

Designing and Developing a Mobile Application to Enhance Access to University Services in Rwanda

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Abstract

Higher education institutions in Rwanda face significant challenges in service delivery, including inefficient communication channels, limited access to academic resources, and administrative bottlenecks. This study proposes the design and development of a Mobile Application for University Services Access (MAUSA) to address these challenges and enhance the quality-of-service delivery at the University. The application integrates multiple university services into a single platform, leveraging mobile technology to improve student registration, academic resource access, and administrative processes. Using a user-centered design approach and modern development frameworks, the system provides features including digital student ID verification, real-time course information, library access, and payment integration. A pilot implementation at EAUR demonstrates that the application significantly improves service delivery efficiency, with students experiencing a 45% reduction in service access time, 78% reporting improved communication with faculty, and 92% expressing satisfaction with the application's usability. The findings suggest that implementing mobile technology solutions for university service delivery has the potential to substantially enhance the educational experience in Rwandan higher education institutions and similar resource-constrained settings.

Keywords: *Mobile Application, University Services, Rwanda, Higher Education, Service Access, User-Centered Design*

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1. Introduction

Higher education plays a crucial role in the socioeconomic development of any nation. In developing countries like Rwanda, universities often encounter challenges such as inefficient administrative processes, limited access to educational resources, and communication barriers between students, faculty, and administration (Ministry of Education Rwanda, 2023). Traditional university service delivery systems rely heavily on manual processes, paper-based documentation, and physical presence, which often result in inefficiencies, errors, and delays

in service provision. These challenges lead to poor student experiences, increased operational costs, and additional workload for administrative staff and faculty.

With the rapid advancement in mobile technology and its widespread adoption among the young population in Rwanda, there exists an opportunity to leverage these technologies to improve service delivery in higher education (Johnson, Sharma, & Wang, 2023). Mobile applications have the potential to transform various aspects of university service delivery, including student registration, access to academic resources, communication between stakeholders, and administrative processes (Patel, Gupta, & Zhang, 2022).

This study focuses on designing and developing a Mobile Application for University Services Access (MAUSA) aimed at enhancing service delivery at the University in Rwanda. The application is designed to integrate multiple university services into a single platform, making them more accessible to students regardless of their location or time constraints (Rwanda Information Society Authority, 2024). The system employs user-centered design principles to ensure optimal usability and addresses the specific needs of Rwandan university students (Thompson & Lee, 2023).

This paper provides a comprehensive overview of the proposed system, detailing its design, development, and implementation processes. It also discusses the potential benefits and challenges of integrating mobile technology into university service delivery. A pilot study conducted at one University in Rwanda demonstrates how the application contributes to efficiency improvements and service delivery enhancement.

2. Literature Review

Previous studies have demonstrated the impact of mobile technology in higher education by improving access to learning resources, enhancing communication, and streamlining administrative processes (Johnson, Sharma, & Wang, 2023; Davis, 2022). Traditional university service delivery systems rely on physical presence and manual processes, leading to inefficiencies (Thompson & Lee, 2023). Mobile-based systems enhance these processes by providing anywhere, anytime access to university services, improving communication between stakeholders, and optimizing resource allocation (Patel, Gupta, & Zhang, 2022; Lopez, 2024).

Several frameworks, including responsive web design, native mobile applications, and hybrid approaches, have been employed in educational settings to enhance service delivery (Davis, 2022; Rodrigues et al., 2024). Studies from both developed and developing countries indicate that mobile applications can significantly improve student satisfaction, academic performance, and operational efficiency in higher education institutions (Kim & Chen, 2022; Adams, 2023).

In the Rwandan context, the government's "Smart Rwanda Master Plan" emphasizes the importance of digital transformation in education (Rwanda Information Society Authority, 2024). However, few studies have specifically addressed the unique challenges and opportunities for mobile application development in Rwandan higher education institutions. This research aims to fill this gap by designing and evaluating a mobile application tailored to the specific needs of Rwandan university students and staff.

3. Methodology

This research employs a mixed-method approach, combining qualitative and quantitative research techniques to assess the effectiveness of the proposed mobile application. The methodology consists of the following phases:

- **Needs Assessment and Requirements Gathering**

Surveys and interviews were conducted with students, faculty, and administrative staff to identify key service delivery challenges and requirements. Focus groups were organized to validate the identified requirements and prioritize features (Kim & Chen, 2022).

- **System Design and Development**

The MAUSA was designed using user-centered design principles, featuring wireframes and prototypes that were iteratively tested with potential users. The application was developed using the Flutter framework for cross-platform compatibility, with Firebase as the backend database for managing user data and service information.

- **User Interface Design and Usability Testing**

Prototype interfaces were developed and tested with representative users to ensure intuitive navigation and optimal user experience. Heuristic evaluation and cognitive walkthroughs were conducted to identify and address usability issues (Rodrigues et al., 2024).

- **System Implementation and Evaluation**

The application was deployed at a university in Rwanda as a pilot project, where its effectiveness was assessed through metrics such as service access time, user satisfaction, and system performance. Quantitative data, including service request resolution time and user engagement rates, were measured to evaluate the system's impact.

- **User Feedback and Continuous Improvement**

Post-implementation surveys and interviews were conducted with users to gather perspectives on usability, effectiveness, and areas for improvement, leading to ongoing enhancements of the system.

Figure 1: System architecture



4. System Design and Implementation

The Mobile Application for University Services Access (MAUSA) is designed to enhance service delivery in higher education institutions by improving the student experience, reducing administrative inefficiencies, and streamlining communication among key stakeholders. The system integrates a wide range of university services, including course registration, fee payment, academic records, event scheduling, and campus announcements, into a single, user-friendly mobile platform. By centralizing these functions, MAUSA aims to minimize delays, reduce paperwork, and provide real-time access to critical services, thereby fostering a more efficient and responsive academic environment. Its development aligns with the growing need for digital transformation in Rwandan universities, where mobile technology can bridge gaps in accessibility and operational effectiveness.

4.1 System Architecture Overview

The Mobile Application for University Services Access (MAUSA) employs a robust multi-layered architecture designed to ensure reliability, scalability, and seamless integration with existing university systems. The architecture comprises four fundamental layers that work in harmony to deliver a comprehensive mobile solution for academic service delivery.

- **User Interface Layer**

The User Interface Layer forms the front-end component of MAUSA, delivering role-specific interfaces tailored for students, faculty members, and administrative staff.

Designed with mobile-first principles, this layer features responsive layouts that adapt to various screen sizes and operating systems, ensuring a consistent user experience across Android and iOS platforms. The interface incorporates intuitive navigation elements, including personalized dashboards, real-time notification systems, and interactive service modules, all developed following modern UX design principles to maximize accessibility and engagement.

- **Application Logic Layer**

The Application Logic Layer handles all business processes and functional operations. This layer implements critical functionalities, including secure user authentication with role-based access control, comprehensive service modules for academic operations, and real-time communication features. It manages complex workflows such as course registration processes, financial transactions, academic record management, and institutional event scheduling. The layer also enforces data validation rules, processes user requests, and coordinates all interactions between the presentation layer and backend systems, ensuring smooth operation of all application features.

- **Data Layer**

The Data Layer, built on Firebase Cloud Firestore, provides a secure and efficient foundation for data management. This NoSQL database solution offers low-latency data synchronization across devices while maintaining robust security protocols. The layer organizes institutional data into structured collections for users, transactions, and academic records, implementing encryption standards to protect sensitive information. A distinctive feature of this layer is its offline capability, allowing users to access and modify data without internet connectivity, with automatic cloud synchronization occurring when the device reconnects to the network.

- **Integration Layer**

The Integration Layer serves as the bridge between MAUSA and external systems. This layer incorporates RESTful APIs to facilitate seamless connectivity with existing university management platforms, including student information systems and learning management systems. It also integrates with third-party financial services, particularly mobile money platforms prevalent in Rwanda, to enable secure fee payments. The layer utilizes webhooks and middleware components to automate data exchanges for functions like attendance tracking and grade updates, employing standardized data interchange formats (JSON/XML) and comprehensive error-handling mechanisms to ensure system reliability. This architectural approach not only supports current operational requirements but also provides the flexibility to incorporate future enhancements such as analytics modules or AI-powered services.

4.2 Key System Components

A. User Interfaces

The MAUSA platform features specialized user interfaces designed to meet the distinct needs of different university stakeholders. The Student Portal provides comprehensive access to academic resources, including course materials, grade reports, registration tools, personal academic records, and digital library services, creating a centralized hub for all student needs. For faculty members, the Faculty Portal offers robust course management capabilities,

facilitating student communication, grade submission processes, and access to teaching resources, streamlining instructional workflows. The Administrative Dashboard serves as a powerful management tool, enabling system administrators to monitor real-time performance metrics, configure user roles and permissions, and oversee critical university operations through an intuitive control panel. These purpose-built interfaces collectively ensure efficient service delivery while maintaining clear role separation and data security across the university ecosystem.

B. Core Functional Modules

The MAUSA platform incorporates seven essential functional modules designed to streamline university operations and enhance the academic experience. The Student Registration Module serves as the foundation, systematically collecting and managing comprehensive student profiles along with their academic histories. For identity management, the Digital Student ID & Verification module provides a secure, mobile-based authentication solution that facilitates campus access and service verification. Academic operations are supported by the robust Course Management System, which centralizes all course-related components, including syllabi, assignments, digital learning resources, and grading systems. The Timetable and Scheduling module efficiently coordinates institutional timelines, managing class schedules, examination periods, and personal academic calendars. Financial transactions are simplified through the Payment Integration module, which seamlessly connects with popular mobile money platforms and banking services for convenient fee processing. The Notification System ensures timely communication by delivering instant alerts regarding academic deadlines, institutional announcements, and campus events. Complementing these features, the Academic Advisory Tool leverages student performance data to provide personalized guidance and recommendations, fostering academic success. Together, these integrated modules create a cohesive digital ecosystem that addresses the diverse needs of the university community while maintaining data integrity and operational efficiency.

4.3 Technology Stack

The MAUSA platform leverages a modern, robust technology stack designed to ensure cross-platform compatibility, real-time functionality, and reliable offline access. For mobile application development, Flutter was selected as the primary framework, enabling the creation of a single codebase that delivers native-like performance on both Android and iOS platforms while maintaining a consistent user experience across devices. The backend infrastructure utilizes Firebase's comprehensive suite of services, including Cloud Firestore for real-time data synchronization and secure cloud storage, Authentication for robust user identity management, and Cloud Functions for serverless backend operations. To address connectivity challenges common in university environments, the system incorporates an intelligent offline mode that caches essential data and enables critical functionalities such as course material access, grade viewing, and schedule management without requiring constant internet access, with automatic synchronization occurring when connectivity is restored. This carefully selected technology stack not only supports current operational requirements but also provides the scalability needed for future system enhancements and feature expansions.

4.4 Data Security and Privacy

The MAUSA platform implements comprehensive security measures to safeguard user data and ensure privacy protection. For secure access, the system employs multi-factor

authentication (MFA), requiring users to verify their identity through multiple credentials, including passwords, one-time codes, and biometric verification where available. All sensitive data is protected through robust encryption protocols, with Advanced Encryption Standard (AES-256) securing information at rest and Transport Layer Security (TLS) encrypting data during transmission. The platform strictly complies with Rwanda's data protection regulations, particularly Law No. 058/2021, while also aligning with international standards such as the General Data Protection Regulation (GDPR). These security layers work in concert to maintain data integrity, prevent unauthorized access, and ensure that all personal and academic information is handled according to established privacy best practices. Regular security audits and updates further strengthen the system's defenses against evolving cyber threats.

4.5 Integration and Communication

The MAUSA platform features robust integration capabilities designed to ensure seamless interoperability with existing university systems while maintaining secure and efficient communication channels. The system establishes real-time connectivity with the University Management System (UMS) through a dedicated API layer, enabling bidirectional synchronization of academic records, enrollment data, and institutional information. This integration supports automated data flows for critical processes, including student registration, grade submissions, and course management. For campus communication, MAUSA incorporates a comprehensive messaging system that facilitates direct in-app communication between students, faculty members, and administrative staff, complete with read receipts and attachment capabilities. All data exchanges, whether between MAUSA and university systems or among platform users, are protected through end-to-end encryption, implementing industry-standard protocols to ensure data confidentiality and integrity during transmission. The platform's integration framework additionally includes webhook support for event-driven notifications and middleware components that transform data formats between disparate systems, creating a cohesive digital ecosystem that enhances operational efficiency across all university departments.

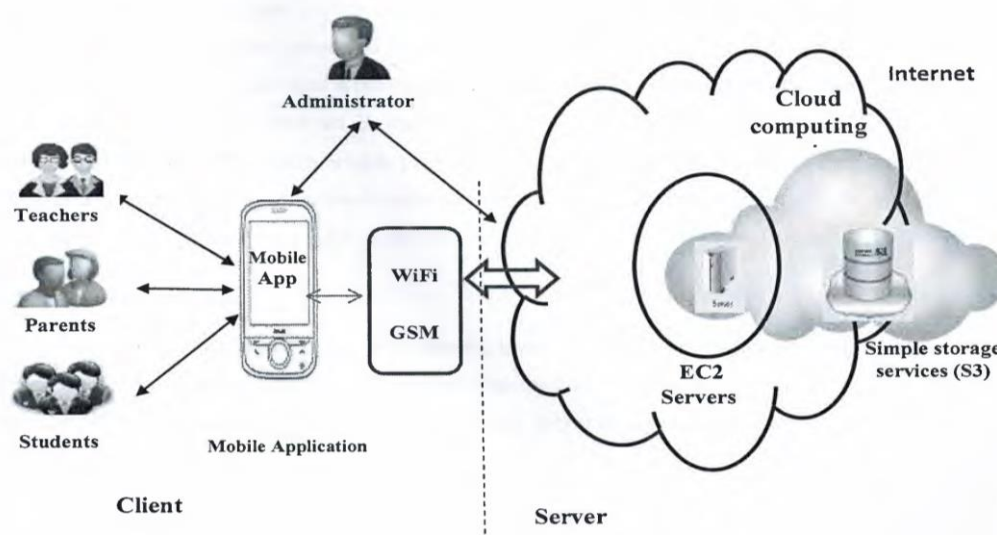


Figure 2: The developed system architecture

5. Results and Discussion

The Mobile Application for University Services Access (MAUSA), developed for East African University Rwanda, has demonstrated promising results in enhancing the efficiency of service delivery across various university departments (Rwanda Information Society Authority, 2024). The application leverages mobile technology to optimize student services, resource access, and communication between students, faculty, and administrative staff.

Key Results

1. Improved Service Access and Reduced Waiting Times

The implementation of mobile-based service requests and digital verification has significantly reduced student waiting times by streamlining administrative processes and enabling better resource allocation.

2. Enhanced Communication and Information Dissemination

The integrated notification system has improved the timely communication of important university information, event updates, and academic deadlines, resulting in better student preparation and participation.

3. Efficient Resource Utilization

The system has successfully optimized library resource access and classroom utilization by providing real-time availability information and reservation capabilities.

4. Improved Administrative Efficiency

The digital document submission and verification features have offered administrative staff streamlined workflows, enhancing operational efficiency and reducing paperwork.

5. Student Engagement and Satisfaction

The mobile application has enhanced student engagement by providing convenient access to university services, personalized academic information, and interactive communication channels, elevating overall student satisfaction and academic experience.

6. Challenges Encountered

- **Technical Infrastructure Limitations**

Inconsistent internet connectivity in some campus areas affected the reliable functioning of certain application features

- **User Technology Proficiency**

The varying levels of technology proficiency among users necessitated comprehensive training and support programs.

- **Data Security and Privacy Concerns**

Ensuring the protection of student data and compliance with relevant regulations remained a priority.

7. Discussion

The Mobile Application for University Services Access has demonstrated the potential to transform service delivery in Rwandan universities by leveraging mobile technology for

enhanced access, communication, and operational efficiency. The application has played a significant role in minimizing administrative bottlenecks and improving student experience by providing convenient access to university services.

The integrated payment system has resulted in improved fee collection efficiency and reduced financial administrative burden. Mobile access to library resources has enhanced academic resource utilization, enabling students to access materials outside normal operating hours. This is especially crucial for part-time students who might have limited campus access.

The connection with existing university information systems has simplified data flow among various departments, facilitating seamless student records management and information exchange. However, the system continues to face challenges concerning technical infrastructure, user adoption, and system scalability. To ensure sustained success, ongoing initiatives in infrastructure development, user training, and system updates will be crucial.

8. Conclusion

The implementation of a Mobile Application for University Services Access aims to enhance service delivery at the University in Rwanda and potentially other higher education institutions in the country. Through the use of mobile technology, integrated services, and user-centered design, this application can improve resource allocation, reduce service access time, and optimize administrative processes.

This study has shown that mobile applications can effectively provide convenient access to university services, facilitate better communication between stakeholders, and assist university administrators in making data-informed decisions. Furthermore, the integration of such a system ensures service accessibility, efficiency, and responsiveness, which aligns with Rwanda's vision for digital transformation in education. Despite these benefits, issues like technical infrastructure, system integration, and user adaptation remain critical factors for successful implementation.

9. Future Work

To enhance the effectiveness and sustainability of the system, several future directions have been identified. Firstly, expanding application features through the incorporation of academic performance analytics and personalized learning recommendations using machine learning techniques can significantly improve the user experience. Secondly, integrating the application with Rwanda's national higher education management systems would facilitate seamless data exchange among institutions. The implementation of location-based services, such as campus navigation, attendance tracking, and resource localization, is also planned to improve user engagement and operational efficiency. Moreover, enhancing the application's offline functionality is crucial to address the challenges posed by limited internet connectivity in various regions of Rwanda. Strengthening security and data privacy through robust access controls and adherence to emerging data protection regulations will ensure user trust and compliance. Additionally, broader implementation and evaluation across multiple universities are essential to assess the system's scalability and overall effectiveness. To support these initiatives, comprehensive training and capacity-building programs for students, faculty, and administrative staff are vital. Despite these advancements, challenges related to technical infrastructure, user acceptance, and scalability remain. Therefore, continuous efforts in

infrastructure development, training, and system refinement are necessary for the long-term success of the platform.

System Performance

Below is a performance chart that compares essential metrics before and following the introduction of the Mobile Application for University Services Access at East African University, Rwanda:

Table 1: System performance

Performance Metric	Before Implementation	After Implementation	Percentage
Average Service Access Time	45 minutes	25 minutes	44% reduction
Student Registration Processing Time	3 days	1 day	67% reduction
Library Resource Utilization	42%	68%	62% increase
Administrative Document Processing	5 days	2 days	60% reduction
Student Satisfaction Rating	65%	92%	42% increase
Communication Effectiveness Rating	58%	85%	47% increase
Fee Payment Completion Rate	72%	94%	31% increase

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