Development of an Improved Model of Unstructured Supplementary Service Data (USSD) Technology in Academic Services: Case Study RP Huye College

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Abstract: Access to academic services remains a significant challenge for students in regions with limited technology and unreliable internet connectivity, particularly for those reliant on basic mobile phones. This research addresses the persistent digital divide in education by exploring the potential of Unstructured Supplementary Service Data (USSD) technology as an alternative platform for delivering academic services at Rwanda Polytechnic (RP) Huye College. Despite the widespread adoption of digital technology in education, conventional internet-based solutions fail to reach students in resource-constrained environments. USSD technology, with its text-based interaction mechanism, offers a cost-effective, accessible, and scalable solution to support essential academic processes such as student registration, course enrollment, dissemination of information, and interactive learning.

The primary objective of this study was to investigate the acceptance and challenges of USSD-based services within RP Huye College, with a focus on developing an improved USSD application tailored to enhance service delivery. Specifically, the study aimed to develop a USSD-based application that provides key functionalities and access to frequently asked questions (FAQs); to assess the impact of USSD technology on expanding the range of academic services; and explore the potential advantages and opportunities associated with adopting USSD in the academic context. Research questions centered on defining the essential functional requirements for a user-friendly USSD application, determining its effects on accessibility and user satisfaction, and identifying the broader opportunities it presents for academic service enhancement.

The findings suggest that, despite inherent limitations such as short session durations and text-heavy menus, USSD technology can substantially improve academic service delivery by bridging the digital divide. Recommendations call for further refinement of USSD service design, increased integration of additional services, and the adoption of USSD platforms in other institutions like the University of Kigali to foster widespread accessibility. Overall, the study concludes that the successful implementation of a USSD-based service model at RP Huye College not only enhances service effectiveness and user experience but also provides compelling evidence for the broader adoption of USSD technology in academic environments, especially in regions with limited internet infrastructure.

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I. INTRODUCTION

This chapter explores the use of Unstructured Supplementary Service Data (USSD) technology as an innovative approach to enhancing academic service delivery, with a particular focus on Rwanda Polytechnics. It underscores the role of USSD in improving accessibility, efficiency, and fairness in education by facilitating tasks such as student registration, grade retrieval, and administrative communication through basic mobile devices, even in regions with poor internet access. The study aligns USSD adoption with Rwanda's broader ICT strategies aimed at reducing the digital divide and promoting inclusive education. While challenges such as short session durations, security issues, and usability concerns are recognized, the research investigates the feasibility, advantages, and adoption trends of a USSD-driven academic service model. This study is pivotal in advancing digital inclusion, streamlining institutional operations, and fostering technological innovation in education.

II. STATEMENT OF THE PROBLEM

Students still face a great deal of difficulty accessing academic services and resources, particularly in places with inadequate technology and internet infrastructure.

While many parts of education have changed as the product of the adoption of digital technology, students who have basic mobile phones or live in places with inconsistent internet availability may not be able to use traditional internet-based solutions. Examining substitute technologies that can offer affordable and easily available ways to give students the support and resources they need for their academic work is necessary in light of these difficulties.

Through text-based interactions, USSD technology offers a viable way to overcome these accessibility barriers by facilitating communication between mobile devices and service providers. The application and efficacy of USSD technology in academic services, however, are still understudied and underutilized, despite their potential.

Investigating the viability, usability, and effects of incorporating USSD technology into different facets of academic services, such as student registration, course enrollment, information distribution, interactive learning, and feedback mechanisms, is the challenge at hand. Important queries to ask are as follows:

Integrating USSD technology into academic service delivery can significantly improve accessibility for students, particularly those in resource-constrained environments. USSD enables educational institutions to offer services like resulting system, access to learning materials, and administrative assistance via simple cell phones, eliminating the need for smartphones or internet connectivity. This is especially beneficial for students in rural areas or regions with limited technological infrastructure, providing a scalable and affordable solution for delivering academic services.

However, there are usability challenges and user experience considerations that need to be addressed for USSD-based academic services to be fully effective. These include the limited session duration of USSD, which can interrupt more complex processes, and the often text-heavy nature of USSD menus, which may not be user-friendly for all students. Improving session continuity and simplifying menu navigation are key areas for enhancing user experience and reducing cognitive load on students. Additionally, ensuring robust security measures is crucial to prevent data breaches, given the sensitive nature of academic information.

USSD technology has the potential to positively impact student engagement and learning outcomes by offering interactive elements such as quizzes, polls, and surveys. These tools can be incorporated into the learning process to increase participation, even in environments where digital resources are limited. The immediacy of USSD also enables real-time communication and feedback, allowing students to stay connected to their academic progress.

Stakeholders, including students, faculty, and administrators, generally perceive USSD-based academic services as a practical and inclusive solution. However, preferences vary, with some users favoring more interactive and intuitive systems, while others may prioritize cost-effectiveness and accessibility. Ensuring that the platform aligns with the expectations of all stakeholders requires continuous feedback collection and system improvements to meet their evolving needs.

By answering these queries, this research sought to shed light on the possible advantages and limitations of USSD technology in enhancing access to academic services and supporting student success in diverse educational contexts.

III. LITERATURE REVIEW

➢ *Concept of the Study*

- *USSD*

The USSD (Unstructured Supplementary Service Data) system refers to several components and services that work together to facilitate real-time communication and service delivery between mobile users the one to consume the service and network services. (N. K. Shahid, 2022)

- *USSD Gateway*

GSM cell phones use a communication protocol called Unstructured Supplementary Service Data, or USSD, to connect to the computers of the service provider.

A gateway is the collection of hardware and software required to interconnect two or more disparate networks, including performing protocol conversion.

USSD gateway is based upon the ability of the delivery agent or the source to send and receive USSD messages. A USSD is a session-based protocol. USSD messages travel over GSM signaling channels and are used to query information and trigger services. Unlike similar services (SMS and MMS), which are forward-based, USSD creates a session in real time between the service application and the mobile device. (Kelli Harris in 2021)
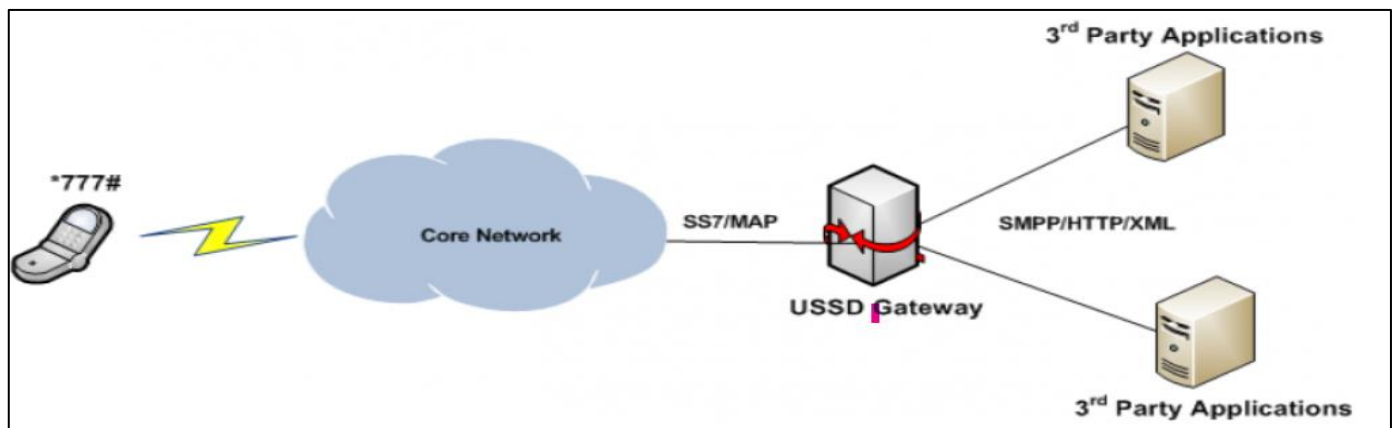
Fig 1 USSD Gateway
Source: https://rwanda.movetechsolutions.com/ussd-development-rwanda/

- *GSM Communication*

The European Telecommunications Standards Institute (ETSI) created the Global System for Mobile Communications (GSM) standard to outline the protocols for second-generation (2G) digital cellular networks that are utilized by mobile devices like smartphones and tablets. (DevX., 2023)
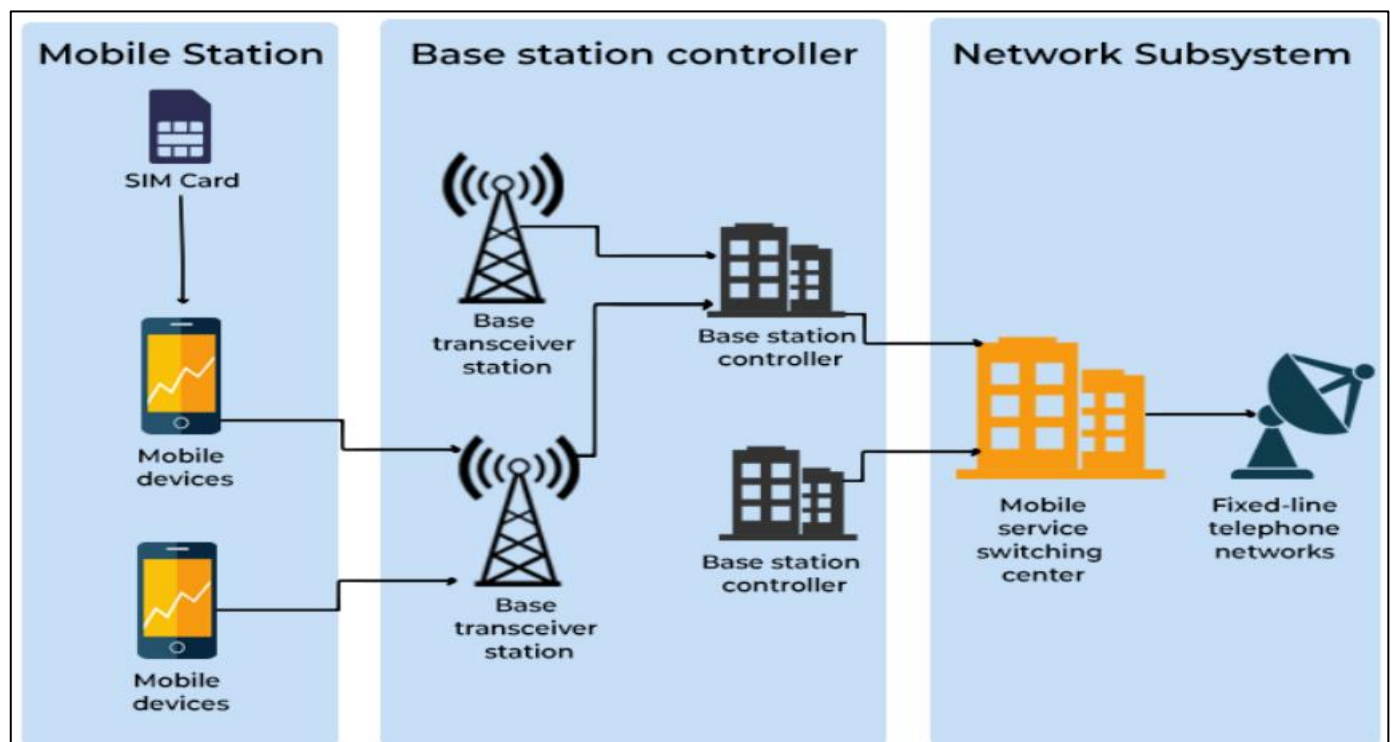

Fig 2 GSM Communication
Source: https://www.spiceworks.com/tech/networking/articles/what-is-gsm/

- *USSD Application Server*

This server hosts the apps and services that are accessible through USSD. Through the USSD gateway, it receives user requests, reacts appropriately, and, if necessary, communicates with backend systems. A server that runs programs or software that distributes business applications via a communication protocol is known as an application server. (Ottinger, Joseph, 2019).

- *USSD Session Management*

A session is started when a user calls a USSD code (such as *123#), and it stays active until the user cancels it or it times out. This is how USSD works. Session management makes ensuring the session is maintained during the conversation and is appropriately ended at the end.

$sessionId = $_POST["sessionId"];

sessionId String

A unique value is generated when the session starts and is sent every time a mobile subscriber response has been received. (Munir H. Qureshi, 2021)
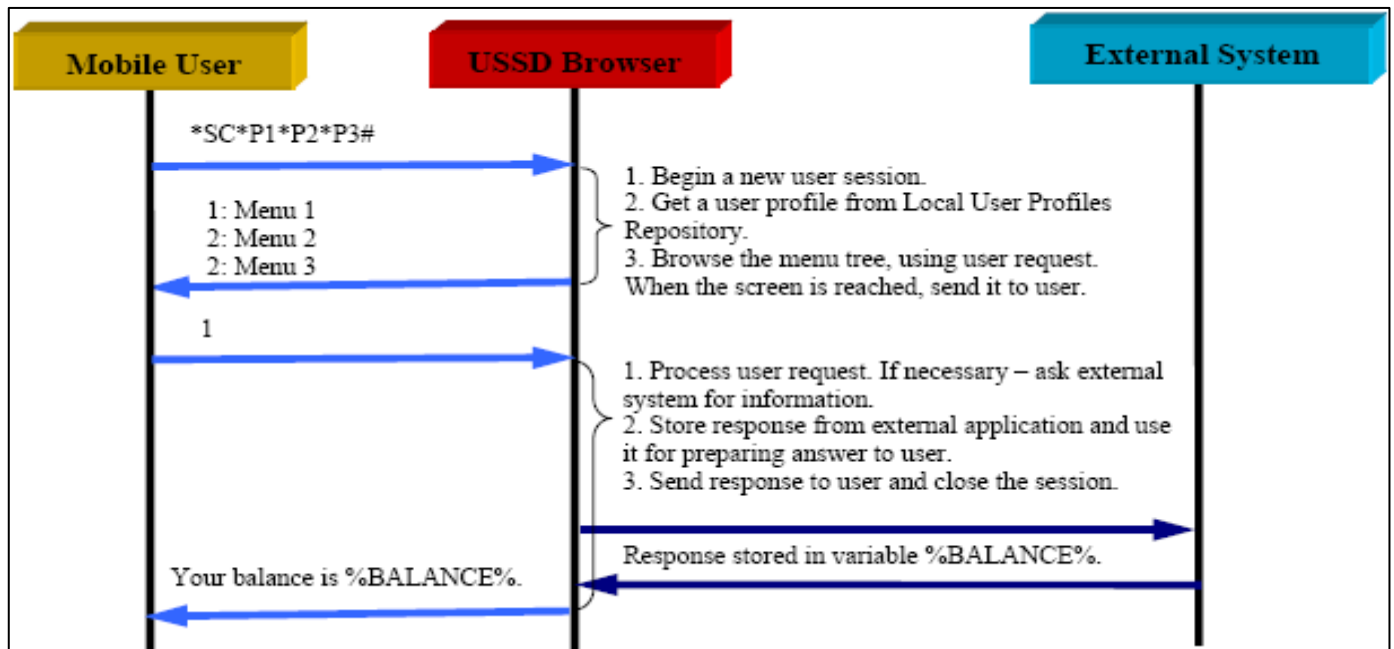
Fig 3 USSD Session Management
Source: https://stackoverflow.com/questions/27593386/

- *Interactive Menu*

Mobile networks come equipped with an interactive USSD menu that enables real-time text-based communication between users and service providers. The USSD creates a direct session with the network, allowing instantaneous two-way communication, in contrast to SMS, which is store-and-forward. Because of this, USSD is especially helpful for services that need immediate input, such as mobile banking, balance inquiries, and different interactive menus that let users choose options from a service provider. (Christian Henke, 2021)
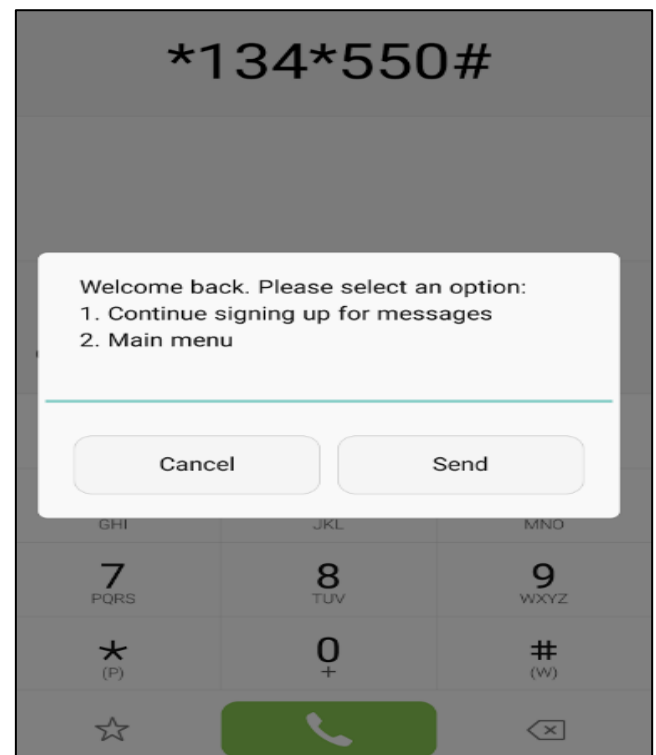

Fig 4 USSD Menu Interaction

- *Existing System Flowchart*

The existing RP system provides different services such as student registration, payment, marks resulting, accessing, and interacting with frequently asked questions. All services are provided through only web application as they indicated on the following flowchart.
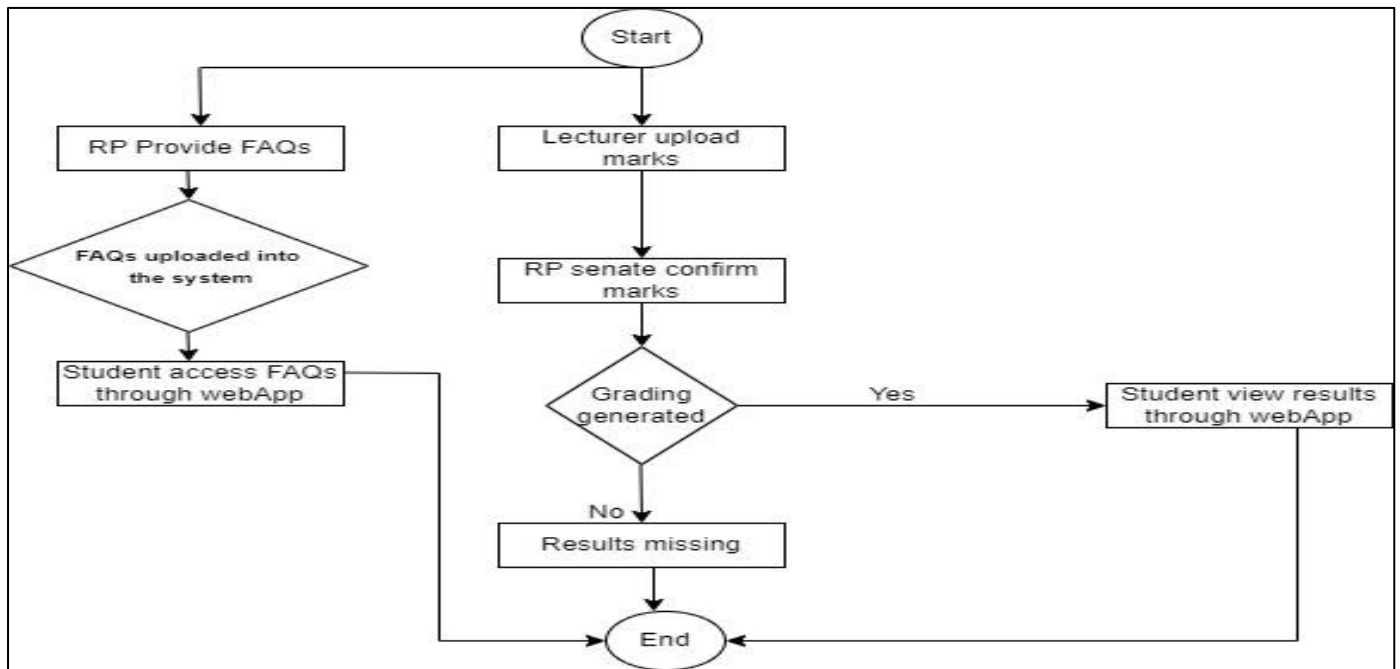
Fig 5 Existing System Flowchart
Source: Researcher (2025)

- *The Proposed System*

In this research **"Development of an improved model of Unstructured Supplementary Service Data (USSD) technology use in Academic Service Delivery"** different solutions for improving the quality of services are proposed, including the Development of USSD based application for RP services delivery, demonstrate the effect of USSD technology use in academic services (RP), identify the opportunities in adoption of USSD technology for academic services and Analysis of adoption rate of RP USSD based services.
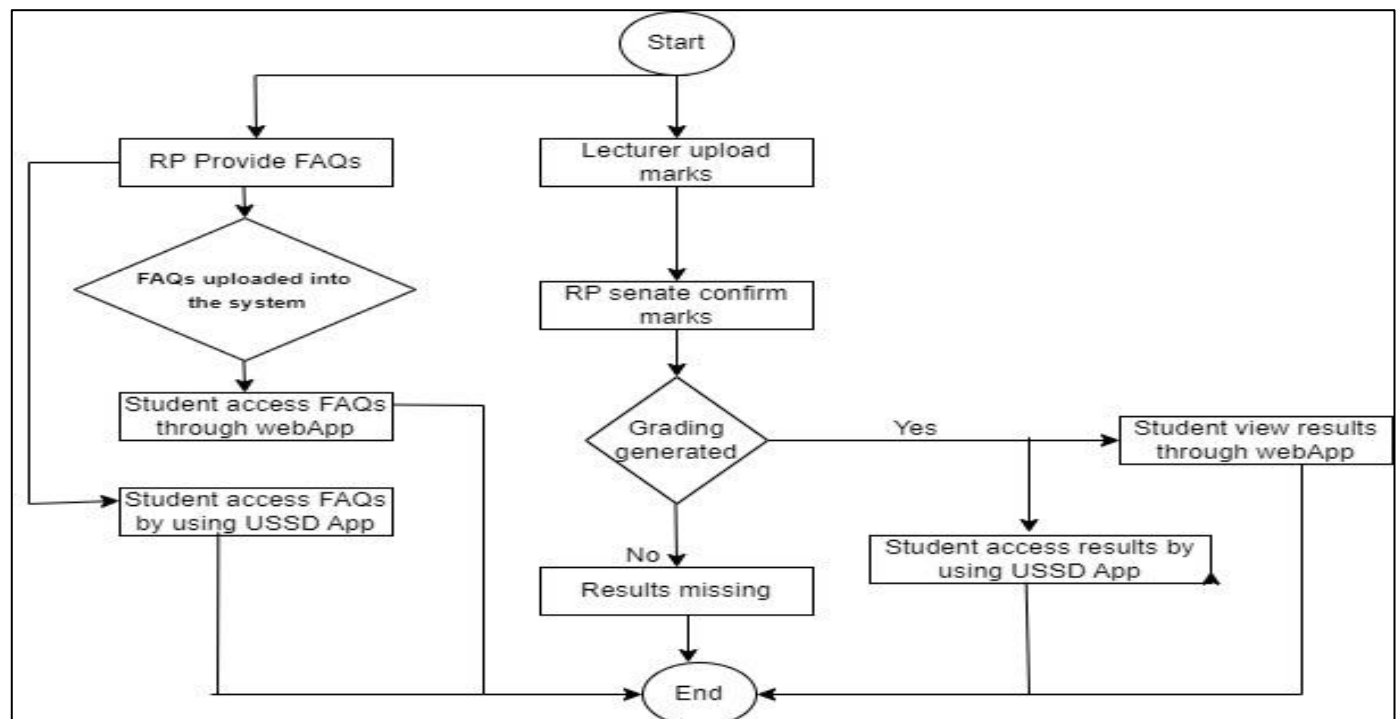

Fig 6 Proposed system Flowchart
Source: Researcher (2025)

The technology is perfect because the cross-platform facility fills the gap for the 85% of people who use feature phones, as only 15% of the 60% of people who own a cell phone less than one million residents own a smartphone.

In order to connect to the USSD platform, the CDR retrieves data from the EHR, optimizes it, and then synchronizes it via an interface.
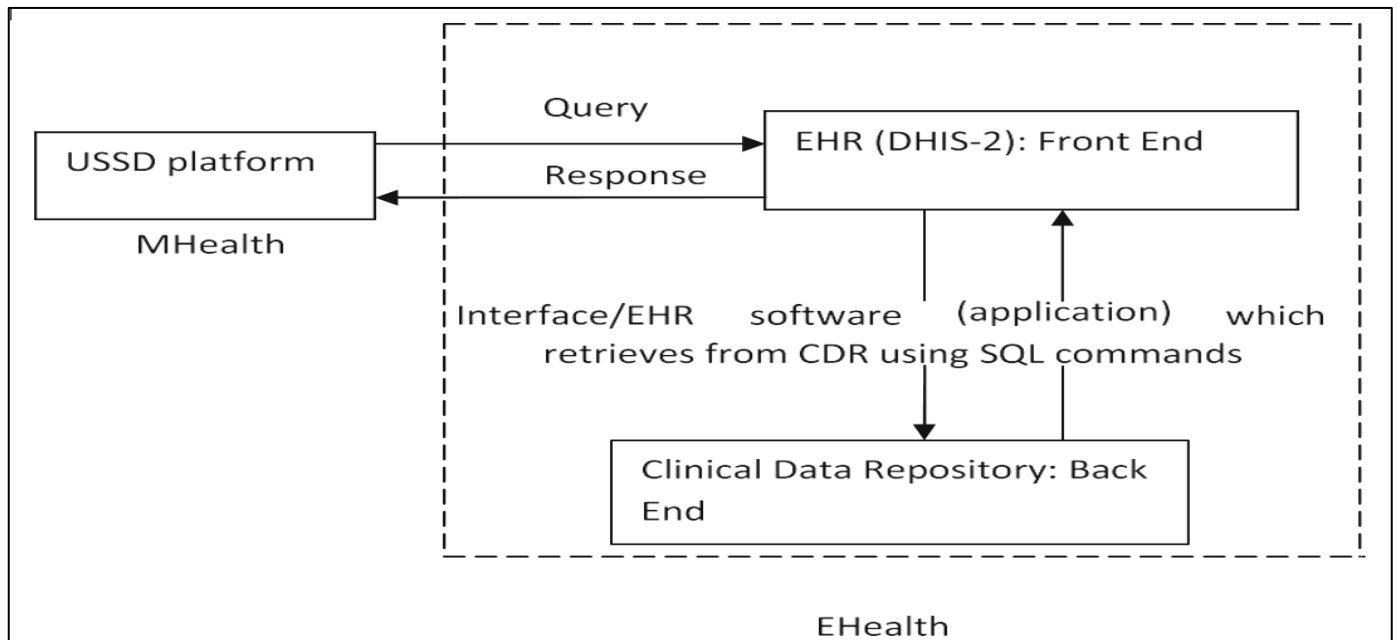
Fig 7 Clinical Data Repository Synchronization with USSD Technology

It displays the system's primary parts and their intercommunication. At this stage of system development, the focus is the definition of the central architecture of the system thus the product at this stage was an architectural model identifying the different components of the system.

The USSD Student Information System's structure and data flow between its various entities are depicted in the framework below. The web server, shared database, and users (parents, students) are the entities.
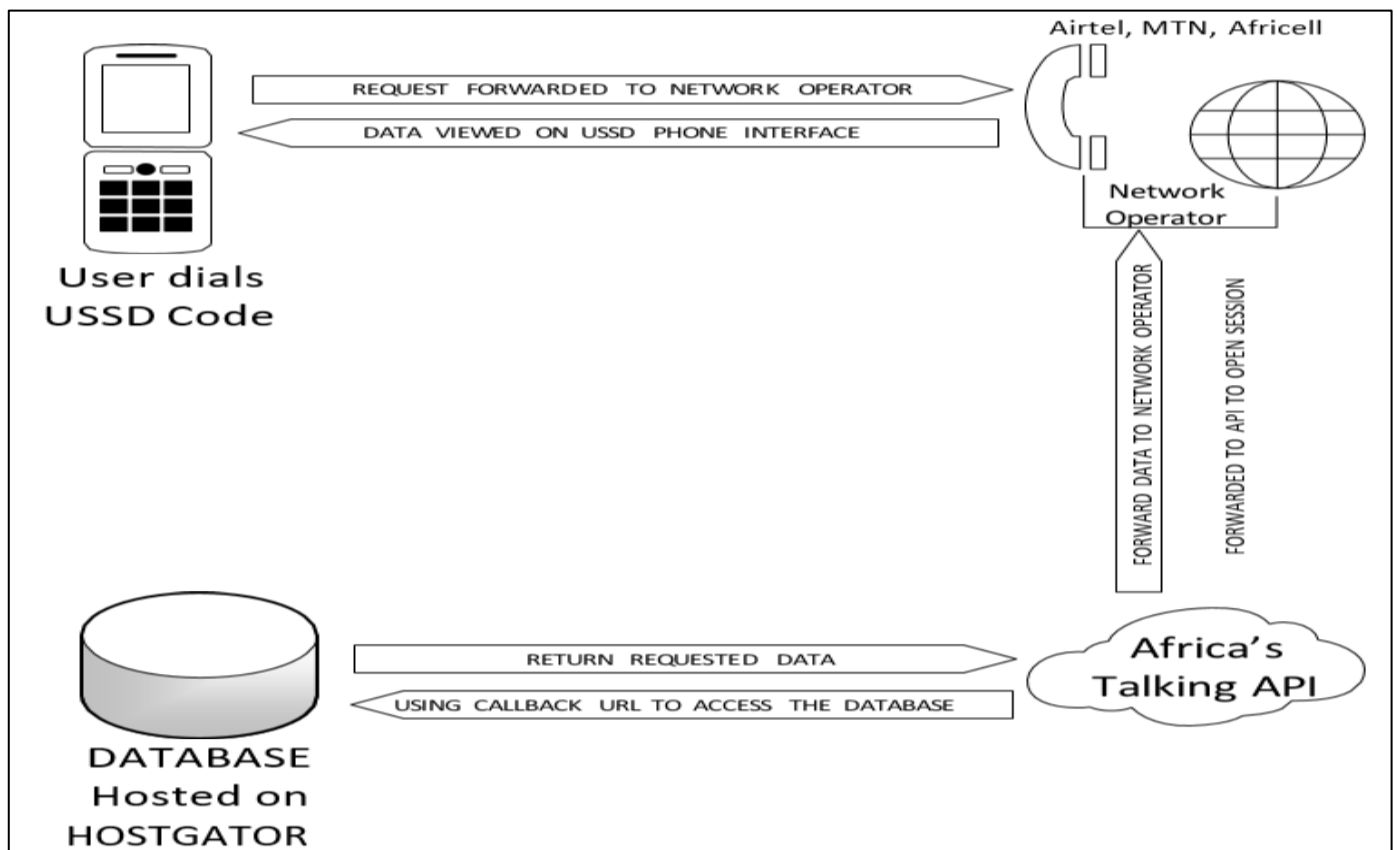

Fig 8 Architectural Design of the USSD Student Information Management System (pg:23)

- *Systems*

    This was accomplished by deploying the USSD Student Information System and the developed web portal in order to identify its strengths and weaknesses and determine whether or not it complies with the intended functionality and specifications.

The testing techniques listed below were used:

- *User Testing*

Target users were chosen to assess the system's operation and offer any workable suggestions.

- *Module/ Unit Testing*

After the system was properly coded, testing was conducted. Before being merged, each system module was examined to make sure it was a fully functional unit. This was accomplished by looking over every unit; every script was examined to make sure it worked as needed and that it carried out precisely as planned.

- *Integration Testing*

We were able to proceed with integration testing after each individual unit was successful. Integration testing was used to make sure that various system modules, such as the developed web system and the USSD student information system, could be combined to create a fully functional system for USSD students.

➢ *National Examination and School Inspection Authority USSD Application*

Through this application the students once a period access national exam results (Primary Leaving Exams, O-Level, A-Level) by dialing a short USSD code on any GSM handset. Upon dialing, the menu first prompts them to select a language, then to choose the exam level and year. Next, they enter their unique candidate index number, after which the system immediately retrieves and displays their subject scores directly on the screen. For longer breakdowns, many implementations also send a follow-up SMS summary to ensure students can review all their marks at leisure.

Behind the scenes, the USSD gateway hosted by the mobile operator interfaces securely with National Examination and School Inspection Authority's results database via an API layer. Session management ensures each query completes within the network's time limit, while optional SMS fallback overcomes menu length constraints. Because no internet or smartphone is required, the service reaches learners in the most remote areas, offering a fast, low-cost, and inclusive way to access critical academic information.
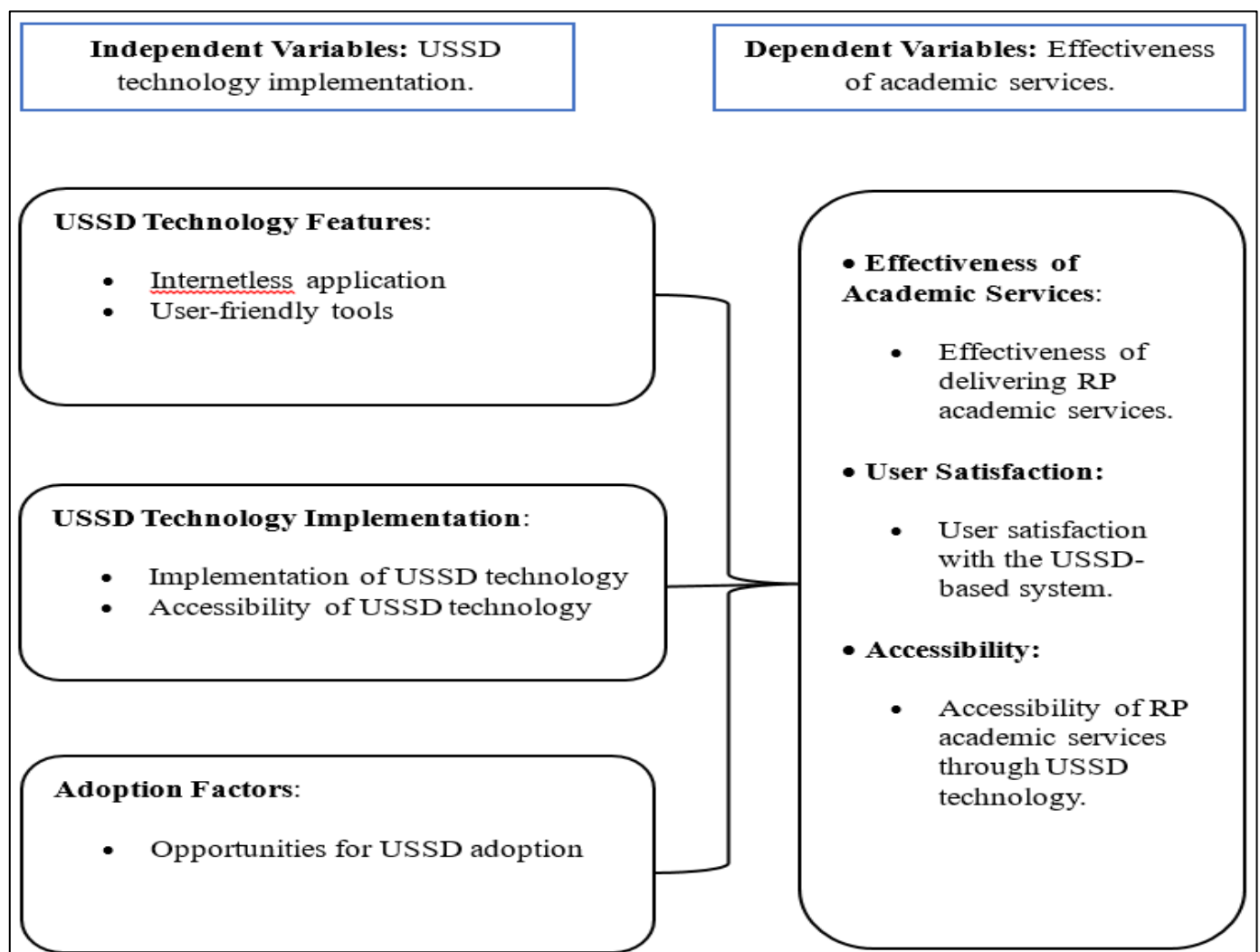
IV. CONCEPTUAL FRAMEWORK

Fig 9 Conceptual framework

V. RESEARCH METHODOLOGY

This study employed a mixed-methods approach, integrating both qualitative and quantitative research designs to assess the potential of USSD technology in academic service delivery at Rwanda Polytechnic Huye College. The research design focused on identifying relationships between dependent and independent variables, using prediction models and incorporating intervening variables to better understand system effectiveness.

The target population consisted of 1,800 individuals, including students, academic staff, and college administrators. A sample size of 327 respondents was determined using Slovin's formula at a 5% margin of error, with participants selected through random sampling to ensure representation across all categories.

Data collection methods included questionnaires, interviews, direct observation, and document review. The survey captured both numerical and descriptive data, enabling a broader understanding of user experiences and expectations. Interviews with students, lecturers, and administrative staff helped validate survey findings, while documentation and internet research provided contextual insights into service delivery structures. Observational data offered firsthand evidence of service accessibility challenges, particularly those related to internet constraints.
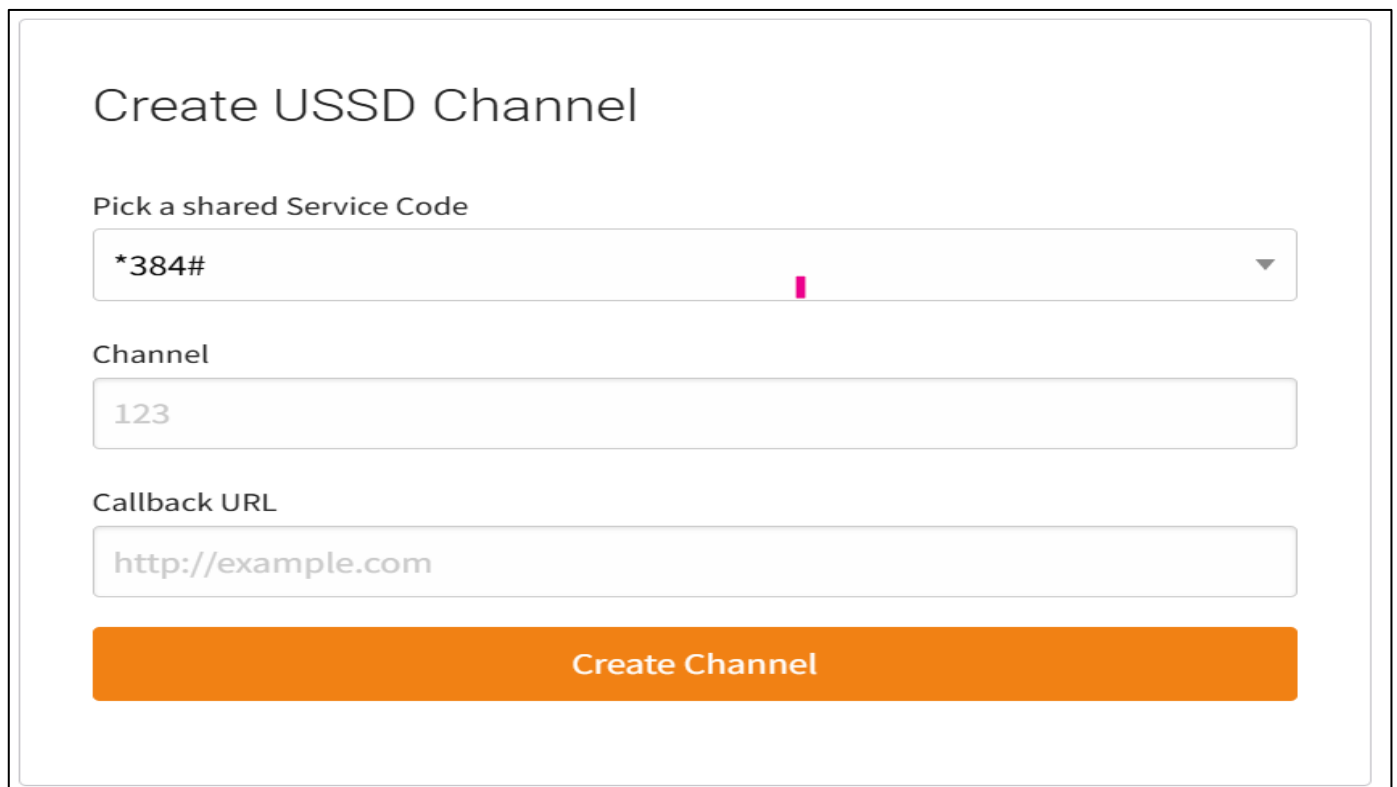
Data processing involved cleaning, categorizing, and coding responses. Statistical tools such as R and Microsoft Excel were used for analysis, while the USSD application was modeled and simulated using Africa's Talking API and mobile simulators. Quantitative data was structured to identify patterns and generate statistical outputs that informed the system model.

The research acknowledges certain limitations, primarily its focus on a single campus, which may affect generalizability. Ethical standards were upheld throughout the study by ensuring informed consent, data confidentiality, and respectful engagement with participants. The findings aim to support more inclusive and accessible academic services, particularly in settings with limited digital infrastructure.

VI. PRESENTATION, ANALYSIS AND INTERPRETATION OF FINDINGS

This chapter presents and interprets data on the implementation of an improved USSD model for academic services at RP Huye College. It evaluates how the system meets the research objectives, focusing on design, testing, and performance. The developed USSD application allows students to access results and FAQs by entering their registration number. Menu options enable students to check marks or request information, with responses retrieved from a backend database. Session limits help manage access and enhance security. Technologies like Africa's Talking API and Ngrok were used for integration and backend support. The system was tested in a sandbox environment before live deployment. A custom USSD short code ($384$73582#) enabled real-time interaction without internet access. Backend logic was implemented to handle user input and return data dynamically. The chapter concludes with system validation, screenshots, and compatibility requirements.

Fig 10 USSD Channel Creation
Source: Researcher (2025)

➢ *USSD Short Code*

A USSD short code is a special number that users dial to access USSD services. These short codes are typically in the format of:

- *The USSD short code can be accessed within two levels as follow:*

✓ *123#) → One-level short code
✓ *123*1#) → Multi-level short code

- *USSD Short code Works as follow:*

✓ The user dials a short code (e.g., *123#).
✓ The mobile network routes the request to a USSD gateway.
✓ The USSD gateway forwards the request to the application server.
✓ The server processes the request and sends a response.
✓ The response appears as a menu or message on the user's phone.
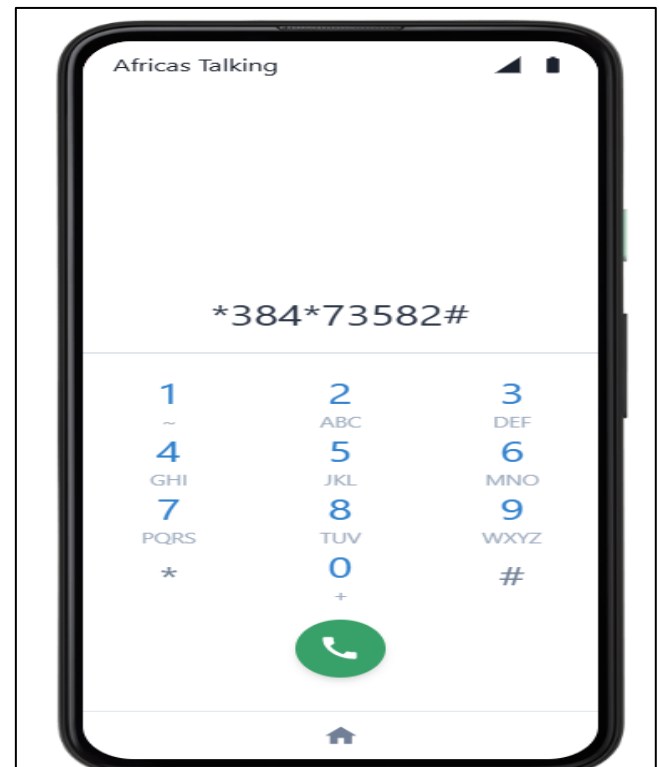
Fig 11 USSD Short Code
Source: Researcher (2025)

➢ *USSD Session Details*

Either success, fail or incomplete status can occur and have detailed information.

- *Success*

Item	Value
Date	February 21, 2025 2:38 PM
Service Code	*384*73582#
Phone Number	+250784215845
Hops	5
Duration	19s
Status	Success
Session Id	ATUid_72168c37e6668726da9f25e67e33609b

Fig 12 USSD Session Details

Item	Value
Start Time	February 21, 2025 12:37 PM
App Response	CON Welcome to RP USSD Services: Enter your Registration Number:
Final Response	CON Welcome to RP USSD Services: Enter your Registration Number:
Error Message	None
Status	Success

Fig 13 USSD Session Hops 1

Item	Value
Start Time	February 21, 2025 12:37 PM
App Response	CON Choose an option: 1. Check result 2. FAQ Access 0. Exit
Final Response	CON Choose an option: 1. Check result 2. FAQ Access 0. Exit
Error Message	None
Status	Success

Fig 14 USSD Session Hops 2

Item	Value
Start Time	February 21, 2025 12:38 PM
App Response	CON Select Department: 1. ICT 2. Manufacturing 3. High Way Technology 4. Veterinary Technology 0. Back
Final Response	CON Select Department: 1. ICT 2. Manufacturing 3. High Way Technology 4. Veterinary Technology 0. Back
Error Message	None
Status	Success

Fig 14 USSD Session Hops 3

Item	Value
Start Time	February 21, 2025 12:38 PM
App Response	CON Select Level: 1. Level 8 2. Level 7 3. Level 6 Y2 4. Level 6 Y1
Final Response	CON Select Level: 1. Level 8 2. Level 7 3. Level 6 Y2 4. Level 6 Y1
Error Message	None
Status	Success

Fig 15 USSD Session Hops 4

Item	Value
Start Time	February 21, 2025 12:38 PM
App Response	END Name: UWERA Anne module_name: Apply Python CAT: 24 SA: 25 Total: 47 Status: Fail
Final Response	END Name: UWERA Anne module_name: Apply Python CAT: 24 SA: 25 Total: 47 Status: Fail
Error Message	None
Status	Success

Fig 16 USSD Session Hops 5

- *Incomplete*

USSD Session Details

Item	Value
Date	February 21, 2025 1:23 PM
Service Code	*384*73582#
Phone Number	+250784215845
Hops	3
Duration	55s
Status	Incomplete
Session Id	ATUid_371d2ef9bcd0e83098c5b6e160be14cf

Fig 17 USSD Session Details

USSD Session Hops

Item	Value
Start Time	February 21, 2025 11:21 AM
App Response	CON Welcome to RP USSD Services: Enter your Registration Number:
Final Response	CON Welcome to RP USSD Services: Enter your Registration Number:
Error Message	None
Status	Success

Fig 18 USSD Session Hops 1

Item	Value
Start Time	February 21, 2025 11:21 AM
App Response	CON Choose an option: 1. Check result 2. FAQ Access 0. Exit
Final Response	CON Choose an option: 1. Check result 2. FAQ Access 0. Exit
Error Message	None
Status	Success

Fig 19 USSD Session Hops 2

Item	Value
Start Time	February 21, 2025 11:21 AM
App Response	CON Select Department: 1. ICT 2. Manufacturing 3. High Way Technology 4. Veterinary Technology 0. Back
Final Response	CON Select Department: 1. ICT 2. Manufacturing 3. High Way Technology 4. Veterinary Technology 0. Back
Error Message	None
Status	Success

Fig 20 USSD Session Hops 3

- *Failed*

USSD Session Details	✕
Item	**Value**
Date	February 21, 2025 2:36 PM
Service Code	*384*73582#
Phone Number	+250784215845
Hops	5
Duration	18s
Status	Failed
Session Id	ATUid_8b967ff9edea88a9efeaeee89cefd167

Fig 21 USSD Session Details

USSD Session Hops

Item	Value
Start Time	February 21, 2025 12:35 PM
App Response	CON Welcome to RP USSD Services: Enter your Registration Number:
Final Response	CON Welcome to RP USSD Services: Enter your Registration Number:
Error Message	None
Status	Success

Fig 22 USSD Session Hops 1

Item	Value
Start Time	February 21, 2025 12:35 PM
App Response	CON Choose an option: 1. Check result 2. FAQ Access 0. Exit
Final Response	CON Choose an option: 1. Check result 2. FAQ Access 0. Exit
Error Message	None
Status	Success

Fig 23 USSD Session Hops 2

Item	Value
Start Time	February 21, 2025 12:36 PM
App Response	CON Select Department: 1. ICT 2. Manufacturing 3. High Way Technology 4. Veterinary Technology 0. Back
Final Response	CON Select Department: 1. ICT 2. Manufacturing 3. High Way Technology 4. Veterinary Technology 0. Back
Error Message	None
Status	Success

Fig 24 USSD Session Hops 3

Item	Value
Start Time	February 21, 2025 12:36 PM
App Response	CON Select Level: 1. Level 8 2. Level 7 3. Level 6 Y2 4. Level 6 Y1
Final Response	CON Select Level: 1. Level 8 2. Level 7 3. Level 6 Y2 4. Level 6 Y1
Error Message	None
Status	Success

Fig 25 USSD Session Hops 4

Item	Value
Start Time	February 21, 2025 12:36 PM
App Response	 Warning: mysqli_stmt::bind_param(): Number of variables doesn't match number of parameters in prepared statement in C:\xampp\htdocs\disseritation\student_all.php on line 45 END No results found for this Registration Number.
Final Response	END Dear customer, the network is experiencing technical problems and your request was not processed. Please try again later.
Error Message	Response does not start with CON or END
Status	Failed

Fig 26 USSD Session Hops 5

➢ *Application Services Analytics*

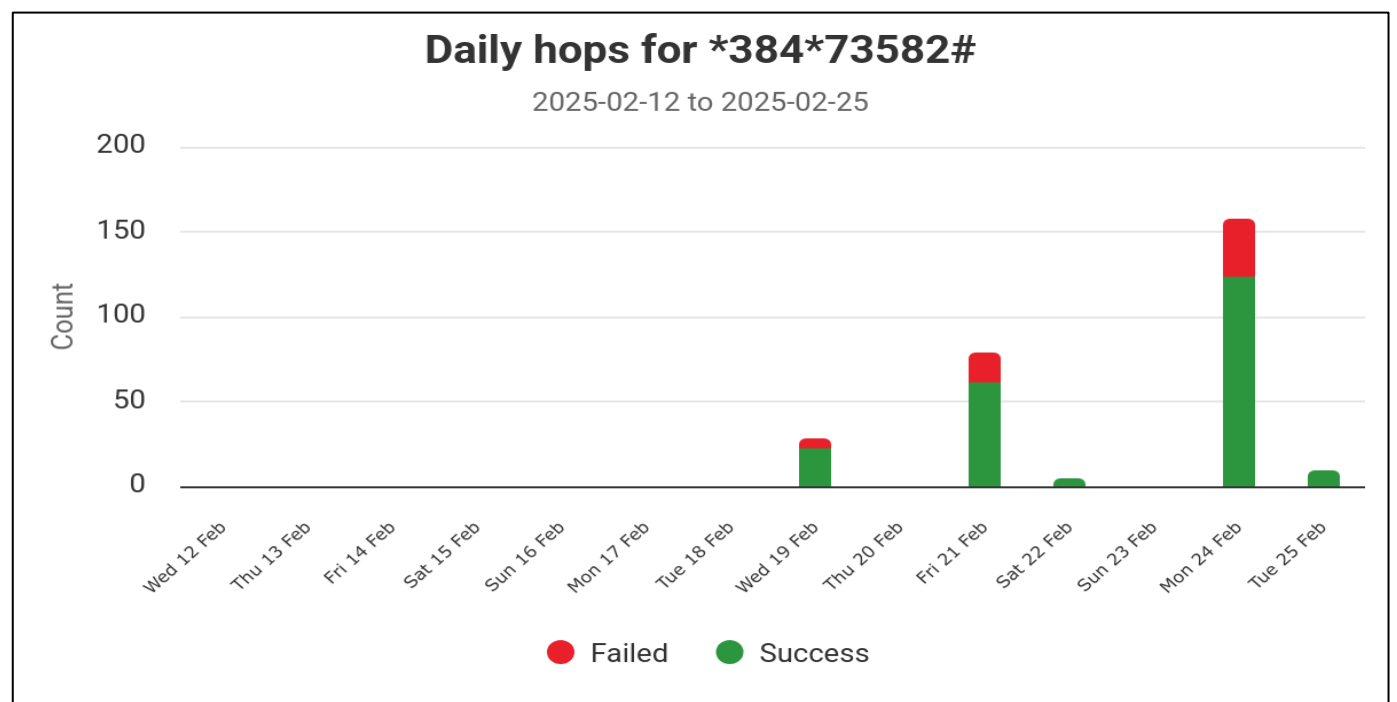● *Filter Hops and grouped by service code*

Fig 27 Filter Hops and Grouped by Service Code
Source: researcher (2025)
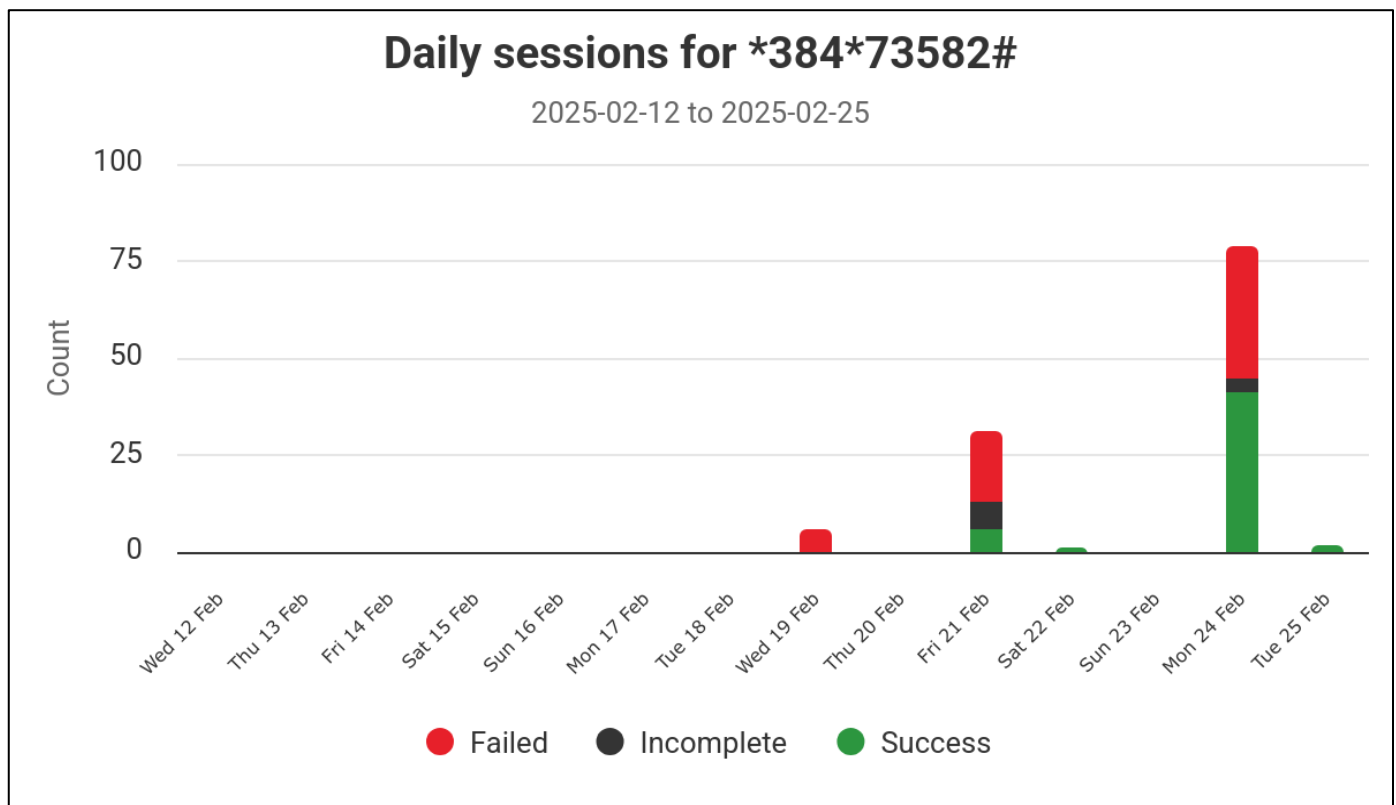
- *Filter Sessions and grouped by service code*

Fig 28 Filter Sessions and Grouped by Service Code
Source: researcher (2025)

➢ *Analysis of Findings*

The improved USSD model enables students at RP Huye College to access academic services like viewing approved marks and FAQs using their registration number, even on basic phones without internet. This enhances inclusivity, especially for students in rural or low-income areas. USSD simplifies access to real-time academic information, reducing reliance on internet portals and physical visits. It automates routine tasks, easing administrative workload and speeding up service delivery. Cost-effective and scalable, USSD improves efficiency and accessibility across the institution.

VII. CONCLUSION

The aim of this research was to develop an improved unstructured supplementary service data for academic service delivery in RP especially in Huye college by using USSD technology. Where there at RP Huye college are some problems to resolve such as **lack of USSD-based application aimed at enhancing service delivery especially students' marks resulting and access to Frequently Asked Questions (FAQs). Assessing the effect of incorporating USSD technology in expanding the range of academic services offered at RP Huye college. And exploring the opportunities to adopt USSD technology in academic services delivery.** The research goals were achieved successfully. After the application implementation we ensure Rwanda Polytechnic this USSD application will express academic service delivery with higher effectiveness,

accessibility and high user friendly. It will also improve most important opportunities and advantages within its usability and adoption. Because of its positive impacts that will produce in academic service delivery, it will encourages colleges to adopt it not only in resulting and FAQs but also in more other academic services.

RECOMMENDATIONS

After this research report and USSD application development of an Improved Model of Unstructured Supplementary Service Data (USSD) Technology in Academic Services. We can't end without recommendations, so at the completion, the following recommendations are provided:

It is recommended that the next researchers on this topic to use their best to increase the additional USSD services to improve the RP academic services delivery.

The researcher recommends University of Kigali, especially in Information Technology add USSD and SMS services for service delivery in their academic programs for the next academic years.

The researcher recommends RP to adopt and improve USSD based services delivery and integrate it as additional platform to the existing ones, while it doesn't require internet connectivity and against digital divide in academic services.

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