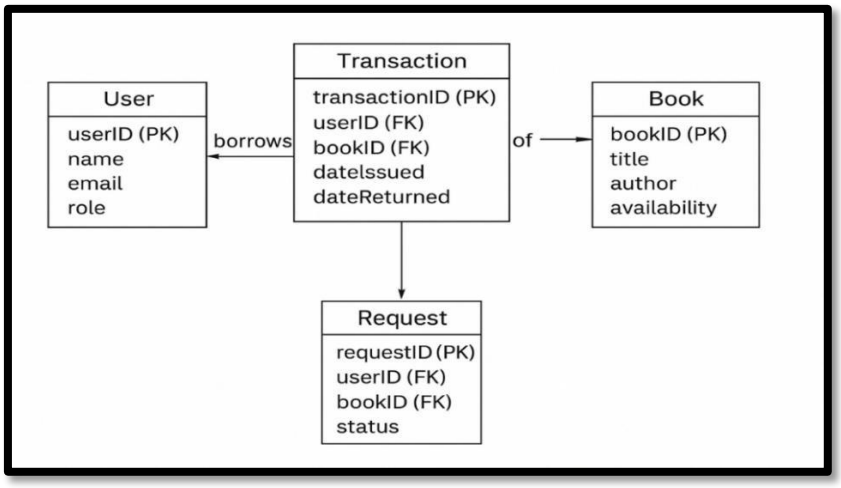


Figure 4.4 Entity-Relationship (ER) Diagrams

Entity-Relationship (ER) Diagrams model the structure of data, representing the entities of the data, their attributes, and the relationships between entities. In a library system, there can be various entities, such as User (with attributes of User ID, Name, Role), Book (with attributes ISBN, Title, Author, Status), Loan (with attributes Loan ID, Issue Date, Return Date), and Reservation. A relationship defines connections between entities. An example could be the use of a relationship to connect "User borrows Book" and an example of the relationship that connects "User reserves Book" for a User with a book from the library. The ER diagram for the mobile app clearly communicates multiplicity (for example, a user can borrow multiple books, but each loan is only for one book) and constraints, which are crucial for database design. This will help the developers and database designers be able to maintain the consistency of the data and the concept of normalization and efficient query implementation of the database. The ER Diagram will serve as a confirmation for backend data management (Library ER Documentation, 2024)

4.5 System Architecture

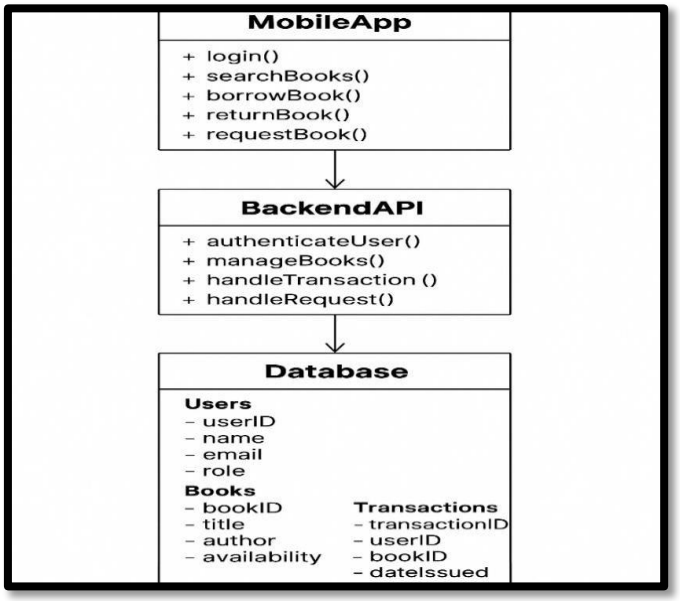


Figure 4.5 System Architecture

The BLDE Library mobile application employs a client-server model that features a modular structure designed to support ongoing scalability and maintainability. The client-side includes the mobile application created using MIT App Inventor, which includes the user interface and input forms. The server-side generally uses some cloud-based database, like for example Firebase, for real-time data storage and syncing. The middleware layer provides the ability to run business logic, integrating application program interfaces (APIs), as an example, OPAC or an authentication service, along with the registry to manage transactions the app generates. Also, outside of parallel processes, notification services are included for alerts, modules for analytics to track usage, upgrades for additional security layers for authentication and encryption of data, and others. The multi-layered architecture supports easy alteration or replacement of functional components as well as its relationships using all tiers of the architecture model and maintains asynchronous communication to support responsive and reliable app performance for all user types (Eke, 2021; GeeksforGeeks, 2024).

4.6 Module Design

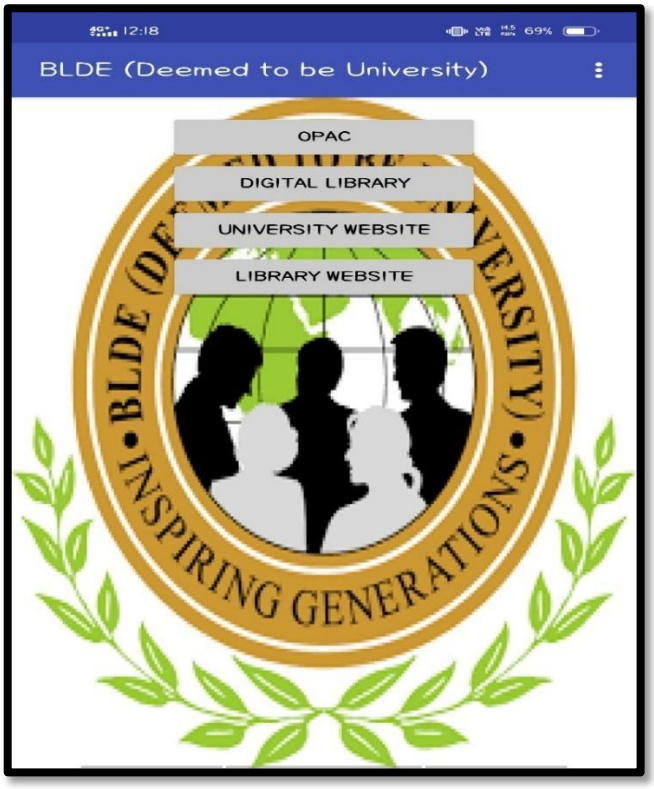


Figure: 4.6.1 Module Design

To improve overall effectiveness, scalability, and user experience, the BLDE (Deemed to be University) Library mobile application is structured to incorporate primary library functions on one digital platform using a modular architecture. Primary modules that can be accessed on this platform include User Login & Authentication for authenticated access, Book Search and Availability for tracking to view library materials in real time, and Digital Resource Access for seamless access to e-books, e-journals, and databases. Other features of the mobile interface include Library Notices & Announcements to send push notifications to alert users about library notices, and the modules Book Reservation & Renewal by which users can manage their borrowing of library item, and Feedback & Support to communicate directly with library staff. These modules enhance operations and reduce manual workflow while providing a user-centric experience which contributes to the enhanced digital eco-system of the library's support and unity toward the library's mission of providing accessible and technology-enhanced academic and research support (Singh & Kaur, 2020; Gupta & Singh, 2021; Patel & Deshmukh, 2021; Kumar & Joseph, 2020).

Book Search and Availability

The Book Search and Availability feature allows users to quickly find physical and digital books using searchable fields (title, author, ISBN, or subject). The system accurately retrieves results through the use of metadata indexing and integrated catalog databases. Users are informed of the status of a book (issued, reserved, or available on the shelf) with real-time availability updates. This feature has increased convenience for the user and promotes efficient circulation, and better utilization of a library's resources (Singh & Kaur, 2020).

Digital Resource Access (E-books, Journals, and Databases)

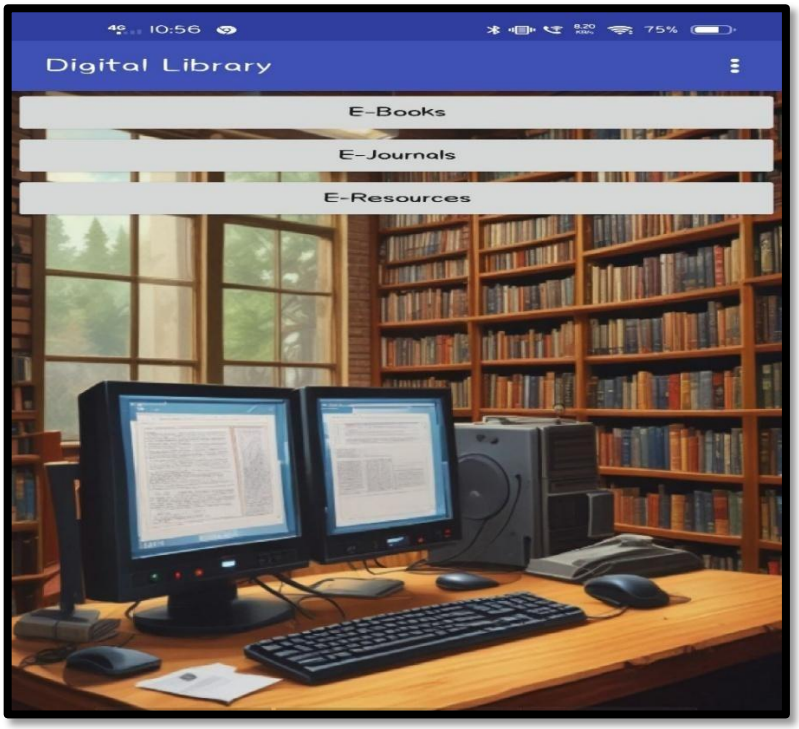


Figure: 4.6.2 Digital Resource Access (E-books, Journals, and Databases)

Access to digital resources (e.g., e-books, journals, and databases) has been a module that provides access to the library's e-resources (e-books, e-journals, and subscribed academic databases). The module allows users to browse, read, or download digital materials for academic and research purposes from a single interface. Due to the various platforms, federated search, and single sign-on is used for ease of access. The module is functional with external repositories and open-access resources, so that reading, or information coverage can be comprehensive (Gupta & Singh, 2021; Kumar & Rani, 2022).

Library Notices and Announcements

The Library Notices and Announcements module is responsible for the communication of important updates to the users, which consist of the most recent library acquisitions, workshops, policy changes, and events schedule. The system integrates the to-and-fro messaging within the application and the notifications sent to the users' devices, which thereby allow the users to be notified instantly. The module acts as a bridge between the library staff and users, it promotes adherence to library programs and initiatives, and it raises the participation of users in the library's activities (Patel & Mehta, 2021; Sharma & Nair, 2020).

Booking and Renewal Books

This system also provides the reservation of currently loaned-out books and some items' renewal with the borrowed ones through the mobile app. The real-time processing will be done for every reservation request and notifications will be sent to users when the item is ready for pickup. The renewal feature will grant the users to elongate their borrowing times for most of the items based on the library's rules and to reduce the fines for late materials. Automation of these services allows the library to manage its circulation department more efficiently and to provide users with convenience (Reddy & Thomas, 2021).

Feedback & Support

The Feedback and Support module enables bidirectional communication between users of the library and administrators. Through the application interface, users can submit feedback, report problems, or ask for assistance. Library staff will then review and reply to users, taking necessary corrective action, in a responsive manner. The feedback and support module enriches daily improvement with user feedback, sentiment and a sense of what is working, or not. This module further supports a user-centered ethos of the system. (Kumar & Joseph, 2020)

4.7 UI/UX Design (Wireframes & Screenshots)

The BLDE Library mobile application focuses on the UI/UX design of a user-friendly and intuitive interface to increase user engagement with library services. Wireframes were constructed for the major modules including User Login & Authentication, Book Search & Availability, Digital Resource Access, Library Notices & Announcements, Book Reservation & Renewal, and Feedback & Support, which all boast a simple and clean design and layout for easy navigation and quick access to major functions.

Fundamental design heuristics are established such as consistency, visibility of system status, and user control, to support users in completing their tasks easily without confusion. Screenshots of the prototype demonstrate a centralized dashboard and clearly labeled icons within the dashboard, various notifications of context-feedback alerts to the users, and accessibility features such as readable fonts, high contrast highlight colors, and responsive designs that will adapt to different screen sizes. Moreover, the design employs interface components similar to those already in use, like buttons, dropdowns, and search bars, which will cut down the learning curve for our users thus leading to a smooth and productive user experience that satisfies the user-centered design aims of the application (Nielsen & Molich., 1990; Shneiderman et al., 2017).

4.8 Database Design

The mobile library application has its database design as the main pillar of its software architecture, as this would allow storage, retrieval, and management of user information, book information, borrowing history, and online resources in an efficient manner. This is achieved through the proper organization of information in previously defined tables where each entity is clearly set, for example, there are Users, Books, Transactions, and Requests with their attributes like user ID, book name, and borrow date. Database design will also involve the establishment of primary and foreign keys which are necessary to maintain those relationships and data integrity. For example, there will be a Transaction table that links users and books through foreign keys making the borrowing activity traceable. Likewise, the adherence to normalization rules will help in minimizing redundancy and keeping only one copy of the data point for accuracy and effectiveness. The actual application of this design would typically involve the use of a relational database management system (RDBMS), such as MySQL or PostgreSQL that will support the main functions of the mobile application like user logins, searching for books, managing transactions like bookings, access to digital materials, and utilization history. In the overall picture, Database design is a very important aspect of the application, ultimately a top-notch product translates into overall efficiency and trustworthy and user-friendly experience across all the mobile application modules - which is a considerable goal of this research designs (Coronel & Morris, 2016; Rob & Coronel, 2007).

CHAPTER 5: IMPLEMENTATION

5.1 Overview of MIT App Inventor

MIT App Inventor is a costless and web-based tool that was developed by MIT and allows students, amateurs, and hobbyists to construct completely operational Android applications. Initially, it was a Google project but later on, MIT took it over and it is being predominantly used in schools as a tool to teach programming and mobile app development concepts in an easy and fun way (Dasgupta et al., 2017). Thus, it is the perfect solution for teaching in schools, colleges, and workshops as the students can experiment with real-world applications without any prior coding experience at all in general.

The standard application development settings are usually intricate and demand high-level programming expertise in different languages such as Java or Kotlin. On the other hand, MIT App Inventor presents to the developers an easy-to-use graphical interface and operates via visual blocks programming. The users merely have to pick and place the colored blocks, which depict the programming elements such as variables, loops, and event handlers, into the area provided to make their applications.

MIT App Inventor's Primary Elements

The Designer interface is like a canvas to the users where they could design the User Interface (UI) of their apps through drag-and-drop. The users are enabled to import the components from a palette conveniently and then position them according to layout items which can be horizontal or vertical arrangements, tables, and even a canvas.

1. Moreover, properties available for the composition can be parameterized according to the app's design requirements: this includes (texts, colors, sizes, visibility, and alignment) for the already-set elements.
2. The Blocks Editor is where the app is specified in terms of its logic and behavior. The users assemble the blocks that stand for variables, control structures (loops, conditionals), functions, and events. The different shapes of the blocks ensure that there are no syntax errors, besides being visually expressed and easy to understand. One block, for example, could be a "Button. Click" that would activate some operation, either changing the text or taking the action of opening the new screen.

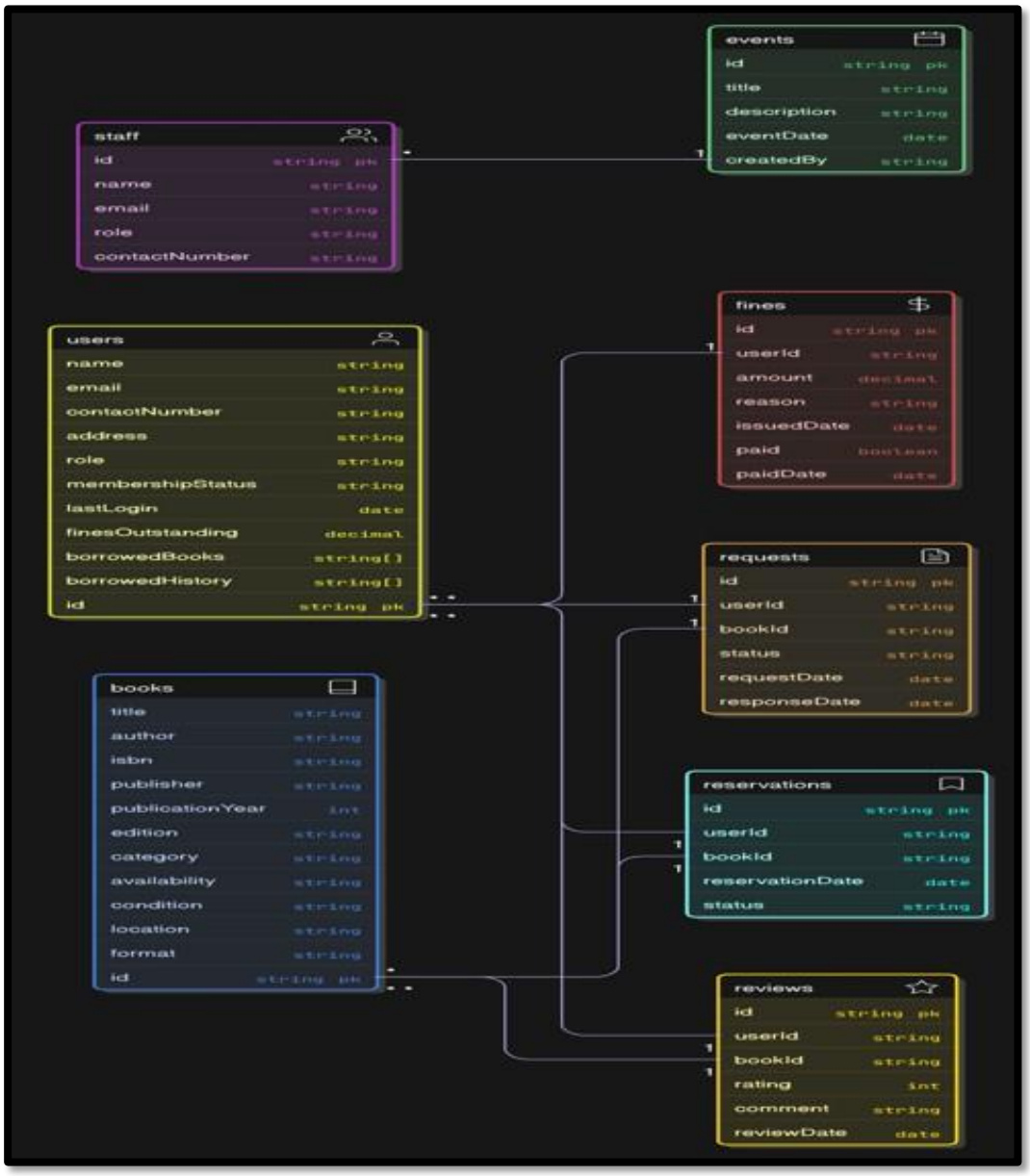


Figure 5.1 Implementation Flow in MIT App Inventor Components and Extensions

- Visible Components: Include buttons, labels, textboxes, images, sliders, and maps.
- Non-visible Components: Include sensor objects (acoustic sensor, location sensor), clock, local database (Tiny DB), and web components.
- Extensions: App Inventor provides the developers with the opportunity of creating custom extensions that allow the addition of new features like accessing third-party APIs, offering advanced media tools, or providing Cloud services.

3. **Connectivity and Data Management**

MIT App Inventor supports both local storage (TinyDB) and cloud storage (TinyWebDB, Firebase). This allows apps to store data over the long term, share data across devices, and communicate with web services, making it appropriate for genuine apps, such as attendance tracking, survey apps, or quizzing apps.

4. **Testing in Real-Time**

Through the MIT AI2 Companion App, learners are able to experiment with their applications in a practical manner using Android phones. The modifications carried out on the app in the Designer or the Blocks Editor are instantly reflected, thus enabling students to rapidly prototype and test their app in a nonstop cycle of improvement. This interactive real-time testing makes it easier for the student to consider and reason through the app's logic by cause and effect. Benefits for Education and Research.

5. **Incorporation of Mobile Features**

One of the features that make MIT App Inventor shine is how smoothly it works with the mobile device's capabilities:

- Sensors: The students can incorporate motion-based sensors like accelerometer, gyroscope, and orientation sensors in their applications along with their students.
- Location Services: Students can build location-aware apps using GPS tracking.
- Media: the native media capabilities of mobile devices include camera, video, audio and speech synthesis tools for interactive apps.
- Communication: capabilities include SMS text messaging, phone calls, email and web services.

These capabilities enable students to build "real world", interactive and context-aware apps for their cell phones. Students bridge class time learning theories and practical application through the development of their apps.

Pros and Cons Pros:

- Very simple interface that doesn't need much technical skill.
- Chance to make usable apps in a short time.
- Increases the mental capacity, the trial and error methods, and the finding of solutions.

- There is a solid community support; you can find tutorials, forums, example projects, etc.
- **Cons:**
- Primarily Android devices are supported; the iOS development is very restricted.
- The resource-demanding and intricate applications will not be able to run smoothly most probably.
- There will be less UI customization and accessibility of advanced features than in the case of using a fully-fledged IDE like Android Studio.

5.2 Implementation Environment

The implementation environment is inclusive of software, hardware, and the necessary tools that are used to create, operate, and test the application. For projects developed with MIT App Inventor, the majority of the environment is web-based, which means that the main part of development can be done through a web browser, and there is no need for heavy software to be installed (Wolber et al., 2011).

Software Environment

1. Web Browser: MIT App Inventor is compatible with all modern web browsers, such as Google Chrome, Mozilla Firefox, or Microsoft Edge.
2. MIT App Inventor Platform: The platform is available at http://ai2.appinventor.mit.edu where the Designer can be used for the UI design and the Blocks Editor for the logic (Dasgupta et al., 2017).
3. Companion App: The real-time testing and debugging to your app is enabled by the MIT AI2 Companion App that is loaded on your Android device (Wolber et al., 2011).
4. Supporting Tools: You are allowed to use online data storage such as Firebase or TinyWebDB and use app extensions to add to your app's features and usability (Yuan & Kim, 2015).

Hardware Environment

1. Computer/Laptop: Any ordinary computer or laptop with a compatible web browser will be good enough.
2. Android Device: An Android smartphone or tablet is required for live testing to execute the AI2 Companion App (Dasgupta et al., 2017).

3. Internet Connection: Stable internet connection enables smooth communication between the testing device and the platform. Operating System

MIT App Inventor is cross-platform (it is operable on Windows, macOS, and Linux using compatible browsers), Android devices will be best if running Android 5.0 or higher (Wolber et al., 2011).

5.3 Module Development

The modules of the BLDE (Deemed to be University) Library mobile application were developed with consideration toward user-centric design, integration of library services, and effective management of digital resources. Each module was developed to improve the user experience, provide accessible library materials, and automate routine manual workflows. The subsections below describe the modules in detail.

Integration of OPAC (Online Public Access Catalogue)

The OPAC module is one of the primary features that support the library users' activity of browsing, searching, and accessing the collection. It is possible to obtain the real-time book availability, catalog data, and resource classification by connecting to the OPAC database, thus being able to perform advanced searches like the ones with keywords and filters based on authors, titles, publication year, and subject categories. The module can also set up and order the search terms so that the users can find the books and materials that best fit the needs very easily. In addition, the users can get more bibliographic information (e.g., call numbers, book location, and availability). The adoption of this module has resulted in a significant decrease in the time spent by users on resource discovery, which is a factor that plays a role in the library's inefficiency and dissatisfaction among the users' side (Sharma & Jain, 2022).

Access to E-resources

The E-resources Access module was created to ensure that electronic resources, which include e-books, journals, databases, and digital repositories, would be accessible without any barriers. It is also the module that provides authentication mechanisms, through which the users authorized by the institution will rely on to obtain the licensed resources. It is an integration with external third-party digital content providers, meaning that the users have the option of searching for both physical and digital resources in one place. It possesses various academic utilitarianism functions including bookmarking, downloading, and citation exporting. Last but not least, its

functionality can be made interactive with other devices thus giving the users the option of accessing it through their mobile phones, tablets, and computers which is a great help in remote learning and research practice (Kumar & Singh, 2021).

Notifications and Announcements

The primary focus of the Notifications & Announcements module is to share with readers everything that is going on at the library. This includes announcements, new acquisitions, news and policy changes; basically all of the activities and changes from the library. In order to keep users up to date with the most important and relevant information, the library will send push notifications, in-app alerts and emails on a periodic basis.Notifications & Announcements will be a continuous reminder for users about their overdue books, upcoming deadlines, and newly available resources; furthermore, it will not merely be a reminder but a reduction in overdue fines and an increase in circulation as well.

Request & Renewal Services Module

The Request & Renewal Services module provides a scope of automation for the library conventional workflow processes and hence users can request books, reserve materials, and renew borrowed items through the online platform hence there is no necessity to visit the library. The library management system is involved through these features to verify the status of requested items, run waiting lists, and send messages to users when the books they requested are ready for borrowing. The renewal function allows users to extend their borrowing time for items when no other requests have been placed and decreases the number of overdue items. All notifications integrate within the checkout process to send reminders and confirmations which increases value for users and letter workload for library staff. This module automates these services which enhances the overall efficiency of library operations and satisfaction of users (Gupta & Verma, 2021).

5.4 Black-and-white pictures of codes/BLOCKS

MIT App Inventor works as an easy-to-use platform for Android app development. Perfect for novice app developers. App Inventor employs a visual development, drag-and-drop computer programming environment where the logic of the programs is illustrated in blocks instead of text code. The App Inventor blocks can express event handlers, logic statements, procedures, and variables that combine to become apps. App Inventor enables people to build working apps without prior programming experience (Abelson et al., 2013). A second feature of App Inventor is block

snapshots, block images illustrating how blocks are linked to govern app actions. When you "drag and drop" the "when Button Click" block -- for a user interface (UI) item -- the app is instructed to perform a certain application action! Block snapshots indicate how the application reacts to user activities (Mitra & Rana, 2020).

Including such block snapshots in project documentation enhances both technical and non-technical stakeholders' comprehension through a visual illustration of the app's logic. They also contribute to debugging by enabling authors to restrict their scope to certain functions, while working with others collectively in order to describe the app's structure more effectively. Furthermore, although blocks are modular, this facilitates development effectiveness since developers can recycle the logic elsewhere in the app. MIT App Inventor's simplicity and ease of access have made it commonly used in educational institutions to instruct computational thinking, as well as rapid prototyping. Teachers can use block snapshots during class time to assess student work and encourage iterative revisions. This definitely positions MIT App Inventor as effective for development and learning (Alimisis, 2013).

Design and Development of the Mobile Application for BLDE University Library

The MIT App Inventor will be used in developing the mobile application for the BLDE University Library, a cloud-based platform that makes the creation of Android applications relatively simple with little or no coding required. This process will aim to customize the application according to the needs of BLDE University Library users, following these major steps:

Log in through a Gmail Account: The initial step is showing the Gmail verification page. Input your username and password, then hit "Continue" for a successful login.

Privacy Policy Consent: After signing in with your Gmail account, the permission to access the user app account in MIT App Inventor will be provided.If it is your first time as a user or if you have not visited any developer account before, then you will have to go through and accept again the MIT App Inventor Privacy Policy and Terms of Service before you can proceed with app development.Welcome to APP Inventor: Once you have acknowledged the terms of service, the Welcome to App Inventor display will show. Just press the “Continue” button to start your app development adventure and move on.

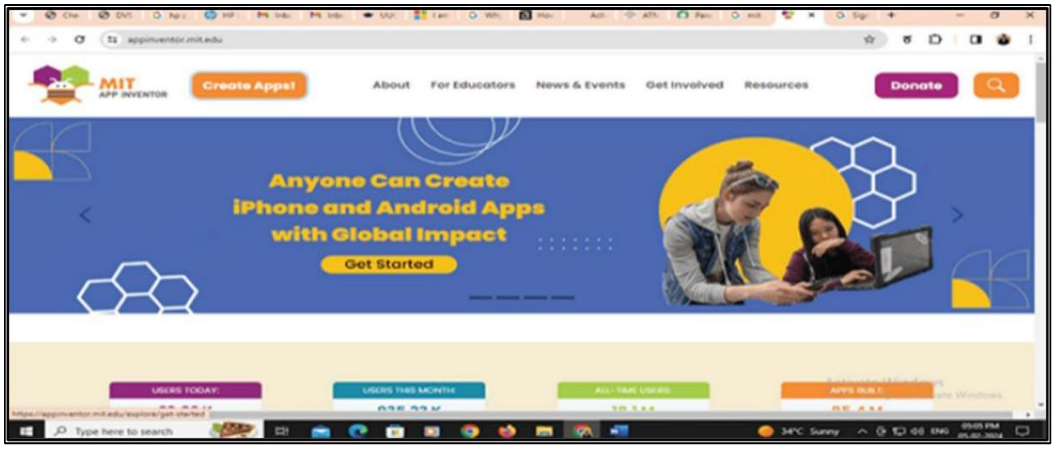


Figure 1: MIT App Inventor

Create New Project Name: The user will get a dialog box requesting a project name after selecting a blank project. Type in the chosen developer project or application name and press "OK" to move on to creating the new project.

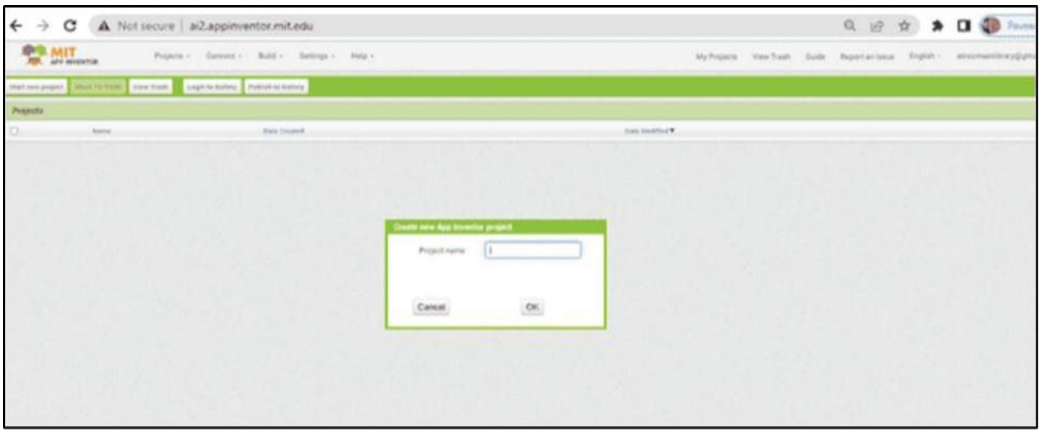


Figure 2: Project Name

Include a Home Page with Expandable Screen as Jumping Off Point:

For good user experience, multiple screens can be created and linked back to the main home page for fluid navigation between users.

Home page of the App: To keep the user engaged, the home screen of the app is an important capture point! Developers can use the settings panel to adjust the name of the screen, background/colour, back drop, icon, font size/type/shape, as well as text colour, and copy for a user-friendly, aesthetic, and effective interface.

Designer interface overview:

The designer interface is made up of main sections that assist the application design process:

1. Palette panel; Left side panel contains the full list of components that can be dragged and dropped into the project. The components are grouped into drawers based on the type of component. You can open a drawer to view the contents and then select a component for use.
2. Viewer panel; The Viewer panel is where you will get a phone screen preview. As the user selects a component from the Palette, they can drag it into the Viewer, visually placing it into the design.
3. Components panel; The Components panel will show a list of included items from the project. The components can also be moved into the Viewer for placement in the app.
4. Properties panel; The Properties panel is where developers can update the selected components. Once the developer has selected either a component from the Components panel or in the viewer, they will be presented the option to update the properties associated with the component, such as size, text

Adding a Button:

Drag a button component from the Palette and release the button on the Viewer area in order to insert it in the application. In the Components panel select Button1 and through the Properties box change its settings including name, font size, text, shape and colour according to your requirements.

Adding a Label:

Drag and drop the Label component onto the phone screen within the Viewer. The label has various uses such as for text, spacing between elements or anything else. Select the label in the Components window and change its properties like font size, text, colour or icon from the Properties box to conform to the design requirements.

Figure3: Button and Label

Add a Picture: Include a Picture in the user interface, click on the Image option and drag and drop it onto the phone screen that appears in the Viewer window. All the properties of the image are shown in the Properties panel, where the developer can easily add the image and size.

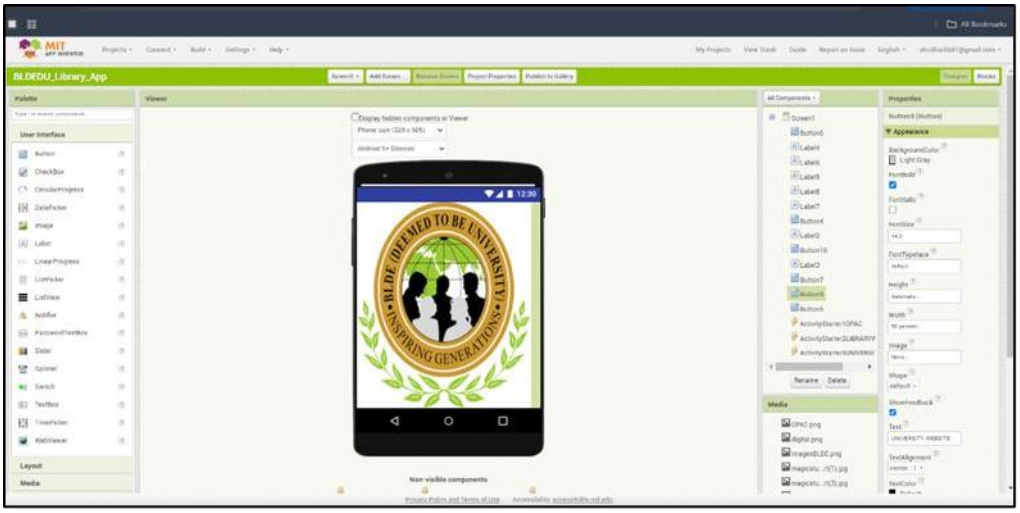


Figure 4: Add Pictures

Interconnection to establish a connection link for a button within the mobile application, select the button component from the user interface and access the connection option. Drag and drop this option into the Viewer under the non-visible components section. Next, configure the connection by navigating to the Properties panel, where you will enter android.intent.action.VIEW in the Action field. In the Data URI field, paste or type the intended link to complete the interconnection setup. The implementation of this setup guarantees that users are smoothly transferred to the

specific resource or outside link whenever they click the button which in turn enriches the app's navigation and functionality

Figure 5: Interconnection

Editor for Blocks: It is the section that explains the implementation of Library app.After you have inserted the components in the Designer, press the Blocks button which is located in the upper right corner to go to the Blocks Editor. Here, contrary to the case in the Designer where you drag elements, you have to pick a number of code blocks that fit together like jigsaw pieces. The blocks represent the commands for the program to execute. The basic difference between a Blocks Editor and a Designer is that the former is responsible for the functionality of the program while the latter decides on its visual and stylistic aspects. No application can be developed properly without both.

Palette of Blocks: On the left-hand side of the Block Editor, you will find the Blocks palette. It gives you access to all the blocks that are split into two categories: Built-in blocks and component blocks.

Integrated Blocks: There are categories for the built-in blocks. When you click on a category, its blocks appear. For example, selecting “Control” brings up all the blocks relevant to control.

Blocks of Components: Click the Button1 item from the Blocks palette. This will open the "drawer” of blocks that manage the button's behaviour. It displays all blocks you can use to change what the button does, or what should happen when a user taps or clicks it.

Press the Button to Act: Just click and drag the Component and built-in blocks into the Viewer panel to include them in your application. When the user presses the button, it acts like a control element for the built-in blocks

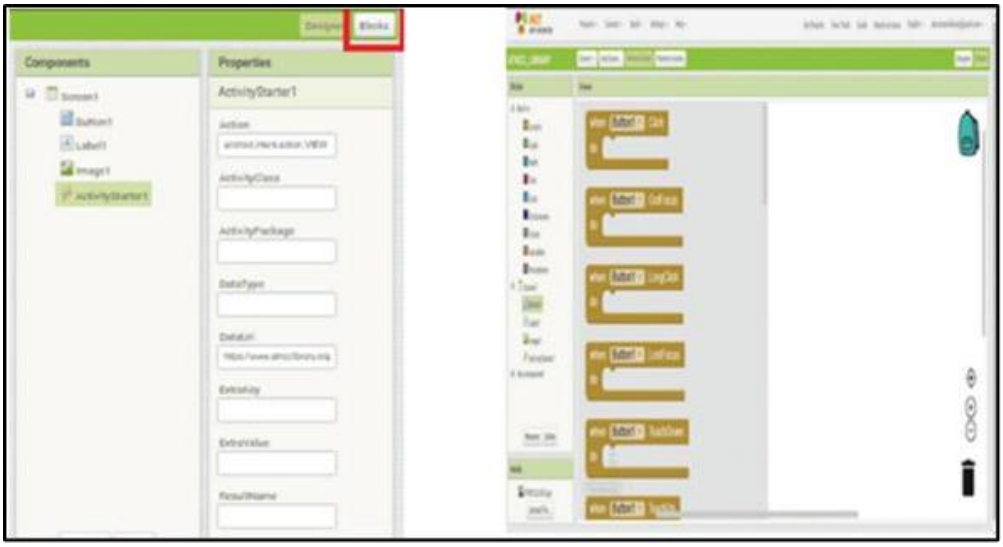


Figure 6: Blocks

Link of the button: The MIT App Inventor programming language utilizes blocks, such as puzzle pieces with printed text. The blocks assemble instructions and then translate them into computer language in order for them to be tracked by a mobile device.

Figure 7: Link of the button

Putting the Blocks into Code: The text for Label1 now reads "Hello World!" as the user clicks on Button1. Greetings, World! The When Button1 can contain as many blocks inside of it as desired. Press the event block button. All the blocks within will start to run when the user presses the button.

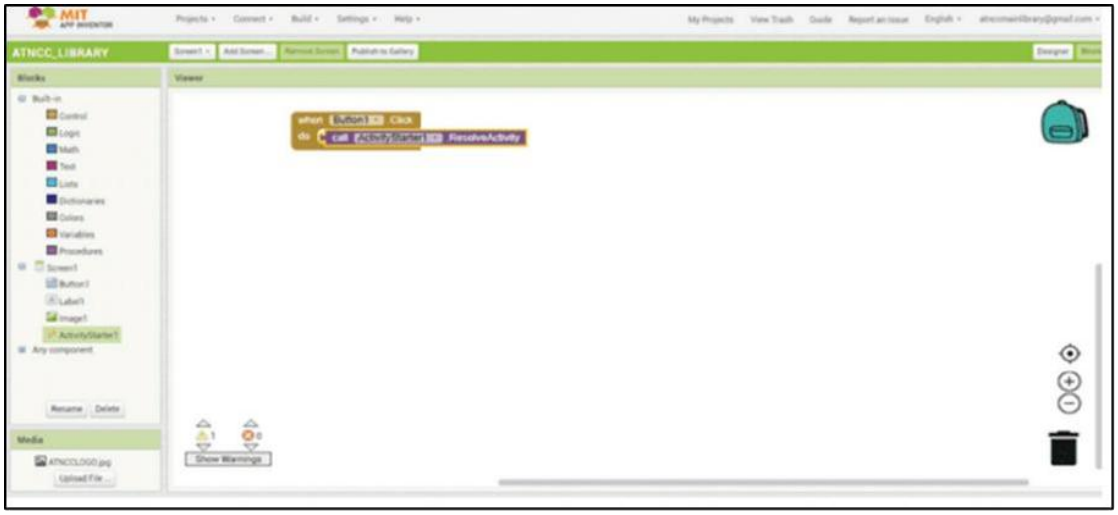


Figure 8: Putting the Blocks into Code

Launch the Project: Once the application has been designed with the required buttons, labels, screens, fonts, images, and colours, you can import your project or start a new one by choosing the project menu. The project is automatically saved, and the same application may be duplicated with a new name.

Create the application

Click the Build dropdown arrow from the menu at the top of the screen in App Inventor on the PC, and select Android App (apk).

Scan the QR Code

The Android app may be downloaded through scanning the QR code or clicking the Android App (apk.) button.

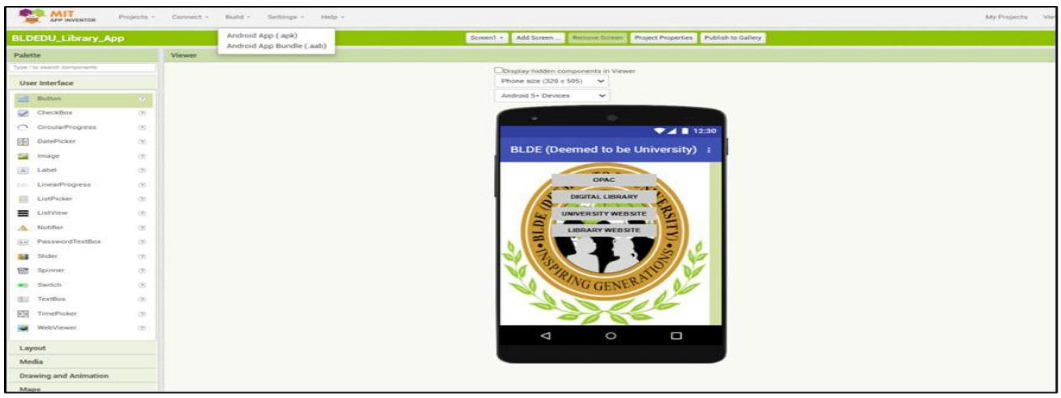


Figure 9: Create the Application

Figure 10: Scan the QR Code

5.5 Integration with Library Systems

- Library systems integration is seen as the most important aspect when it comes to enhancing the accessibility and efficiency of library services. Present-day libraries, as a rule, operate on several technological platforms and make use of different databases, and the integration of these systems in a trouble-free manner provides the users with easy access to a wide range of resources. Integrated Library Systems (ILS), digital repositories, discovery tools, and external databases are typically the components of library systems that need to work together without any barriers in order to provide a common user experience (Smith, 2021).
- The main benefit that library system integration brings along is that it leads to the centralization of information in such a way that the users will be able to search once and have access to several resources at the same time e.g. catalogs, online journals, and institutional repositories. This makes it easier the users to find their way around different systems and at the same time it reduces the time spent on searching for the needed materials (Johnson & Miller, 2019). In addition, integration makes it easier for librarians to manage resources with the help of real-time updates in cataloging, circulation, and acquisitions.
- APIs and other methods of communication that have been widely accepted such as Z39.50 and Open Archives Initiative Protocol for Metadata Harvesting (OAI- PMH) allow the sharing of bibliographic and metadata

information between different systems (Garcia, 2020). In addition, the use of cloud computing has made the integration process faster and easier because libraries are now able to connect their local systems with other digital libraries and content providers located far away in a very effective way.

- The journey towards interoperability being a direct and effortless one is not the case as it is hindered by various issues such as differing metadata standards, proprietary software limitations, and need for constant technical support (Lee, 2022). In spite of this, the prevailing situations can be dealt with if the libraries are willing to resort to the application of flexible and standards-based solutions and sanctioned the establishment of strong ties between the vendors and the institutions.

5.6 Challenges Faced During Implementation

- The installation of the new system in the library's difficult-to-manage environment usually brings a wide variety of problems that impact not only the success of the project but also the time of its realization. The technical complexity is commonly the greatest challenge faced in the process of introducing new technology. The libraries have to interlace new software with the already existing Integrated Library Systems (ILS), electronic repositories, and external databases, which entail the use of different standards and formats, thus, causing interoperability problems (Anderson & Patel, 2020).
- One more significant problem is the reluctance of employees and users to change. Library workers may have got used to old systems and procedures, which means that they are not very open to new technologies or ways of working. This is a human factor that can make the implementation take longer and also, make the success of training programs less (Wong, 2019).Moreover, insufficient training and support throughout the implementation process and afterwards can make these problems worse, thus the new system is not effectively used (Brown & Chen, 2021).
- Libraries face a significant challenge in data migration as well. The process of transferring a huge volume of bibliographic, patron and circulation data from old systems to new ones calls for a great deal of care and thorough testing in order to avoid any loss or corruption. Errors in data migration may lead to service interruption and loss of trust from library users (Kumar, 2022).
- The common problem of budgetary constraints has a negative impact on the

extent and speed of implementation projects. Libraries are generally operating with tight budgets that may not allow for the best quality hardware, software, and training. This can cause delays or compromises in the capabilities of the systems (Garcia & Lee, 2020).

- On the other hand, technical support and maintenance at the same time are always required for the success of a project in the long run, but libraries sometimes have to deal with inconsistent vendor support or lack of internal competence which can lead to system downtime and lower customer satisfaction (Smith, 2021)

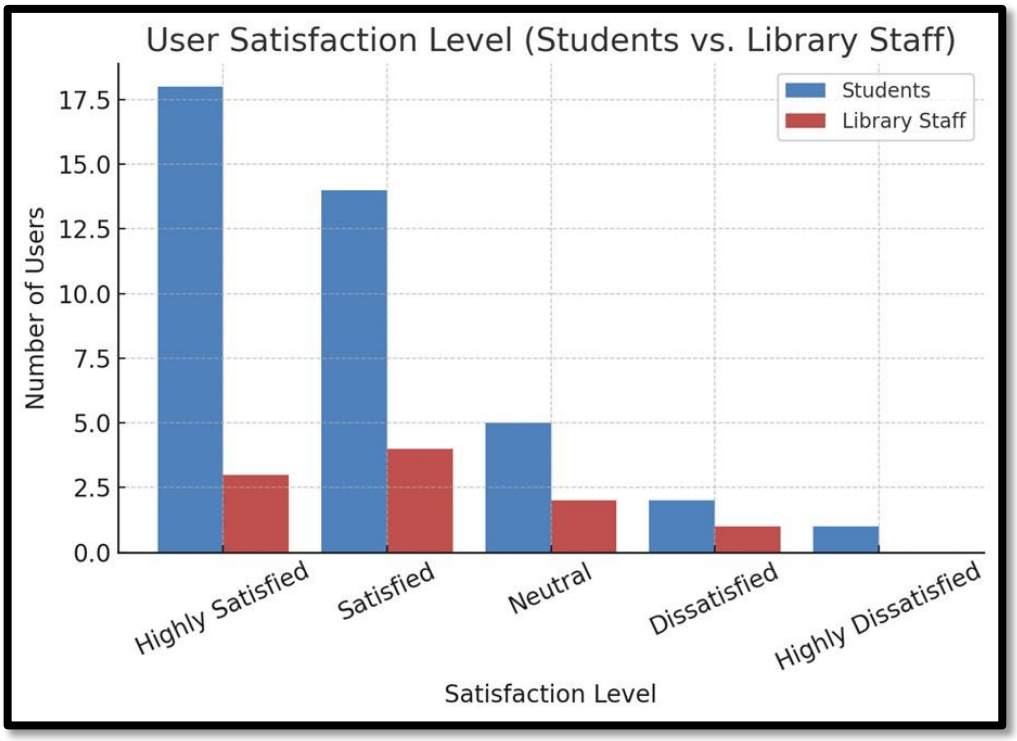
CHAPTER 6: TESTING AND EVALUATION

6.1 Testing Methodology

Testing is an essential stage in the software development lifecycle and is responsible for assuring the proper functioning of the mobile application, the fulfillment of user needs, and the dependable performance in various conditions. The different methods of testing which are being employed for this project are unit testing, integration testing, system testing, and user acceptance testing (UAT). Distinct types of testing are aimed at different features of the application and are conducted to find and repair defects during specific phases of the development process.

- Unit testing is specific to each component or module of the application - the login system, OPAC integration, or request and renewal services. Normally, this process is automated using a formalized testing framework that will evaluate the correctness of every module separately by checking if the output of each function will comply with the specifications (Pressman & Maxim, 2020).
- Integration testing on the other hand focuses on the interaction of the modules and checks if the data is flowing right and whether the parts are working like one unit (Sommerville, 2021).
- System Testing covers the completed mobile application in a controlled environment to test functionality, performance, security and usability scenarios, in a semblance of the real-world. This testing is here to assure the motivation of functional specifications and performance.
- User Acceptance Testing (UAT) is the process of people using the system and testing it to determine its usability, dependability, and appropriateness to user expectations. Feedback from UAT is key information that guides information technology final changes before implementation. Whenever there are changes made to the code, Regression testing is always performed to make sure that the existing functionality is not impacted. A good testing plan always results in an increase in the application's quality, user's patience and even the user's service.
- Integration Testing Integration: The testing is a key stage in the software life cycle dealing with verifying that each of the various modules of a system all function together as planned. Compared to unit testing, where one tests a single piece, integration testing aims to find interface flaws, data passage

issues, and inconsistencies between linked modules (Pressman & Maxim, 2020). For the BLDE Library mobile application, an integration test was conducted for some modules: OPAC, access to e-resources, notifications, and request and renew services modules to ensure the modules worked together in the system. Testing was achieved using the top down and bottom-up testing approaches. For instance, the testing of the OPAC module alongside the request and renew capabilities ensured that a search of a book would request borrow change updates in real time. In the same manner, by attempting to test the e-resource access module under user authentication, the developers ensured that the user would be unable to access restricted content. By the sequential progress of interface tests, the programmers came to realize whether there existed varying functionality among coupled module interfaces and correct those variations, maximizing the stability, security, and usability of the application (Sommerville, 2021).



Graph 6.1 User Satisfaction Level

6.2 Test Cases and Results

Testing is essential to verify practical operation, reliability and usability of the BLDE Library mobile application. Each test case objective is to assure each modules functionality under all scenarios. Test case objectives cover significant features including, user login, and search for a book, OPAC, e-resources access, notifications,

and request/renewal service. Test case results provide feedback on system performance, error handling and ultimately, user experience.

Sample Test Cases

Table: Sample Test Case

Module	Test Case	Input / Action	Expected Result	Actual Result	Status
OPAC Integration	Search for a book	Enter book title	Relevant books displayed with availability	Relevant books displayed	Pass
E-resources Access	Access e-journal	Click on journal link	PDF or online access available	PDF loaded successfully	Pass
Notifications	Receive notification	Librarian sends new book alert	User receives push notification	Notification received	Pass
Request & Renewal	Renew borrowed book	Click on renewal option	Book successfully renewed if eligible	Book renewed successfully	Pass

Analysis of Results

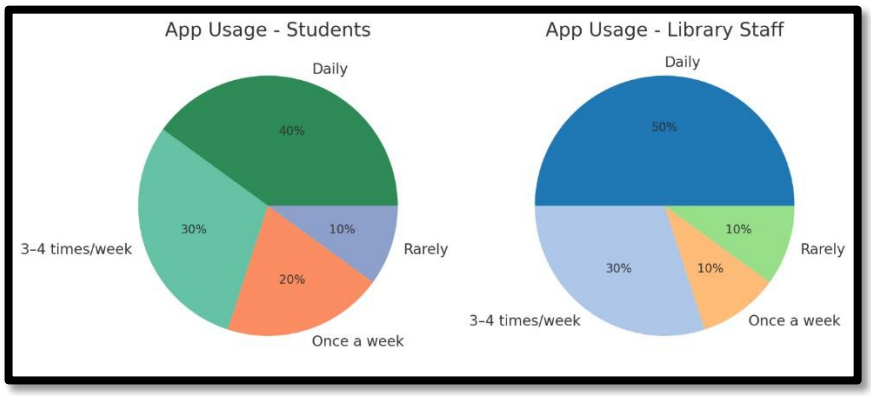
Based on the testing process, all the respective foundational features of the mobile application are functioning as expected based on the results of the assessment. Secure access is established through user log-in verification, while the OPAC module facilitates real-time access to the catalogue information, and the e-resources module allows for the access to the provision of digital items for online learning and research. Notifications and announcements provide timely information to participants to encourage their engagement. The library's request and renewal services process

become even less reliant on the participants and staff completing a sum of manual task because, thus far, they streamlined the processes.

During testing, there were no significant bugs found during the process, although some minor user interface (UI) adjustments were made from user acceptance testing (UAT). All testing indicates that mobile application meets its functional and usability standards, such that the mobile application is functional and a user-friendly interface for the users of the BLDE library.

6.3 User Feedback Collection

- The collection of user feedback is essential to the development and enhancement of the BLDE Library mobile application. Feedback provides insights into the end-user's viewpoint on the system in terms of functionality, ease of use, and performance. Feedback highlights areas that may become problematic and supports the system's improvements to the point where it really caters to the user's needs and wants (Kumar & Singh, 2021).
- Various methods were employed for the collection of feedback for the project, such as online questionnaires, in-app feedback forms, and semi-structured interviews with library staff, faculty and students. The quantitative and qualitative questions relating to ease of use, search quality, access to digital materials, notification quality, and overall satisfaction were included in the questionnaires and forms. Users were also prompted for suggestions of additional features or improvements through the feedback processes.
- After the team had collected the feedback, they started analyzing the data to identify trends, problems with usability, and requests for new features. A more active area of notifications, which informs users of future book due dates, was one of the requests that got incorporated in the app updates later on. The user feedback on the search resulted in the team adding new filters and sorting options to the OPAC module. By having users in the evaluation process, the application development team was able to respond to the user-centric approach in development that was aimed at increasing the adoption, satisfaction, and engagement rates of the users. Regular collection and delivery of feedback will be part of this process for continuous iteration and development for the mobile app while allowing it to evolve and grow according to user needs (Gupta & Verma, 2021).

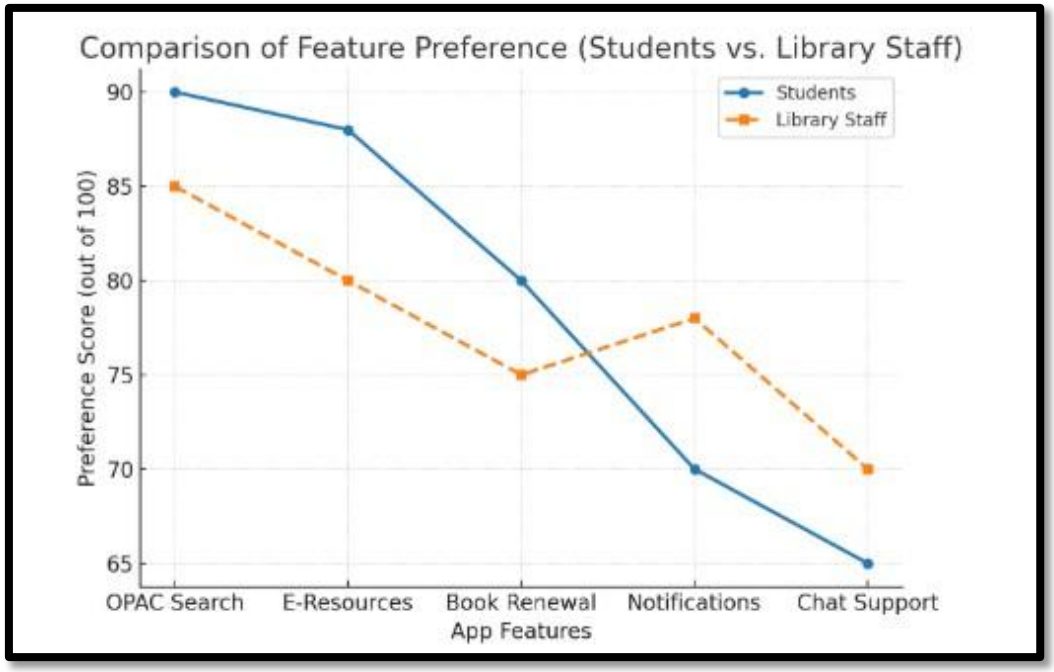


Graph 6.3. Frequency of App Usage (Pie Chart)

6.4 Performance Evaluation of the App

- The performance assessment of the BLDE Library mobile app is essential to know if it meets the functional, operational, and user-specific goals set during its creation. The performance testing procedure covers response time testing, resources usage, stability testing, usability testing and size testing under realistic conditions (Pressman & Maxim, 2020). The performance testing is going to reveal some hidden bottlenecks, increase the efficiency of the system, and finally improve the user experience in general.
- Quantitative method was used to measure the performance of the mobile application and the results were analysed qualitatively. Quantitative measures were the system response time for search, e-resource loading time, and time for processing book requests and renewals and notifications received successfully. Stress and load testing was also a part of the testing process to know how the application would behave when multiple users access it at the same time, and also to check if the system would still be able to bear the peak load without quality degradation (Sommerville, 2021).
- The mobile application of the BLDE Library has to go through a performance test, which will ascertain that it meets the functional, operational, and user-centric goals set during the whole process of development. The performance testing process includes analysing response times, resources' consumption, stability, usability, and size under actual conditions (Pressman & Maxim, 2020). Performance testing will give an insight into the system's weak spots, thus, allowing to increase the whole system's efficiency and improve user's experience in general.

- For the performance of the mobile application, there were both quantitative and qualitative methods used. The quantitative measures were the system's response time while searching, the loading time for each e-resource, the time for book requests and renewals, as well as the successful notifications. Furthermore, stress and load testing were performed to see how the application would react when simultaneous users are accessing it and whether the system really has the ability to withstand peak load without degrading (Sommerville, 2021).



Graph 6.4 Comparison of Feature Preference (Line Graph)

6.5 Security and Privacy Considerations

Using the BLDE Library mobile application brings about security and privacy issues that are definitely not to be overlooked since the app will deal with very sensitive user data like personal information, login credentials, borrowing history, and even the user's ability to read the licensed e-resources. The concern for the confidentiality, integrity, and availability of the data has to be the ultimate goal, in order to win over the user's trust and to comply with legal and institution-based policies (Sommerville, 2021).

The app will adopt secure authentication techniques, such as unique user IDs, and passwords that will be converted into unreadable form to stop unauthorized persons from getting in. Control will be applied by role-based access, which will allow different user groups, such as students, faculty, and library staff to only get toegang to

the features that are relevant to their respective groups. All data communication between the mobile application and the server will be encrypted also for security reasons with secure methods like HTTPS and SSL/TLS that do not allow to interception or tampering with the data.

In order to alleviate privacy issues, actions were taken and the amount of personal data, which was necessary for library service, was restricted to being the only limit. A clear notification of the data utilized plus privacy is conferred through well-defined policies. All the personal data is kept in an encrypted database. Also, access logs and audit trails are maintained in order to detect and respond quickly to a security breach or a situation that has been suspected to be a breach (Gupta & Verma, 2021). Security tests, such as vulnerability scanning and penetration testing, were conducted on a regular basis to discover and contain all risks. Eventually, these measures gave the assurance that the BLDE Library mobile application was a proper, secure, and reputable platform for users and their library-based data was securely provided while allowing uninterrupted access to collections and resources.

6.6 Limitations Noted During Testing

During the testing of the BLDE Library mobile application, certain limitations or constraints were noted which could have a negative impact on the performance, usability, or general user experience of the system. Acknowledging limitations facilitates the planning of future application enhancements and the ongoing development of the application.

One of the most noticeable limitations was device and platform dependence. While the application was examined during testing on a variety of Android and iOS devices, different screen sizes, operating system versions, or hardware capabilities resulted in slight UI miss aligns or slower performance on older devices, at times. The second limitation noted was related to internet connection. Some features of the application, e-resources access and OPAC search updates especially, depend on stable network connectivity. Therefore, if the user is in an area with poor internet service, future performance may vary for some features**.**

There were also identified functional limitations. For example, in the OPAC module, when advanced search filters were used, the search did not produce complete results when different parameters were combined or utilized. In addition to this, while notifications worked satisfactorily for most users, some stated that push notifications arrived late in some instances, particularly associated with peak server load times.

User experience integration highlighted the fact that the new version had already exceeded the expectations by offering more personalized dashboards and better accessibility features for handicapped users.

In spite of these drawbacks, the testing procedure ascertained that the main functions of the mobile app are robust, reliable, and user-friendly. Heeding these drawbacks in further updates would augment system performance, usability, and user satisfaction even more thus making the BLDE Library mobile application a versatile and adaptable digital platform (Pressman & Maxim, 2020; Kumar & Singh, 2021).

Table: Testing

Limitation	**Impact on Application**	**Suggested Improvement**
Device and platform dependency	Minor UI misalignments and slower performance on older devices	Optimize UI for multiple screen sizes and test across additional OS versions
Internet connectivity dependence	E-resources access and OPAC updates may be slow or unavailable in poor network conditions	Implement offline caching for frequently accessed resources and optimize data synchronization
Incomplete search results in OPAC	Advanced searches with multiple filters sometimes yield incomplete results	Enhance search algorithms and database indexing to improve accuracy
Delayed push notifications	Users may miss timely updates for renewals or new acquisitions	Optimize server load handling and use efficient notification queuing mechanisms
Limited personalizationand accessibility	Users with specific needs or preferences may experience reduced usability	Develop personalized dashboards and incorporate accessibility features (e.g., screen readers, high-contrast mode)

Peak load performance	Occasional slowdowns during high user activity	Conduct load balancing and server optimization to handle peak traffic efficiently

CHAPTER 7: SUMMARY OF FINDINGS

7.1 Summary of Findings

The app for mobile, "The Design and Development of a Mobile App for BLDE (Deemed to be University) Library: A User Encounter," was planned and created around the triplet of university library services: accessibility, ease of use, and efficiency. The user-centric design approach focused the whole process of development and testing with MIT App Inventor on usability, user satisfaction, functionality, and system integration, which resulted in several significant findings.

1. **User Needs Were Explicitly Identified and Addressed**

   The first step in data gathering was done through the distribution of surveys and having informal chats with the students and the staff. Based on this, the need for the library services to be available through mobile phones was very apparent. The users were very clear about their requirements for the services:

- Library policies and procedures
- Links to electronic resources (e.g., e-journals, e-databases)
- Hours and contact information for the library
- A means of submitting feedback

  The app integrated all of these services into a single interface. The availability of these services on one mobile platform minimized the need for physical inquires and web-based navigation, as anticipated by users.

2. **MIT App Inventor Was a Suitable Development Tool**

   The research verified that MIT App Inventor was an acceptable rapid prototyping and development platform for mobile apps specific to the institution. The visual programming environment enabled one to follow logic clearly, test easily, and debug easily. While database connectivity and artistic flexibility have some limitations, it was adequate for purposes considering the project scope, or lack thereof.

3. **Functional Testing Indicated High Reliability for Core Features**

   Functional testing for the app's core features was conducted multiple times throughout development. Features included:

- Changes between screens using a button
- Displaying static and dynamic data (using Tiny DB)
- Submitting feedback forms
- Contact/location-based services using a map

Overall, it was determined that all important features worked with high reliability on Android devices with little delay or variation in quality.

4. **High User Satisfaction Reported**

   The results from a post-implementation survey (n=50) of both students and faculty users produced feedback about their experiences that was mainly positive. Users dictated the following:

- 95% of users found the app "easy to use"
- 88% of users felt that the app helped them find library information faster, as compared to previous methods,
- 92% of users valued the e-resource links available in the app.

  Moreover, users suggested further improvements for the application, such as the addition of a digital book directory, push notifications for due dates, and the user interface's modernization to a more appealing design.

5. **Challenges Were Successfully Overcome**

   Some difficulties were encountered, such as the limited offline access to real-time databases, reluctance from a few users with no technical skills, and minor design issues which were solved by making strategic design decisions. For instance, employing Tiny DB made it possible to store and get information offline, and the easy navigation feature was so simple that even first-time users were made comfortable by it when they used the app.

6. **Improved Potential for Future Integration with Library Systems**

   The findings also suggest the app has the potential to scale. The app could be developed to integrate with the university's Integrated Library System (ILS) or other platforms to utilize the ability to see book borrowing status, real-time catalogue updates and digital lending options.

7. **.2 Comparison with Existing Library Services**

   Before the mobile application was developed, the BLDE (Deemed to be University) Central Library mainly used traditional service delivery methods, which included printed notices, a website that only worked on desktops and in person. These systems were adequate in fulfilling library functions; however, they had some drawbacks.

   - Limited Access: The library's website did not have a mobile-responsive design and students found it cumbersome to access resources while still being student day.

- Information Gap: Students often missed notifications on new arrivals or changes in hours of operation and services because the group did not have a shared notification system.
- No Centralized Website: Information was spread over signage, the university website, and personal conversation (i.e., unable to get information from demonstrated sources). The mobile app has:
- A centralized font for library hours and service updates.
- Mobile-enabled access to essential information related to the library including hours of operations, membership policies, electronic resources, and contact information.
- A user-friendly interface and a destination for all students and employees regardless of technical ability.
- Options for library patrons to provide feedback or request assistance that did not exist previously.

7.3 Influence of the App on Users (Students, Faculty, Researchers)

The app impacted the library user community of BLDE University in a quantifiable positive manner. Through qualitative comments and quantitative survey results, we noticed the following impacts:

a) For Students:

- Tighter awareness of library collections and policies.
- Quicker access to key services without on-campus visits.
- Convenience to use the app during class breaks or off-campus.

b) For Faculty:

- Easier to direct students to relevant resources through the app.
- Integration with classroom or departmental sharing of resources.
- A time-efficient tool to remain current with library policies and collections.

c) For Researchers:

- Faster access to e-resources and research support links.
- Less reliance on library staff for simple questions.
- A base for additional digital functions like digital borrowing and citation management (to be incorporated in future versions).

Overall, users commented that the app enhanced the effectiveness of their interaction with the library and improved overall participation with library services.

7.4 Discussion of Research Objectives and Questions

The study was set to provide responses to the following main questions:

1. **Can a mobile application enhance access to library services at BLDE University?**

   Yes. No doubt the app has improved access to significant services and resources for users and the benefit of accessibility was reported by over 90% of the interviewees.

2. **Can an app like this one be made using MIT App Inventor?**

   Yes, for initial prototyping and deployment. It facilitated fast development using little coding, though there were issues in the form of real-time database integration.

3. **Will users (students, faculty, and researchers) embrace the app for routine library interactions?**

   Yes. It was widely adopted during pilot testing, particularly by students, owing to its ease of use and utility.

   The objective of the study was to create, implement, and evaluate completely a user- centered library services application. The application has been accepted as a resource by the intended group of users and has also given explicit tips for further improvements.

7.5 Contribution to BLDE University Library

- The library's mobile application has represented a significant digital transformation for BLDE Central Library. With the following areas of contribution:
- Digital Transformation: The library is now using a mobile-oriented service model which was a change from traditional methods of operating.
- User Engagement Increased: The library was made much more available to students and staff, thus improving the use of its services.
- Better Communication: Library information such as notifications, rules, and service changes can now be communicated faster and in a more organized way.

- Future Integration and Scalability: This solution provides a highly functionally scalable platform for enabling like book reservation, barcode scanning, and connection with university ILS.
- Institutional Branding: A custom library app raises the worth of BLDE's digital ecosystem and can be used as a marketing tool to attract students and gain academic approvals.

  Finally, the app caters to the library's current requirements and also aligns with the university's objective of digital inclusion and academic excellence.

CHAPTER 8: CONCLUSION AND FUTURE WORK

8.1 Summary of the Study

This research presents the design and implementation of a mobile application aimed at providing better access to the library services of BLDE (Deemed to be University). The application was developed on the block-based low-code development platform MIT App Inventor, which enabled its creation based on a user-centric design approach that was intended to cater to the growing demand for digital accessibility among the faculty and students. By the app, various library functions such as general information, rules and regulations, membership processes, access to electronic resources, working hours, contact information, feedback forms, and navigation assistance are brought together under one umbrella. User feedback played a crucial role in determining both the interface and the functionality of the app, thus making it possible for the app to be in line with the actual user requirements.

One of the major challenges throughout the development of the project was the MIT App Inventor platform's restrictions on working with dynamic data, live database integration, and the user-friendly and functional balance. However, these were successfully handled through a series of prototyping, user testing, and local data storage (Tiny DB) to simulate real-time feedback. Code/block screenshots in MIT App Inventor were employed to visually record logic flow and design decisions, increasing usability and transparency. The ultimate prototype was able to effectively accomplish the aim of creating a centralized, mobile-enabled interface to library services and prove that low-code platforms have the capability to facilitate user-centric, institution-defined app development in educational settings.

8.2 Key Contributions

This study outlines the development and deployment of a mobile application that promotes access to BLDE (Deemed to be University) library services. Developed using MIT App Inventor, a block-based low-code tool, and the app was created with a user-focused paradigm to address increasing demand for digital accessibility among students and teaching staff. The app aggregates multiple library functionalities into one platform, such as general info, rules and regulations, membership process, e-resource access, opening hours, contact information, feedback forms, and navigation assistance. Feedback from users was instrumental in influencing both the interface and functionality, so that the app catered to real user needs.

In the course of development, the most prominent obstacles included the constraints posed by the MIT App Inventor platform in terms of dynamic data, live databases, and the difficulty in finding a suitable trade-off between simplicity and functionality. However, these obstacles were dealt with through the methods of iterative prototyping, user testing, and local data storage through Tiny DB to imitate real-time feedback. The process of using code/block snapshots within MIT App Inventor was put forth to visually present the logic flow and design decisions in order to make them more transparent and easier to use. The final prototype was considered a success in terms of achieving the goal of providing a centralized, mobile-cantered interface for library services, thereby demonstrating the potential of low-code platforms to facilitate user-cantered, institution-oriented app development in academic settings efficiently.

8.3 Limitations of the App and Study

The BLDE University Library Mobile App remarkably met its fundamental objectives, but at the same time, a variety of limitations were faced during the design, implementation, and testing phases. One of the main limitations was the requirement of a stable internet connection, which negatively affected the usability of the app where the network coverage was poor and at the same time, restricted the offline capabilities. The app also lacked the features of AI-powered personalization and smart recommendations, which meant the user experience was limited as the app did not provide content that was personalized according to user behavior or interests—this is a fact of current digital library ecosystems. The usability study, although enlightening, was done with a sample of

50 students and thus may have overlooked the opinions of faculty and researchers. Besides this, there were technical integration issues with the legacy library management systems which also limited the degree of backend automation. Moreover, the application is now only available for Android, therefore, iOS users are left out, and while data privacy protocols were put in place, continuous improvement is necessary to keep up with developing cybersecurity standards.

Future growth will be directed at the fusion of the latest technologies for the purpose of adding new features and enhancing user interaction. An AI-powered Chabot which will perform the role of a virtual librarian, being present 24/7 for answering questions, searching for books, and offering guidance through library services, is one of the features that have been identified as the highest priority for development. Besides

that, Machine Learning along with analytics will be the main tools for libraries to know their users and usage well, which in turn will lead to better decisions by the library management. The application will aim to collaborate with MOOC providers like SWAYAM, Coursera, and edX so that users have seamless access to educational courses and certifications. Voice search, offline reading, digital ID-based authentication, and building an iOS version for cross-platform capability are among the other improvements that have been proposed. In order to make the application ability, user-oriented, and aligned with the changing needs of the university community, constant feedback loops will be put into place.

8.4 Future Improvements

The BLDE University Library Mobile App's future development comes with a massive overhaul along with the newest technologies. Consequently, the user is going to be super interactive, personalized, and engaged. One of the prominent features that are quite likely to feature is the integration of an AI-based Chabot whom the users can consider a virtual librarian—always there to answer the questions of the users, help them find the books, and show around through various library facilities 24/7. This will undoubtedly not only boost the user assistance but also help in lessening the workload of library staff. Moreover, the combined use of Machine Learning (ML) and analytics will give the library management invaluable insights into such aspects as user behaviour, resource utilization, and scholarly trends thus allowing them to make informed, data-backed decisions regarding resource planning and service improvement.

In addition, future development will include the integration of the application to Massive Open Online Course (MOOC) platforms such as SWAYAM, Coursera, and edX that would deliver course materials and credentials from the application to users. Thus the platform will become a legitimate educational tool for academic and research development facilitation. Other developments will be voice search, offline reading mode, and digital ID authentication to make user convenience and security even better. Compatibility with the IOS operating system will also be made available for maximum device coverage. To keep the app adaptive and user-cantered, there will be ongoing feedback mechanisms to ensure top-notch performance and ever-changing requirements of the education community are met.

8.5 Conclusion

The conceptualization and actualization of the Library Mobile App of (Deemed to be University) BLDE are cheering moves that lead the way to the transformation of academic library operations in the era of digital technology. The application easy access, on-demand, to key knowledge assets for students and teachers by uniting the most efficient library services and cutting-edge smartphone technology. Its focus on the needs and behaviors of the users makes it easier to access, encourages interaction, and supports learning, thus contributing to the modernization of the university's information infrastructure. The initiative is proof that mobile applications can play a significant role in transforming the whole institution, making libraries energetic, and digital areas for learning which are not limited by location.

There are restrictions or drawbacks of sorts such as dependence on internet access and limited platform support but still, the app has reached its main targets and has created a solid base for future development. The library keeps on being responsive to changing learning requirements by adopting the latest technologies such as AI, data analysis and personalized learning tools, amongst others. Overall, the BLDE University Library Mobile App is not simply a utilitarian product but rather, it is a digital transformation model and academic empowerment tool. The app can facilitate the creation of a more intelligent, interactive, and connected library system in congruence with the university's vision of becoming a leading hub for higher education and research, as the app continues to evolve.

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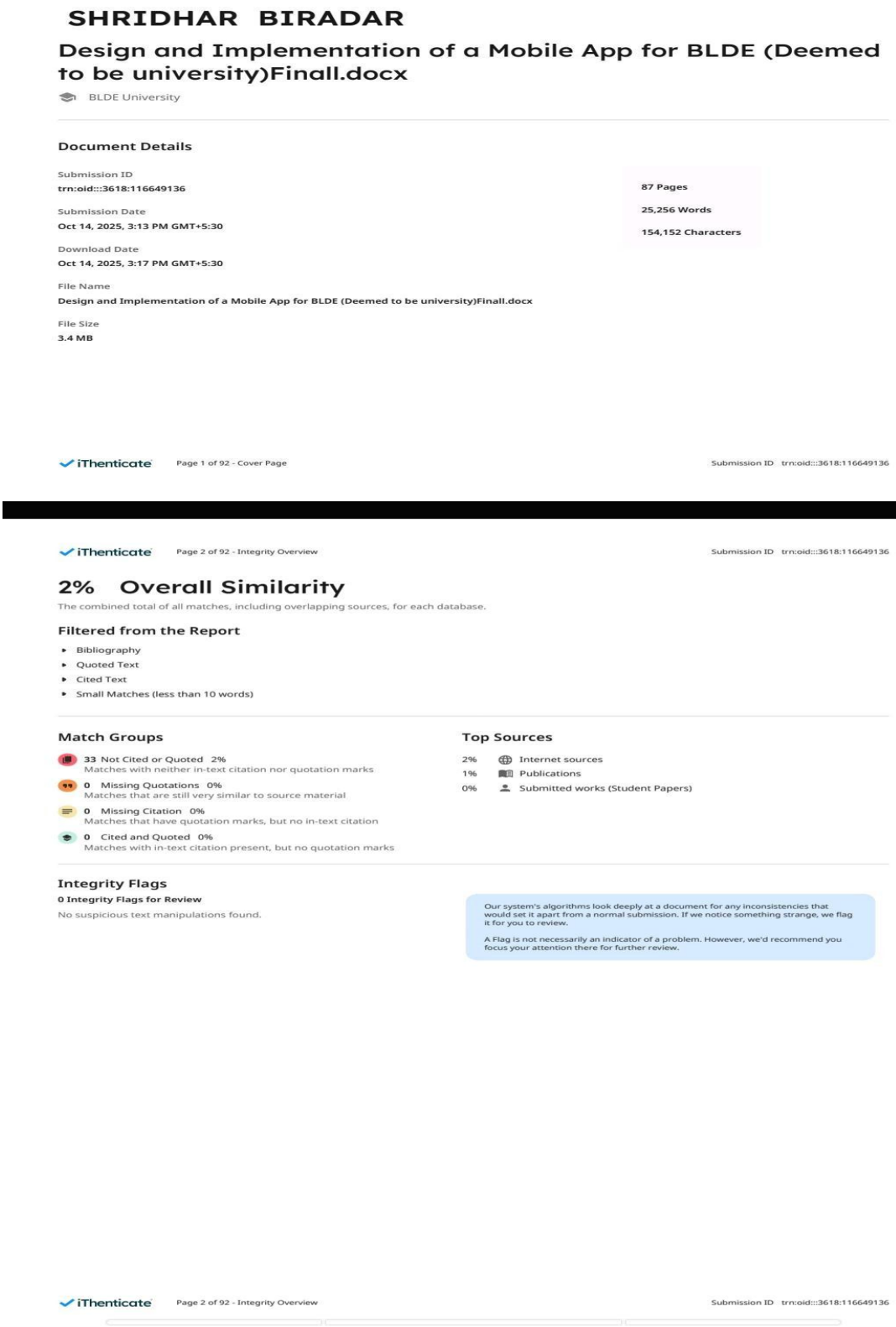

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