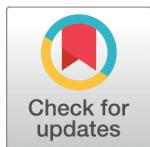




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Integrating Mobile Computing in University Information Management Systems to Improve Access and User Experience

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Abstract

Objectives: To develop a mobile application and integrate it with an existing University Management System for improving access and user experience for services to be accessed anytime, anywhere through connected smartphones.

Methods: An online survey, interviews, and observations to collect the system requirements were gathered and analyzed essential requirements for the design and development of the mobile application. Agile software methodology was used because of its flexibility to accommodate changes. The integration architecture was based on RESTful API and SOAP web services. The System Usability Scale (SUS) methodology was applied to assess the user's perception and usefulness of the mobile application. **Findings:** The developed Pwani University (PU) mobile application was able to successfully connect with the Students Information Management System (SIMS) to access services. Unit, integration, and system testing were performed to ensure the intended specifications were met. The key findings from the survey show that smartphones, the majority of which run on the Android platform, are the most commonly owned and used mobile devices among students. The majority of students 97% agreed that the justifications for developing the app were valid. The study indicated that 68% of students want access to course information, hostel information, and exam results via their mobile gadgets. The usability and acceptance testing were very successful with more than 90% of users liking the app and more than 80% did not need any assistance to use the app and did not find it cumbersome. **Novelty :** The developed mobile application provides seamless integration with the PU SIMS, increasing access to services, portability, and convenience to staff and students.

Keywords: Mobile application; App design; University app; App integration; User experience; ERP

1 Introduction

Technologies have taken center stage, especially in education, health, the economy, and commerce⁽¹⁾, this has accelerated the access to digital services and online interactions across the divide. Advances in technology have led to more widespread use of mobile technology in education, especially at the university level⁽²⁾, thus providing a virtual platform for electronic teaching, learning, and service delivery. This new reality is forcing universities, both private and public to consider how to integrate phones into educational settings⁽³⁾. Mobile applications have a lot of potential for educational use, particularly in university studies⁽⁴⁾. The rising need for Enterprise Resource Planning (ERP) systems to be accessed via mobile devices has been fueled by the proliferation of mobile devices, ongoing developments in mobile computing⁽⁵⁾, creating a major shift from desktop ERP systems to mobile platforms. One of the most important factors that determine the performance of many applications is usability⁽⁶⁾, which is one of the determinant factors in the adoption of those applications. Since 2015, the average annual growth rate in smartphone connections in Sub-Saharan Africa has been 28%, and smartphones now account for nearly half of all connections⁽⁷⁾. The widespread usage of cell phones has linked all stakeholders in the value chain⁽⁸⁾. Smartphone ownership and usage have increased in Kenya, this can be attributed to affordable prices, reasonable calling charges, and internet bundles. Mobile telephony subscriptions in Kenya were recorded as 45.6 million, which represents a 97.8% rate of penetration⁽⁹⁾. Therefore, as more people get connected to the network, they create the demand for mobile applications to access various services based on their needs.

Laptops and desktop computers which are mainly fixed in the offices are used to access the SIMS, since the systems are accessible via these devices, fewer people can use them. As a result, this project suggested developing an Android mobile app to link it with the SIMS which is currently hosted on-premise at PU. Therefore, this paper reports an integration of mobile computing based on RESTful API and SOAP web services to improve access and user experience of SIMS with a case of PU in Kenya. The PU App will be conveniently accessible through the internet compared to the existing local area network access on desktops and laptops. The acquisition cost, portability, and navigation, besides it, save time and cost.

The previous study was conducted; A review study of COVID-19 mobile applications with various features integrated with health care facilities, the study examined and assessed the many features, functionality, and efficacy of the mobile apps⁽¹⁰⁾. To design cardiopulmonary resuscitation assistance apps, the Kano model is utilized to elicit user requirements and provide insight into their needs and priorities⁽¹¹⁾. However, it does not provide a more complete description of those needs, necessitating the use of additional approaches. An ERP framework was proposed to integrate ERP with mobile applications through Service Oriented Architecture (SOA) and web services to synchronize data between the systems⁽¹²⁾. The disadvantage of the approach is the web service security, which relies on a password in the body, but it would be preferable if security could be added to the header. A method for connecting different ERP systems with mobile applications is by creating a communication and information standard and adjusting each system's information to the standard by using adapters⁽¹³⁾. The drawback is the process of developing the information standard has been a long one that has necessitated extensive investigation to identify various ERP data and their relationship to the standard. Currently, the adapters that have been developed only cover a tiny portion of the ERP's conceivable functions. Problems associated with mobile ERP adoption rates and measuring the level of complexity, acceptance, and learnability⁽¹⁴⁾. A study on Using an Adaptive System Architecture to Create Adaptive User Interfaces for Mobile ERP Apps according to the context of use⁽¹⁵⁾. The study was implemented with Odoo ERP with the Odoo server, while the proposed solution will be integrated with Microsoft Dynamics NAV 2018 ERP. A mobile ERP architecture for an ERP system's sales department with a web service-based framework⁽¹⁶⁾ but the study focused only on the mobile ERP architecture for an ERP system's sales function. Also, a mobile ERP framework for SAP, a global ERP system company, is a research restriction in the paper because SAP ERP is not deployed in all businesses. Study to modernize the notion of controlling and handling information exchange on campus through a more user-friendly through the use of an Android app⁽¹⁷⁾. An Android-based ERP solution that can be accessed from anywhere in the world and helps to keep ERP data in a centralized area⁽¹⁸⁾. The mobile application for alumni of Soegijapranata Catholic University was developed and after graduation, the software was used to stay in touch with the university⁽¹⁹⁾. The developed mobile applications in 17,18 and 19 were largely based on a native app model which hosted their resources as one full system compared to the proposed solution, which integrates the SIMS and mobile application.

The literature review was studied and analyzed. It has presented conceptual guidelines as well as architecture for the integration of mobile applications with management information systems popularly referred to as ERP systems. However, from the review, most of the studies were based on SAP and Odoo ERPs with adapters as the main architecture for integration, besides the developed apps were native. This paper presents the implementation of the Microsoft Dynamic Navision ERP-based SIMS and mobile app integration through RESTful API and SOAP web services thus, solving the problem of accessing university services from fixed laptops and desktops in offices.

2 Materials and methods

This study's general approach involves a survey, literature review, data collection methods, interviews, observation, and a questionnaire for data collection and analysis. The Agile software development approach was used to build the PU App. The survey aimed to learn more about the mobile app development process, specifically the issues and challenges that arise when linking the mobile app's inbuilt database to the student's management information system.

2.1 Research case study area

One of the most critical sections of the first objective of the analysis was to understand and address research questions such as "What would be the criteria for the PU mobile application?" "How will the new student management system be combined with the mobile system's database for real-time access?" and "How will the current student management system be integrated with the mobile system's database for real-time access?" The case study's findings helped to shape the criteria for the PU App's growth. The research was carried out at Kenya's Pwani University.

PU became a chartered university on 31st January 2013. It is located in Kilifi County, about 60 kilometers north of Mombasa and adjacent to the Indian Ocean, in the scenic resort town of Kilifi. PU's position helps to empower the city, inspiring many to seek higher education⁽²⁰⁾.

2.2 Data collection methods

The simplified formula was used to measure sample sizes⁽²¹⁾. Where population size was 8,500 and acceptance sample error of 5%. The sample size was found to be 368. Questionnaires, structured and semi-structured interviews, and observation were used to obtain quantitative and qualitative data for the analysis. Data were collected for two months in 2021, from January to February.

Structured questionnaires were issued to both the staff and students according to the research objectives. In this study, the interviews were mainly targeted at collecting technical requirements from the technical personnel. The observation was conducted especially during current systems performance and the users while interacting with the systems. Students and staff queuing seeking various services, especially from the ICT department. The survey data was analyzed using Google Forms' built-in functions for translating collected data into useful information through charts, graphs, and tables.

2.3 System development methodology

Agile methodologies were used to develop the mobile app. This is because the agile approach means developers and customers have a direct line of contact⁽²²⁾. Requirements changes are a common occurrence that can trigger user frustration if incoming changes are limited, or project delivery delays if too many changes are allowed⁽²³⁾. A combination of Agile hybrid approaches to meet the demands of developing volatile agile mobile applications⁽²⁴⁾. Summary of agile software methodology into four major phases; envision, solution, quality assurance, and product release⁽²⁵⁾.

The mobile application was created using the tools and techniques; Flutter which is a Google released an open-source mobile app development framework in 2017⁽²⁶⁾. XML and JAVA which are the key sources of interaction between the mobile application interface and user inputs were created using Extensible Markup Language (XML) while the Java programming language was used to code the mobile application's functionalities. Android studio layout operations, which are the key source of interaction between the mobile application interface and user inputs, were created using Extensible Markup Language (XML). Android SQLite database is inbuilt by default in an android mobile operating system. It's also known as a "lighter" version of SQL, and it's supported by the majority of popular programming languages⁽²⁷⁾.

3 Results and Discussion

3.1 Results for requirements gathering and analysis

The survey was completed by 385 respondents. The key findings are presented as below; -

The occupation and gender of respondents in the university are male 66% and female 33%. With regards to device ownership and frequency of use, 97% of the respondents owned smartphones, and 39% own laptops. The aim was to check the prospective users of the proposed mobile app. For the respondents who owned more than one device, they were further asked on their most frequent device, of which almost 66% were frequently using their smartphones, with almost 29% on laptops. This indicated the frequent usage of smartphones more than the other devices. Of the respondents who owned smartphones, 96% were on

the android platform, while 2% were on the iOS platform as results shown in Figure 1. Thus, Android is the ideal platform for mobile applications. When respondents were asked whether they needed a mobile application to access PU services, an overwhelming majority responded positively. This is one of the justifications for the development of the PU App. The use of smartphones with 52% using their smartphones continuously while 47% use several times a day. This indicates the potential of the proposed mobile application with the user expected to interact more with the application. The respondents connected through the internet mostly through the campus Wi-Fi and mobile data.

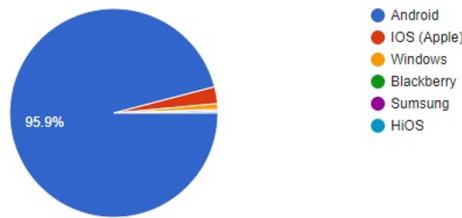


Fig 1. The pie chart represents the mobile applications platforms

3.2 Results for system design

The proposed mobile application has two main modules the existing SIMS and the inbuilt mobile application database and the user interface. Use Case modeling was used to show the processes and actors for the mobile app. The Activity diagram depicted the operation for viewing student profile use cases. User Interface (UI) design was simple, yet easy to navigate to provide a great user experience. Database design uses the information provided by the domain class diagram and use case. The database for the PU App was designed based on the requirements as depicted in the Use Case, activity, and sequence diagrams. The mobile app database design was on SQLite database which will link with API to interface with the MySQL server in the core student's management system. For the requirements specifications, the functional requirements for the mobile app that were extracted from the requirements specification phase are shown in Table 1, while the non-functional requirements were also considered; the system will be updated and upgraded to accommodate new and improved functionalities, should be expandable without a major overhaul, the system will be stable, avoid frequent crashes, increasing uptime less downtime among others. The Conceptual framework is as shown in Figure 2.

Table 1. Functional requirements

Requirement	Description	Actor
1. Register New User	The users will be assigned security privileges and assigned secured login credentials i.e. user name and password	Systems Administrator /student/staff
2. Register Semester	The system will allow a user to register for a new semester	Student
3. Register Units	The system will allow a user to register for new semester units	Student
4. Check Fees Balance	The system will allow a user to query the balance of their fees	Student
5. Download Fees Statement	The system will allow a user to download fees statement in read-only mode	Student
6. View Payslip	The system will allow a user to view monthly payslip	Staff
7. Download Payslip	The system will allow a user to download a monthly payslip in read-only mode	Staff

3.3 The developed mobile application

The "Pwani University app" or "PU app" key features are that students can view their profile, course management, finance management, and download read-only reports such as fees statements, unit registration forms, and examination cards from anywhere as long as they are linked to the internet. The mobile application, which was available for both iOS and Android, had many features; Login and verification; the default username is the student's registration number for example, "E40/PU/1234/20" and a one-time password (OTP) which must be changed after initial login. Semester and course registration were successful.

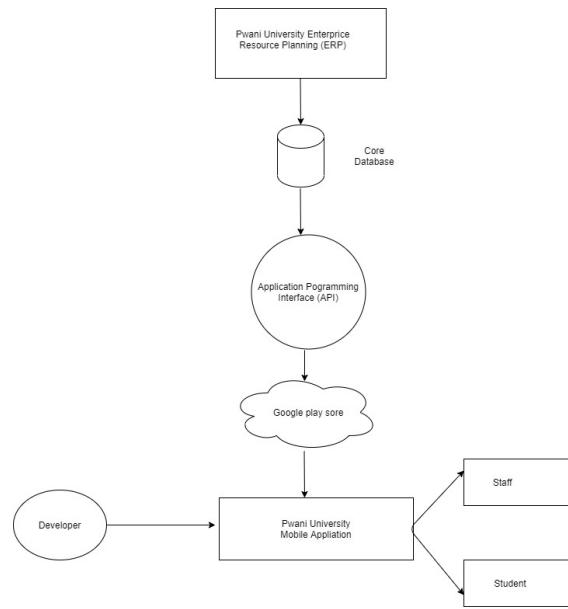


Fig 2. The conceptual framework for the mobile app

The students can quickly check the balance of their fees in their student portal account and download fee statement in pdf format. Figure 3 shows the main dashboard for the mobile app



Fig 3. Main dashboard screen

3.3.1 SIMS and mobile app integration

The integration between the PU student's management system and the mobile application was achieved by connecting through the Microsoft dynamics nav adapter acting as a bridge to translate service requests between the two systems. The web services RESTful API and the Web services SOAP API are protocols for exchanging data through the adapter.

3.3.2 Challenges of the SIMS/Mobile app integration

The SIMS is currently hosted on-premise, sometimes users experience slight delays in response also depending on the speed of their internet connection and performance of their mobile devices.

Security of the data transfer was a key issue due to highly sensitive data that was stored on the core information system, the management of the university approved access to the academic module, and on READ-ONLY mode, which means the mobile application was supposed to view the contents but not to write.

3.4 Validation of the mobile application

During the validation process, the software was checked to confirm if the desired results were obtained, thereby enhancing the software's accuracy. Unit testing was done to test the functionalities of independent modules of the mobile app to ensure they perform as designed. The main modules that were put to the test: - layout activities, transfer of data between the mobile app and main server, user authentication, and user interaction. In integration testing, the integrated part of the PU mobile app and the main server of the SIMS was linking very well and it was possible to exchange data and transactions between the two main independent components. For the testing, layouts, operations, tools, databases, and java code for the PU mobile application were all merged into one framework. The results of the device testing are shown in Table 2.

Table 2. System testing results

System Requirement		TestResults
1. Register New User	The system should allow registered users to log in	PASS
2. Register Semester	The system should allow a user to register for a new semester	PASS
3. Register Units	The system should allow a user to register for new semester units	PASS
4. Check Fees Balance	The system should allow a user to check the balance of their fees	PASS
5. Download Fees Statement	The system will be used to download fees statement in read-only mode	PASS
6. View Payslip	The system should allow a user to view monthly payslip	PASS
7. Download Payslip	The system should allow a user to download a monthly payslip in read-only mode	PASS

User acceptance testing was performed as data was collected through a questionnaire to collect feedback. The sample was determined from research conducted by⁽²⁸⁾, according to this study, five users are enough to reveal 80% of usability issues. The System Usability Scale (SUS), a questionnaire to assess user perception and was previously proposed for evaluating office electronic systems⁽²⁹⁾. The results of the usability and acceptance testing are presented in Table 3

Table 3. Usability and acceptance testing results

	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)
I believe I would enjoy using this mobile app	0	0	0	27	73
I thought the app was overly complicated	36	64	0	0	0
The app was easy to use for me	0	0	0	45	55
I assume I may need technical assistance to use this app	45	55	0	0	0
The app's different functions were well incorporated in my opinion	0	0	0	55	45
This app had a lot of inconsistency in my opinion	27	73	0	0	0
Most people, I believe, will quickly pick up on how to use this app	0	0	0	27	73
I considered the software to be extremely difficult to use	36	64	0	0	0
I gained a lot of trust after using the app	0	0	0	55	45
I had to learn a lot of things before I could get started with this app	55	45	0	0	0

3.5 General discussion on the results

The use of mobile apps by students to access the core university student management system and their integration were explored in this paper. This paper presents the results of statistical analyses and validations conducted on data obtained through testing instruments and the design of mobile application systems. Findings show that laptops and smartphones, the majority of which run on the Android platform, are the two most common mobile devices among students, smartphones and laptops were the most commonly used mobile devices (98.7%) and laptops (94.0%). The majority of students agreed that the justifications for developing the app were valid while many students want access to course information, hostel information, and exam results, according to the study's findings, on the perceived use of mobile applications, 56% of students desired apps for classes and 53% exam results. The developed PU mobile application was able to successfully connect with SIMS to access services. Students and staff were able to log in to their accounts after authentication from the main server.

Unit, integration, and system testing were performed to ensure the intended specifications were met. The usability and acceptance testing were very successful with more than 90% of users liking the app while 45% more than 80% did not need any assistance to use the app and did not find it cumbersome. Also, 73% of the respondents did not find inconsistencies in the app as well as 73% learned quickly how to use the app. The conclusions that can be taken from the findings: first, universities have a lot of potentials to use mobile apps to provide seamless services to their students, employees, and stakeholders by integrating their current management systems with mobile apps, thus fully optimizing them; this paper adds to the limited literature on collecting, analyzing, specifying, and designing mobile device requirements and contributes to the knowledge on university mobile app usability and acceptance testing. Compared to standalone native apps, discussed in the literature review, the main advantages of the developed system are as follows;

- Students and staff can easily access the SIMS through their connected smartphones anytime, anywhere.
 - Large queues and congestion in offices have been reduced since most of the students prefer the mobile application to a physical office visit.
 - Continuity of services during natural calamities or unforeseen disruption of services e.g. during a pandemic
 - The use of the online support ticketing system in the mobile app for students seeking assistance on services.
- The limitations of the study are as follows; -
- Some faculty members and students are used to hardcopy paper surveys, hence could not fill in through an online platform.
 - Since testing on a physical iOS smartphone was not possible due to resource limitations, it was performed on an emulator.

4 Conclusion and Future Work

4.1 Conclusion

The paper analyzed previous work on a mobile application for universities and institutions of higher learning and conducted the requirements and specifications of the mobile app. In the design phase, based on the functional and non-functional requirements were used to design the database and the user interface of a mobile application for accessing the students' management system in PU, which solves the problem of increasing accessibility of the university services to the staff and students.

The created mobile application "Pwani University" allows staff and students to access the SIMS, making university services more accessible anytime anywhere to them. The app's key benefit is the convenience that students can use their smartphones with Android or iOS platforms to access resources from anywhere as long as they are connected to the internet, saving them time and money. Therefore, the main contribution, is that higher education institutions can leverage their existing management information systems to extend and make them more accessible from fixed locations to connected smartphones for value addition, enhance staff and student's user experience.

4.2 Future work

The following are recommended for future work;

- Design of security architecture to add more sensitive features in mobile applications since the security of the university mobile application is paramount to ensure reliability and availability of services.
- Exploring the viabilities and validity of automated testing.

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