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Original Article

On Development of a SIM-Based Prototype for Enhancing the Usability of Mobile Value-Added Services

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Mobile Value-Added Services, USSD, SIM Toolkit Application, Usability, Basic Phones.

ABSTRACT

The advent of Mobile Value-Added Services (VAS) has witnessed widespread adoption in developing regions, notably within East Africa. This surge is attributed to advancements in information and communication technology, 3G/4G proliferation, growth of mobile internet accessibility, and rising smartphone penetration. Despite this progress, a significant segment of the population continues to rely on basic phones. Studies have shown that the text-based applications used on these types of mobile phones still pose significant obstacles in delivering a user-friendly VAS experience. This paper explores the potential for improving the usability of mobile value-added services on basic phones. We employed an action research approach, utilizing quantitative and qualitative data collection methods. Questionnaires gathered feedback on end-user testing, while in-depth interviews with five industry experts provided insights into potential solutions. This multi-faceted approach ensures a comprehensive understanding of user feedback and expert insights, culminating in the design of an intuitive SIM-based user interface prototype. This highly customised prototype prioritises services and functionalities simplify the user experience through improved navigability and accessibility. The effectiveness of this prototype was quantitatively analysed using descriptive statistics, focusing on ease of use, efficiency, effectiveness, and user satisfaction. With an average ease of use score of 85.8%, a geometric mean time on task of 29.43 seconds, and a user satisfaction score of 79.5%, the prototype demonstrates impressive functionality and garners acclaim for improved navigation and information discovery from users and experts. Further, comparative analysis from expert interviews reveald a more nuanced understanding of technology preferences for basic phone usability, contrary to previous studies. Building upon these demonstrably positive results, the paper concludes by advocating for user interface standardisation and recommending user-generated content for a more inclusive VAS ecosystem.

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INTRODUCTION

The usability of mobile value-added services on basic phones presents significant challenges in the current telecom landscape (Perrier et al., 2016). According to Adjei *et al.* (2019), the physical limitations of basic feature phones necessitate that users exert considerable effort to access Mobile Value-Added Services (*m*VAS). Key constraints, such as the small screen size, basic input methods, and the usability challenges of text-based applications, pose significant obstacles in delivering an engaging and user-friendly experience, as highlighted by Weichbroth (2020) and (Weld *et al.* (2018). *m*VAS are non-core services provided by telcos beyond text, voice, and data. In principle, they add value to the standard service offering by enticing subscribers to use their phones more and assisting service providers in driving up their average revenue per user (ARPU) (Al-Debei et al., 2022). While *m*VAS offers numerous benefits, the adoption and usage of these services are lower on basic phones than smartphones (Al-Amri et al., 2018). This digital divide deprives basic phone users of financial tools and information services and reduces ARPU and growth potential.

Basic phones (popularly known as *'tochi'* or *'mulika mwizi'* in Tanzania and Kenya) often lack advanced mobile operating systems and have no internet services, which makes them incompatible with some of the feature-rich *m*VAS delivered through smartphone applications like the M-PESA or My Airtel app. This is why text-based menu technologies such as SIM Application Toolkit (STK) and Unstructured Supplementary Services Data (USSD) are preferred, as they are compatible with a wide range of mobile devices (Asrar, 2018; Manisha, 2013). However, despite being the most prevalent technologies available for non-smartphone users, studies have shown that the text-based menus of USSD and STK still pose usability obstacles (Perrier et al., 2016; Sowon et al., 2023). Such hurdles, including complicated hierarchical menus and perplexing User Interface (UI) elements, have led to several drawbacks, including difficulties in navigation and discovering information, user frustration, and abandonment of services.

Undoubtedly, smartphone apps have transformed the VAS landscape (Huang & Benyoucef, 2023). While they remain dominant, it is crucial to acknowledge the usability disparities between smartphone and basic phone users. These apps offer a plethora of services, all conveniently accessible via a user-friendly interface. The allure of smartphone apps lies in their versatility, efficiency, and seamless integration with virtually all other services. However, this transformation comes at a cost: significant investments by telcos in developing and promoting these apps, fuelled by high smartphone penetration campaigns, often at the expense of other platforms (Kaya et al., 2019). Regrettably, there is a relative lack of studies focusing on the unique usability issues encountered in the text-based applications used by basic phone users. And this is precisely the discrepancy that this paper wishes to address.

MOTIVATION FOR ENHANCING USABILITY

Studies have demonstrated the critical role of technology and usability as other key factors influencing the adoption and usage of *m*VAS (Abdinoor & Mbamba, 2017; Al-Debei et al.,

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2022; Bhatt, 2021; Kazemkhanlou & Boozary, 2015; Wang & Lin, 2012). They have identified the challenges within the VAS as not only socio-economic but also technological, i.e., ease of use, navigation, visual design, and user-friendliness of the interface. However, while some design elements might entail trade-offs between usability and factors such as security, performance, or scalability, usability remains a high priority for users.

Meanwhile, smartphone penetration is increasing, but a significant portion of the population, particularly the elderly and those with lower literacy levels, continues to rely on basic phones (Breitinger et al., 2020). This enduring popularity is reflected in the substantial market share held by basic phones, exceeding 50% in Kenya and 60% in Tanzania (Malephane, 2022). This highlights the importance of this demographic, as basic phone usage is expected to remain prevalent in the foreseeable future.

We investigate the inherent device limitations that hinder VAS usability. By identifying these challenges, we establish key requirements for the prototype. However, redesigning Text-based User Interfaces (TUIs) for basic phones presents distinct design challenges. Conventional methods and design guidelines developed for graphical user interfaces require significant modification when applied in this context. To address this, we first identify the specific usability challenges encountered by users of basic phones. We then outline the adapted TUI design guidelines implemented to address them, as presented in the following sections.

- **Small screen.** The small screen size of basic phones affects the usability of mobile applications (Weichbroth, 2020). The compact screens enable portability, but it becomes necessary to simplify features when applying usability guidelines. The result is “feature shedding"—only focusing on essential features and logically structuring the menu to minimize scrolling while maintaining quick access to desired options.
- **Context of use.** The context of basic phones is dynamic, influenced by affordability and user demographics. For instance, they are often used by individuals in regions with limited access to advanced technology or those who prioritize simplicity and cost-effectiveness (N. T. Krell et al., 2021). This calls for emphasizing simplicity, consistency, and familiar inputs while balancing between bundling and unbundling menus for novice users. Furthermore, a help/support feature could provide expedited assistance for novice users, offering instantaneous feedback or prompts to acknowledge users' actions, preceding steps, or encountered errors.
- **Limited processing and storage.** Basic phones are limited by their storage and computing capacities, which consequently restrict their capabilities (Weld et al., 2018). As newer, more advanced smartphones become prevalent, basic phones may struggle to keep up with the growing demands for cutting-edge services their more sophisticated counterparts provide. Therefore, we overcome the challenge of limited computing power by delivering dynamic, single-task content, optimizing code for lightweight applications, and utilizing efficient data structures.
- **Limited input options.** Using a basic phone for input can be challenging and requires a certain level of dexterity. The small size of physical keypads and labels can impede users' effectiveness and efficiency, potentially slowing input and increasing errors (N. Krell et al., 2020). To address this limitation, we proposed using predictive text, short labels, and user-friendly abbreviations to minimise input errors and a menu-driven approach instead of text-driven navigation. Moreover, context-based input options automatically adapt to the input requirements based on the selected item.
- **Platform heterogeneity.** Being budget phones with a low cost of production and cheaper materials, basic phones have attracted

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various manufacturers. They come on various customised operating system platforms, like Symbian OS, KaiOS, Samsung's Tizen, etc. (Riasat et al., 2022). To address the diverse operating systems in budget phones (e.g., Symbian OS, KaiOS, and Samsung's Tizen), the design considerations included adopting a modular design and developing SIM-based applications using Java cards for broad compatibility.

- **Limitations of the text-based menu interfaces.** The current text-based menu interfaces used on basic phones have several limitations that hinder usability. These interfaces often have complex menu structures with options buried within multiple layers, resulting in cumbersome and time-consuming navigation. The absence of icons, visual cues, and customisation options further reduces intuitiveness. For example, research by Rama and Sarvan (2022) highlights shortcomings in SIM-Toolkit-based mobile banking that lack "one-click" functionality, straightforward authorisation, compatibility with different devices, and seamless resumption of tasks. Similarly, Oladele et al. (2023) found challenges in USSD platforms, such as difficulty reversing actions, memorising service codes, and a lack of effortless back navigation. To address these issues, efforts are made to make actions easily repeatable, incorporate search and auto-complete functionalities for better content discovery, and allow menu customisation. Additionally, including an extensive USSD service code catalogue could help users find unfamiliar service codes, reducing cognitive load.

METHODOLOGY

Research Design

We adopted an action Research Methodology (AR) to bridge the gap between theory and practice. AR fosters collaboration between researchers and those in the field (practitioners), ensuring stakeholders are involved in the research process. Ultimately, this results in improvements within the field by directly confronting practical issues (Coghlan & Brydon-Miller, 2014). The cyclical nature of this approach, as depicted in Figure 1, facilitated the continuous refinement of the prototype, enabling it to address the unforeseen issues that also emerged during the study. Table 1 summarises the two cycles that were undertaken.

Figure 1: Action research cycle for enhancing mobile vas usability

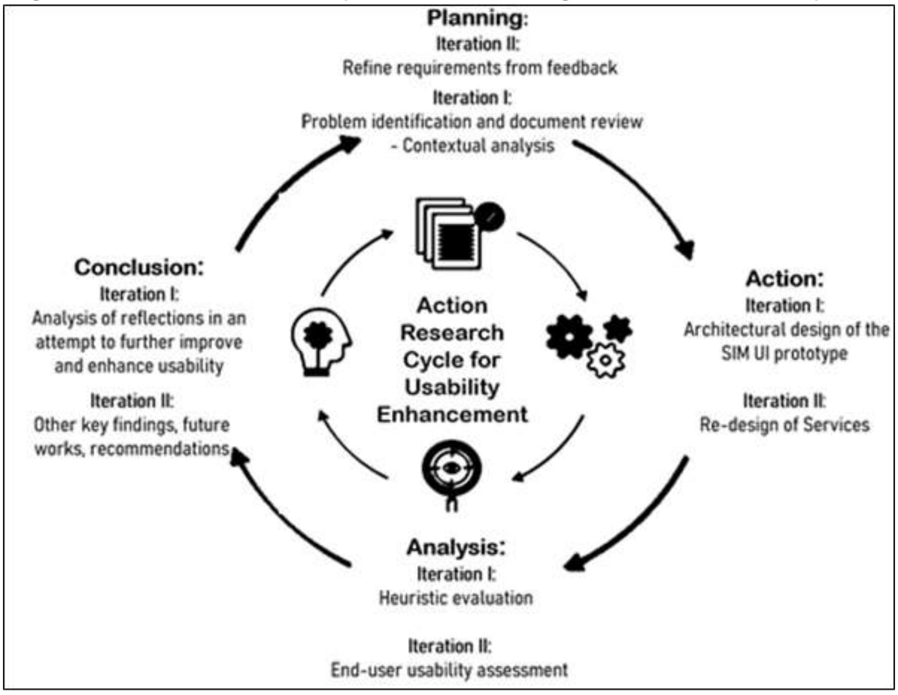

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Table 1: Action research process used in this study

AR Step	How it was Applied in the Study
Planning	• *Identification of problems and review of documents*: This review process highlighted technology limitations and user interface design as critical factors impacting usability and, ultimately, service adoption. • *Analysis of context*: We then examined basic phones' inherent limitations and constraints. This also involved characterising the target user demographics. • *Refinement of requirements:* Following the feedback from the previous cycle, the preliminary requirements were prioritised and refined to ensure that the design is continually improved.
Action	• *Architectural design and service implementation:* From the design artefacts, this sub-phase focused on the technical implementation of the SIM UI prototype and the associated services. • *Service redesign and heuristic evaluation:* We targeted refining and improving the designed VAS services. These insights informed the redesign process, leading to an enhanced version of the services before the final user assessment.
Analysis	• *Heuristic evaluation:* We utilised Jakob Nielsen's ten usability heuristics (see Table 3) for user interface design. By analysing the feedback and recommendations provided by the experts, we made improvements to the prototype, including the relocation of some menu items for easy access to users. • *End-user usability assessment:* We adopted Brooke's (1995) System Usability Scale (SUS) and a usability questionnaire to measure the prototype's effectiveness. Tables 4 and 5 provide more details.
Conclusion	• *Integration of reflective analysis and heuristic evaluation findings:* The concluding phase of the initial cycle entailed a critical introspection of our experiences and observations during the evaluation process. Combining these reflections with the experts' feedback gave us a more profound understanding of the prototype's strengths and weaknesses from diverse perspectives. • *Conclusion and dissemination of key findings:* We synthesised our findings and made additional observations regarding future works and recommendations.

Research Approach

This paper adopted a mixed-methods approach that draws on the examples of Tanzania and Kenya from users and experts of two renowned telcos. Quantitative data gathered through questionnaires allowed for the efficient collection of user feedback from a larger sample size of users. Qualitative data obtained through interviews provided more in-depth on usability. The criteria for selecting the two countries are the cases of its two leading Mobile Network Operators (MNOs) from the Vodafone Group. Vodacom, which operates in Tanzania, and Safaricom, which operates in Kenya, both joint owners of the M-PESA brand, embraced different technologies for the demographic under study. Vodacom used USSD technology, and Safaricom ventured with STK technology for their M-PESA services (Bolarinwa, 2021). Although both technologies offer unique strengths, this paradox underscores the need for careful consideration of usability beyond mere technological capabilities.

Sampling

The study employed purposive sampling to select research participants. This included identifying users with basic feature phones and those who extensively use USSD and/or STK to test the prototype. Expert sampling was also used to select participants with specific expertise in VAS from the two telcos in both countries to evaluate the prototype and interviews. The sample size was determined using Yamane's formula because it considers a finite population size. It allows researchers to set a desired confidence level, ensuring the purposefully chosen participants are enough (Berndt, 2020). Given that the research was conducted in two regions (Iyumbu and the

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University of Dodoma—Tanzania, and Nairobi City Center—Kenya), the total adult population *(N)* was estimated at around five million users who had access to basic phones or used USSD and/or STK. The margin of error *(e)* was set at 0.1 to ascertain the minimum sample size *(n)* needed to represent the population value, as in Equation 1.

Table 2 breaks down the sample size distribution. Our study utilised a sample size of 102, extending beyond a basic survey by conducting in-depth testing, training participants, and observing their interactions with the tool. This comprehensive approach and regional diversity to capture user variations provided richer data than a simple survey. While larger sample sizes can be beneficial, Lakens (2022) suggests that for studies like ours, combining in-depth testing with qualitative insights and expert heuristics is substantial in providing broader applicability of the insights gained.

$$n = \frac{N}{1+Ne^2} = \frac{5{,}000{,}000}{1+(5{,}000{,}000 \; X \; 0.1^2)} = 100 \quad (1)$$

Equation 1: Yamane’s Formula

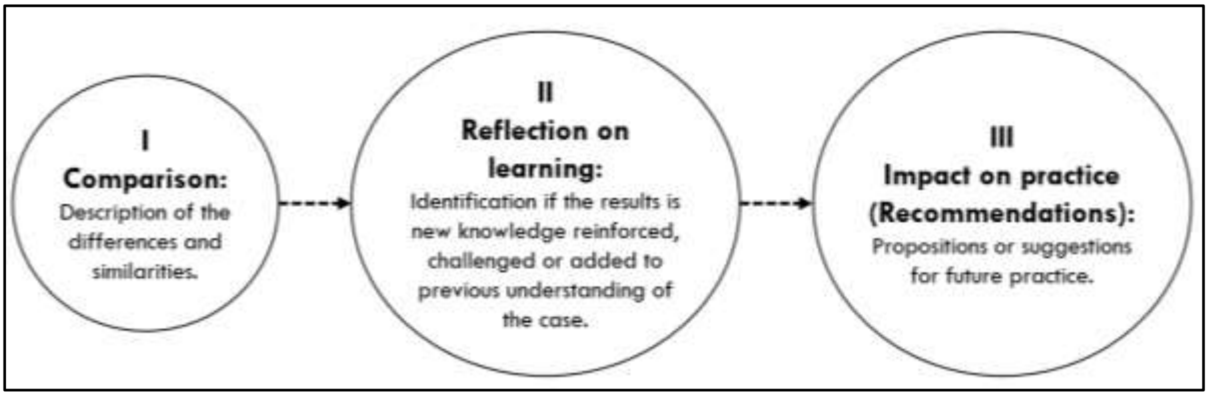
Table 2: Breakdown of the sample size distribution.

Data Collection Tool	Mode	Size
Expert Interviews:		5
▪ System administrator for USSD and voucher management system (VoMS) (1)	Telephone and WhatsApp	
▪ VAS developer (1)	Telephone and WhatsApp	
▪ VAS solutions manager (1)	Face-to-face, email, and WhatsApp	
▪ Customer Journey Experts/UX (2)	Email and WhatsApp	
Usability Questionnaire	Google Forms, in-person	42
SUS Questionnaire	Google Forms, in-person	50
Heuristic Evaluation (experts)	Google Forms, in-person	5
Total		102

Data Analysis Plan

Descriptive statistics was used to analyse the numerical ratings from questionnaires and draw conclusions about the prototype’s effectiveness. Comparative analysis was employed to examine qualitative data from expert interviews. As depicted in Figure 2, we sought to identify areas of consensus and differences in usability across the two technologies and how these findings either reinforced or challenged our previous understanding as found in the literature. Finally, we recommended specific methods that telcos could use to implement our solution.

Figure 2: Qualitative analysis plan



Adopted from: Lutzi et al. (2023)

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Validity and Reliability

Prior to user testing, we conducted a pilot test with a small group comprising participants with varying experience levels to refine the data collection tools. Based on feedback from the pilot participants, we adjusted our tools to better align with real-world use cases to ensure the content accurately measured the established metrics in the context of basic phones. Reliability was ensured by adopting well-established scales and metrics from Jakob Nielsen’s ten usability heuristics and Brook’s SUS questionnaire (Brooke, 1995; Nielsen, 1994). These standardised approaches could be easily replicated to achieve similar results across different testing environments.

TOWARDS ARCHITECTURAL DESIGN OF THE SIM UI PROTOTYPE

The component-based architecture adopted for the SIM UI eschews the monolithic approach in favour of a robust and scalable framework. This framework seamlessly integrates modular components, each with well-defined functionalities and interfaces. As depicted in Figure 3, the SIM UI leverages a three-tier architecture to compartmentalise functionality into distinct layers. The modular nature of the architecture also facilitates seamless integration with complex systems. In essence, the architecture serves as a blueprint, meticulously outlining essential components, functionalities, and features for implementation. The three-layer component architecture of the SIM UI is described in detail below.

Presentation Layer (UI engine)

This layer renders optimised text-based menus and manages user input through keypad entries. It allows for customisation of the menu structure and manages navigation and other UI elements. Compatibility is ensured via a UI mapping and translation service that translates between USSD and STK protocols, adapting UI elements to match the capabilities of each interface while maintaining context and culminating in a seamless and consistent UI presented to the end-user.

Service Management Layer (logic)

This orchestrates various mobile services, including transaction processing, information retrieval, and entertainment services. It integrates seamlessly with external systems through the service gateway to deliver these functionalities. This gateway enables secure communication with third-party service providers and payment gateways. Essentially, this tier bridges the gap between the user interface and back-end systems, ensuring a smooth flow of data and a secure environment for transactions.

Data Management Layer (data)

This component is tasked with storing and managing various services-related data, performance optimisation, content management, and user profiles. The data security functions implement robust security measures to ensure user data's confidentiality, integrity, and availability at rest and in transit. The reporting and analytics component generates insightful reports and analytics, providing valuable insights into user behaviour, service usage patterns, and overall system performance.

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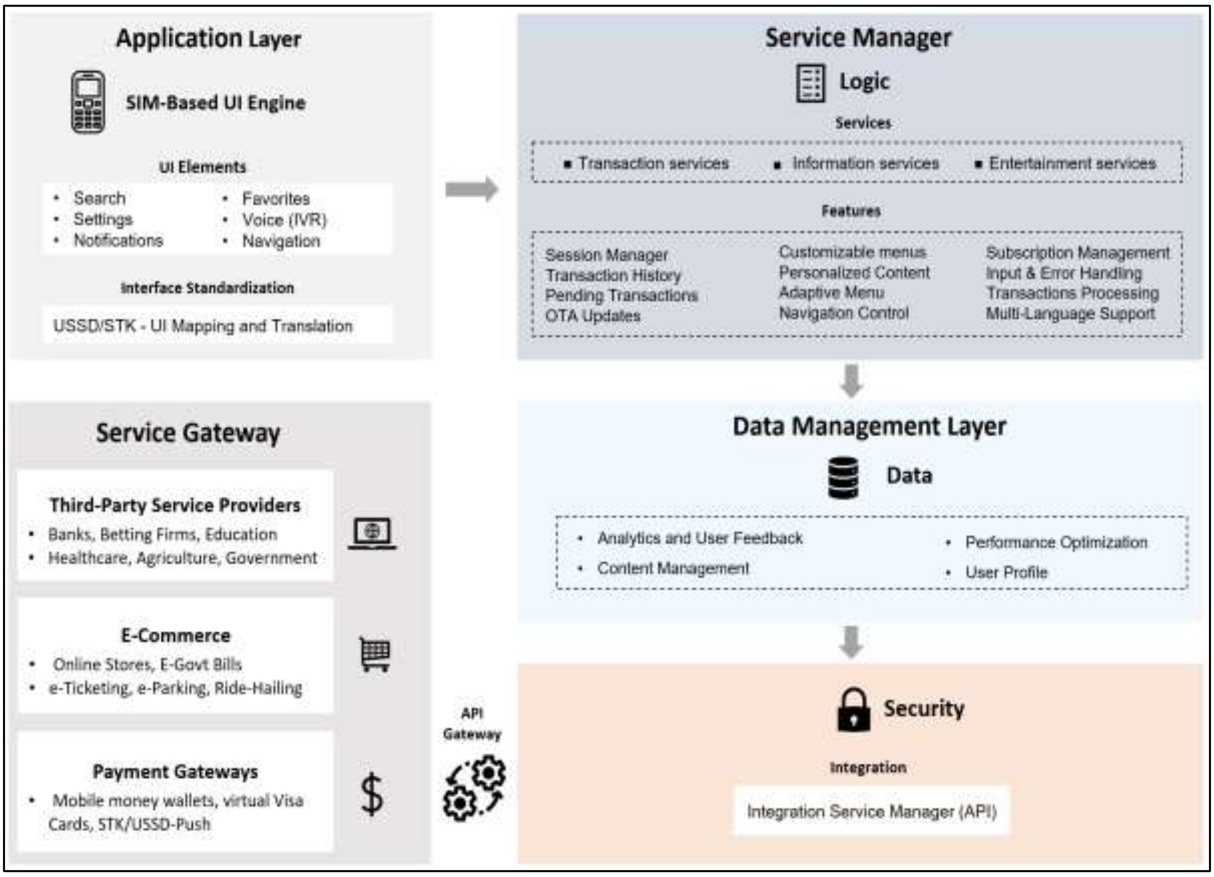
Figure 3: Component-based architecture of the SIM UI.



Source: Authors own work

SERVICE IMPLEMENTATION

The services (VAS) for the SIM UI were developed using Java Card and deployed onto a programmable SIM card. Java Card technology allows Applets to run securely on various silicon form factors, including removable SIMs (Abdallah & Al-Rifaee, 2017). This ensured compatibility with other types of phones, including basic phones, thus maximising the reach and usability of the prototype across diverse mobile platforms. It simulated typical services offered by MNOs. The SIM UI strived to provide an intuitive and user-friendly interface. It is customised to address the challenges above. The following are the core services and features of the prototype:

System Main Services

The primary services menu is a central hub, providing easy access to various services and functionalities, as illustrated in Figure 4. It includes the following items:

Service S1—Search Functionality: The search service has clear matching capabilities based on keywords or partial phrases to enable users to pinpoint the exact content they need with effortless precision. This significantly reduces the customer journey by eliminating the need to navigate lengthy menus.

Service S2—Favourites Option: This enables users to create and manage personalised lists of frequently accessed services for rapid retrieval. This feature aims to enable users to curate their ‘own’ menus instead of the standard menu.

Service S3—Transaction Services: This service was designed and implemented to incorporate all mobile financial services, including mobile money and banking services. While traditionally, MNOs often focus solely on mobile money or require separate service codes in the case of USSD for different Mobile Financial Services (MFS) services, the SIM UI unifies this experience by providing a seamless and secure platform for conducting mobile money, banking, and financial transactions, ensuring a smooth experience.

Service S4—Information Services: The SIM UI groups all related services under one roof to streamline information service discovery. Each service includes clear terms and conditions and allows users to manage their subscriptions easily. It offers access to diverse informational content, including news, business updates, stock market data, and more, catering to users' informational needs.

Service S5—Entertainment Services: It provides many entertainment options, ranging from sports updates and betting to horoscopes and tunes, catering to users' diverse interests. A key challenge highlighted was the inconvenience of navigating through various service codes for different providers, such as betting. The SIM UI tackles this problem by unifying access to these services regardless of the provider.

Service S6—USSD service Catalog: This readily accessible catalogue allows users to browse and select their desired codes anytime. Upon selection, the application seamlessly redirects the user to initiate a standard USSD call using the chosen code. This functionality addresses the challenge of users forgetting or not knowing all available USSD codes across different service providers, thereby reducing the cognitive burden of memorisation.

Service S7—Help Menu: This service allows users to access helpful information and tips on using the application. It includes answers to frequently asked questions and quick guides to useful features. More importantly, it should include the settings option to enable users to adjust their preferences, security, or preferred language.

Figure 4: A Screenshot of the SIM UI (a) Android phone (b) Nokia Symbian-based phone.

USABILITY EVALUATION

Usability is a multifaceted concept that plays a critical role in the success of any Human-Computer Interaction (HCI) system. The ISO 9241-11 standard defines three core usability aspects: effectiveness, efficiency, and satisfaction (Karisha et al., 2023). However, researchers have adopted different approaches for specifying usability elements or dimensions. Nielsen categorised the dimensions of usability, including learnability, efficiency of use, memorability, errors, and satisfaction, into two groups: objective and subjective (Paz et al., 2023). Shneiderman and Plaisant (2010) identified five usability measures: time to learn, speed of performance, rate of user errors, retention over time, and subjective satisfaction. Additionally, Huang and Benyoucef (2023) categorised usability dimensions as

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efficiency, learnability, memorability, error frequency, and satisfaction.

Building upon these established frameworks, this paper adopted *ease of use, effectiveness, efficiency,* and *satisfaction* as the key metrics to measure the proposed prototype's usability. The evaluation consisted of two primary assessments: 1) a heuristic evaluation by experts from two well-known telcos from Tanzania and Kenya with experience in interface design and/or HCI, and 2) end-user usability testing. This combined approach leverages the strengths of both objective and subjective evaluations from industry experts and the target user base, respectively.

Heuristic Evaluation

The heuristic evaluation's main goal was to identify design problems in the prototype's UI and its adherence to HCI principles for mobile phone interfaces. We utilised Jakob Nielsen's ten usability heuristics for user interface design, which have demonstrated enduring relevance through continued application in contemporary usability evaluations conducted by experts in the field of HCI (Kumar & Goundar, 2019). According to Nielsen, there should be three to five evaluators who have training in HCI in the field of informatics. A quality possessed by all five evaluators. They included a VAS developer, a VAS solutions manager, a system administrator for USSD and voucher management systems (VoMS), and two customer journey experts/UX.

Table 3: Mean and Standard Deviation (S.D) of the Heuristic's Evaluation of the SIM UI.

Usability Factor	Mean	S.D.	Sample Comments
Visibility of system status	3.4	0.89	"The user is informed about where they are in the menu at all times."
Match between the system and the real world	2.6	0.54	"Enter recipient number instead of phone number" may not be evident in some cases.
User control and freedom	3.8	0.83	"Need to consider a sub-menu or option to return to the main menu at any point instead of scrolling back."
Consistency and standards	2.2	0.84	"Manageable"
Help users recognise, diagnose, and recover from errors.	2.4	0.55	"Include clear prompts with suggestions for errors."
Error prevention	2.8	1.09	"Need for input validation, i.e., check the length of the input where you need MSISDN or country code."
Recognition rather than recall	3.8	0.83	"Well-recognizable menu"
Flexibility and efficiency of use	4.2	0.84	Separate the menus for "buy airtime and buy bundles."
Aesthetic and minimalist design	4.4	0.55	"Excellently done"
Help and documentation	2.4	1.14	"Help option" to be relocated to the main menu

Table 3 presents the evaluation results, including vital comments and recommendations. The heuristics were rated on a scale of 1 to 5, ranging from bad to excellent. The average mean of 3.2 and standard deviation of 0.811 indicate an overall rating of "*acceptable*." Among the key usability problems identified was the need for an option or sub-menu allowing users to quickly return to the main menu instead of scrolling back. Another issue highlighted was the hidden placement of the help menu within the settings option, which was suggested to be relocated to the main menu for easier access. Enhancements were made to address flexibility concerns, including unbundling specific menus and incorporating input validation. These changes, driven by evaluator recommendations, played a pivotal role in refining the prototype before the final end-user assessment.

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End-User Usability Assessment

Following improvements to the prototype from heuristics evaluation, we conducted two user assessments with usability questionnaires and System Usability Scale (SUS) questionnaires for two groups comprising 42 and 50 respondents, respectively. These participants were selected based on their status as basic phone users or users of USSD and STK. Each group received identical use cases and a comprehensive description of the prototype system's functionality before completing the questionnaires. The usability questionnaire was customised to evaluate the ease of use, effectiveness, and efficiency. It was based on established frameworks such as the user experience questionnaire and the customer effort score to ensure comprehensiveness and alignment with best practices in usability assessment.

After the participants had the opportunity to test and interact with the prototype, they were given clear and concise instructions for completing each questionnaire in person and sometimes via Google Forms. We counterbalanced their order to address potential biases that could arise from the sequence in which the questionnaires were presented. This approach was intended to mitigate any order effects that might influence the participants' responses. The numerical ratings underwent descriptive analysis, evaluating usability metrics of ease of use, effectiveness, and efficiency through task completion rate, error rate, task time, and learnability, while satisfaction was measured using SUS.

Table 4: Ratings of usability indicators from end-user assessments.

Usability Metric	Component	SD	D	N	A	SA	Total	Total A	Total D
Ease-of-use	"It was easy finding features and services."	0	4.8	4.8	33.3	57.1	100	90.5	4.8
	"Easily navigated the menus without needing help."	0	4.8	14.3	42.9	38.1	100	81.0	4.8
	"Remember how to use the system even after not using it for a while."	0	4.8	9.5	38.1	47.6	100	85.7	4.8
Effectivenes s	"When I encountered errors, they were easily reversible and did not cause delays or frustrations."	4.8	14.3	9.5	28.6	42.9	100	71.4	19.1
Efficiency	"Time on task: menus are organised to save time with fewer steps."	0	0	23.8	38.1	38.1	100	76.2	0
	"The system should be optimised to allow you to complete tasks more quickly?"	38.1	23.8	9.5	14.3	14.3	100	61.9	28.6

Keywords: SD = Strongly Disagree, D =Disagree, N = Neutral, A = Agree, SA = Strongly Agree

Ease of Use

Ease of use is a pivotal aspect in assessing usability; it measures a user's perception of how easy a system is to use. According to Li et al. (2020), if a system is relatively easy to use, individuals will be willing to learn its features and continue using it. We evaluated this metric subjectively, based on users' ability to effortlessly

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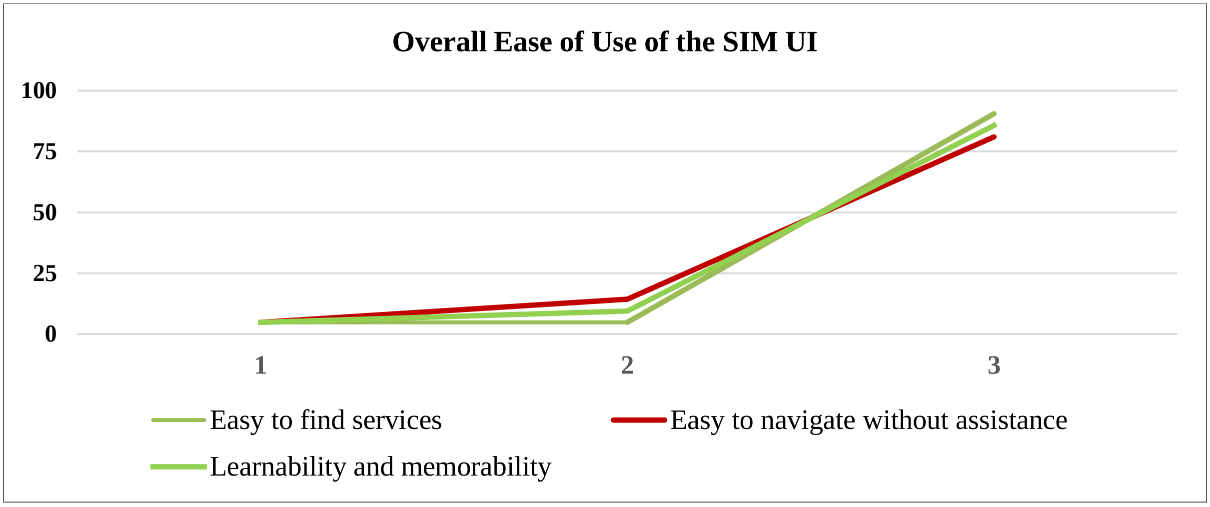
find services, understand features, navigate menus without assistance, and recall how to use the proposed solution even after not using it for a while. Respondents were asked to provide ratings on a scale of 1 to 5, where 1 indicated strong disagreement, and 5 denoted strong agreement, as depicted in Table 4.

Figure 5: Overall ease of use of the SIM UI



As summarised in Figure 5, the results indicated a high level of agreement, with 90.5% finding the menu intuitive and easy to discover services, 81% expressing ease in navigation, and 85.7% finding the prototype easy to recall and use. This resulted in an average score of 4.29 on a Likert scale, implying that the prototype is user-friendly, enabling users to perform tasks in a familiar, standardised, and intuitive manner. In basic phone use, assessing ease of use was particularly important in understanding how the elderly and novice users perceived the system. The prototype effectively accomplished this, demonstrating the importance of ease of use for this demographic.

Effectiveness

Effectiveness is defined by the ability of a user to complete a task in a specified context. Seen as an objective quality, it is measured by the completion and error rates (Nkgau et al., 2016). The completion rate is calculated by dividing the total number of successfully completed tasks by the total number of participants (See Equation 2*)*. By assessing effectiveness, we can determine how well users access VAS without errors or difficulty. Notably, all participants completed all tasks in the given scenarios, resulting in a completion rate of 100%.

$$\textbf{Completion Rate} = \frac{\textbf{Total number of tasks completed successfully}}{\textbf{Total number of participants}} \textbf{ X 100} \quad (2)$$

$$= \frac{\mathbf{42}}{\mathbf{42}} \textbf{ X 100 } = \textbf{100\%}$$

Equation 2: Calculating the task completion rate. Source: (Nkgau et al., 2016)

The error rate is calculated by dividing the total number of errors by the total number of test cases (Equation 3). The errors were categorised as errors preventing task completion, errors causing significant delay or frustration, and errors with a minor effect on task performance. Out of the participants, 80.95% completed the task without errors, and only 19.05% encountered errors with a minor impact, as illustrated in Figure 6.

$$\textbf{Error Rate} = \frac{\textbf{Total number of Errors}}{\textbf{Total number of test cases}} \textbf{ X 100} \quad (3)$$

$$= \frac{19.05}{100} \text{ X } 100 = 19.05\%$$

Equation 3: Calculating the error rate. Source: (Nkgau et al., 2016)

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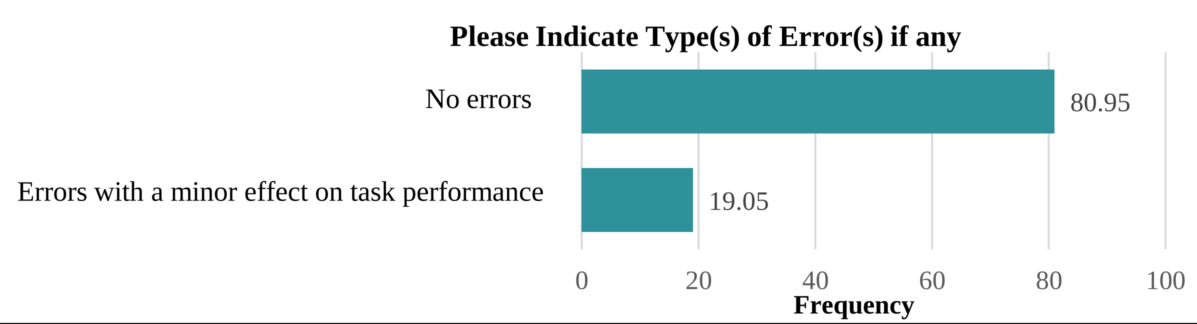
Figure 6: Error rate



Given the error rate of 19.05% caused by errors that had relatively minor effects on task performance, further analysis into the severity and impact on the user experience is provided in Table 5. The majority resulted from user errors during input, navigation, and, in some instances, technical glitches in the system. For instance, navigation errors commonly arose because of the mixup between the "OK" and "BACK" buttons. Users frequently pressed "BACK" instead of "OK," leading to unintentional cancellations or regressions. The HELP option helped reduce errors by familiarising users with the tool.

Table 5: Types of errors that had relatively minor effects on task performance

Type of Error	Description	Frequency	Impact on User Experience
Erroneous Input	Erroneous entry by users, such as wrong options or data types, i.e., due to keypad limitations or lack of input validation.	35%	Minimal service interruption, as it requires users to repeat actions, leading to minor frustrations.
Navigational Issues	The interchange between the "OK" and "BACK" buttons leads to unintentional navigation.	25%	Minimal user frustration and increased ToT; however, users became more familiar.
Response Time Delays	Unresponsive or delayed responses to user actions.	15%	Increased ToT and impact on user satisfaction
Unclear Prompts /Displayed Information	Unclear or mismatched display elements or prompt messages	5%	Increased likelihood of user committing errors
Difficulty Adding/Removing Favorites Services	Challenges in adding or removing favourite MVAS from the user's personalised list.	5%	Creates a barrier to efficient use of the Favorites feature, hindering user experience.
Search mismatch	Misspelt keywords or unfamiliar terms resulting in "service not recognised" while using the SEARCH feature	5%	Users may need to refine their search terms or browse categories to find the desired service, causing some delays.
Limited search scope	search functionality only covers a subset of services within the SIM UI; users might be unaware of additional options and give up after unsuccessful searches	5%	Users could miss out on relevant services if the search scope is limited, potentially affecting their experience.
Misreading Instructions	misread on-screen instructions or labels, leading to confusion or minor errors in task execution.	5%	require users to re-read instructions or take slightly longer to complete tasks.

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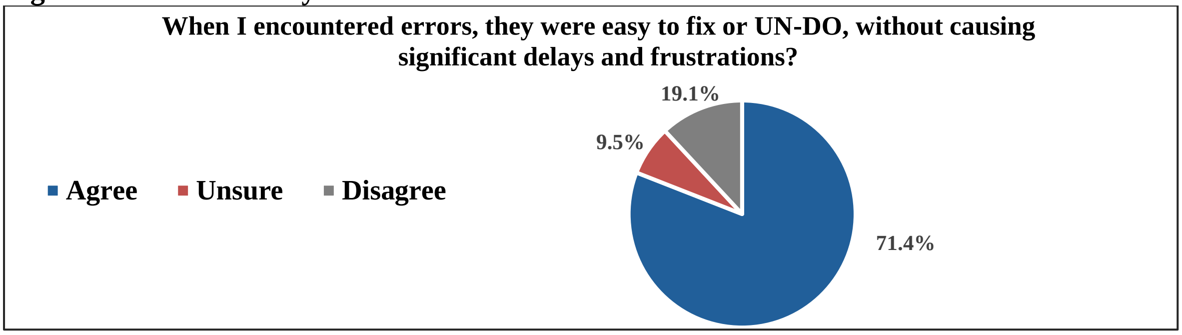
Furthermore, we evaluated user perceptions of error recovery for errors with minor impacts, as error recovery is particularly critical given the input constraints of basic phone keypads. As depicted in Figure 7, 71.4% of users found it easy to recover from errors, while 19.1% reported difficulties in doing so. This suggests that most users were generally able to effectively address and correct common errors, such as those related to menu structures, feature management, limited search functionality, input mistakes, and other user errors like entering invalid data types or misreading instructions. These findings highlight the overall effectiveness of error handling.

Figure 7: Error recovery



Efficiency

Efficiency is an objective quality characterised by a user's capability to accomplish their task quickly and accurately, and it is quantified through the Time on Task (ToT) metric (Nkgau et al., 2016). ToT can be used as a benchmark for comparing the efficiency of different product designs, features, or versions. A lower ToT than the original interface suggests that the redesigned menus are streamlined and allow faster navigation. This paper assessed efficiency by measuring participants' time to complete transactions in the provided use cases and comparing them to similar transactions via USSD and STK as shown in Figure 8. The geometric mean of the average time taken for participants to complete transactions or obtain information was 29.43 seconds obtained by Equation 4. This indicates the effectiveness of the search and favourites options in expediting transactions, highlighting their time-saving attributes.

$$\boldsymbol{g = (x_1 x_2 \dots x_n)^{1/n}} \quad (4)$$

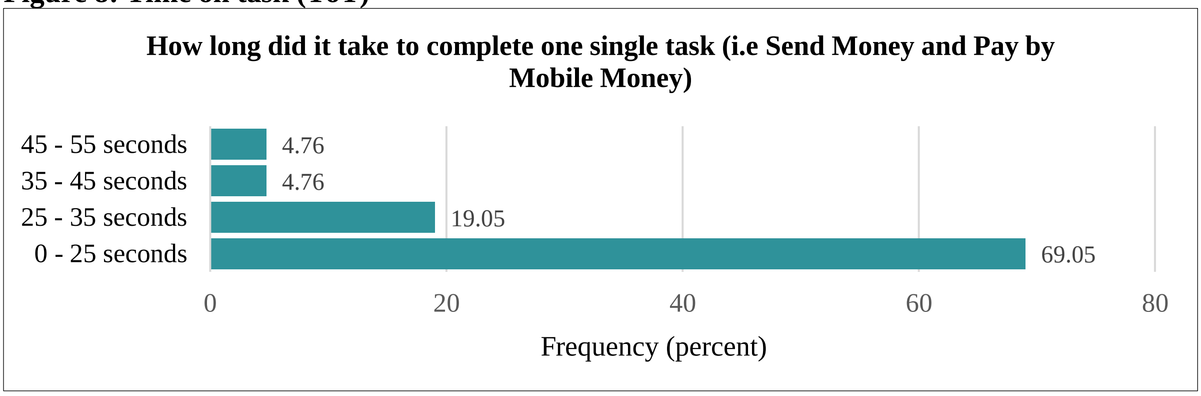
where x_n are the midpoints and n is the total number of data points

$$g = \left[\left[\frac{0+25}{2}\right] x \left[\frac{25+35}{2}\right] x \left[\frac{35+45}{2}\right] x \left[\frac{45+55}{2}\right]\right] \wedge \left(\frac{1}{4}\right)$$

$$g = 29.43 \ \mathit{Seconds}$$

Equation 4: Geometric Mean. Source: (Gary, 2015)

Figure 8: Time on task (ToT)



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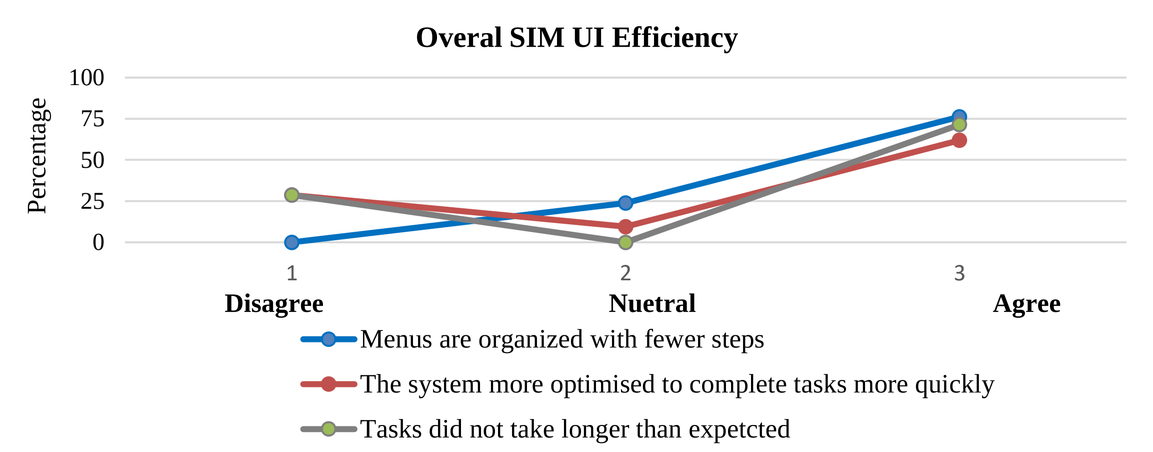
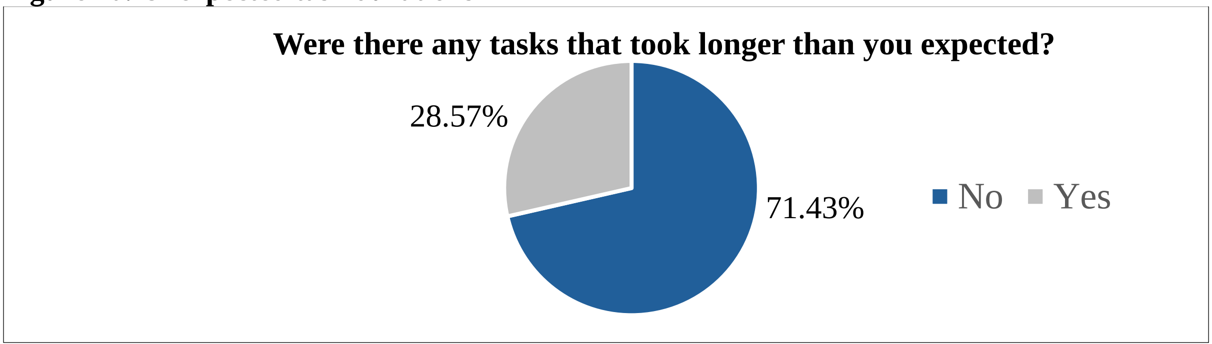
Additionally, Figure 9 indicates that 76.2% of participants agreed the menus were well organised to save time, while 61.9% differed from the 28.6% who believed the tool required further optimisation, indicating overall efficiency.

Figure 9: Overall SIM UI efficiency



While the geometric mean stood at 29.43 seconds, users were also surveyed about any tasks that took unexpectedly longer than anticipated. As shown in Figure 10, 71.43% of users reported that they did not experience extended task durations, whereas 28.57% indicated that some tasks took longer than expected. Initially, the lack of a “HOME” button at each menu level prompted users to restart the app rather than navigate back manually, affecting ToT and the overall experience. After changes were made to correct this, the overall implication was that most users could perform tasks efficiently. This efficiency can also be attributed to features such as the search function and favourite menu options, facilitating quick access to frequently used services. Additionally, users appreciated a novel approach within the prototype that further streamlined their navigation and task completion, highlighting the effectiveness of these enhancements in reducing time and effort for everyday tasks.

Figure 10: Unexpected task durations



Satisfaction

Though considered a subjective quality, satisfaction is the primary usability element and is considered to be the main criterion. The user’s perceptions and responses result from using and anticipating a system, product, or service (Masaaki, 2019; Nkgau et al., 2016). High user satisfaction signifies that the solution successfully addressed user needs and resulted in a more positive interaction. A satisfied user is more likely to continue using the platform and explore its functionalities; hence, a strong relationship exists between satisfaction and user experience.

We employed a SUS questionnaire developed by Brooke (1995) to assess how pleasant it was to use the SIM UI interface (Trukenbrod et al., 2020). Table 6 presents the SUS items and the

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corresponding mean scores and standard deviations. The SUS scale ranges from 1 (strongly disagree) to 5 (strongly agree). For instance, a score of 1.56 on item R_6, "*I thought there was too much inconsistency in this system,*" indicated that most users *disagreed* with this statement. This implied that most users found the interface consistent, as evidenced by the 76.8% who disagreed with the proposition. Table 7 shows an average SUS score of 79.5%, signifying overall user satisfaction with the prototype.

Table 6: SUS Results for SIM UI

SUS Items	Mean	95% CI	SD	Median	Min	Max
R_1: I think that I would like to use this system frequently.	3.96	3.67 - 4.24	0.74	4	3	3
R_2: I found the system unnecessarily complex.	1.68	1.26 - 2.09	1.07	1	1	1
R_3: I thought the system was easy to use.	4.12	3.86 - 4.38	0.67	4	3	3
R_4: I think that I would need the support of a technical person to be able to use this system.	1.56	1.14 – 1.98	1.08	1	1	1
R_5: I found the various functions in this system were well integrated.	3.76	3.49 – 4.02	0.67	4	2	5
R_6: I thought there was too much inconsistency in this system.	1.16	0.97 – 1.35	0.47	1	1	3
R_7: I would imagine that most people would learn to use this game very quickly.	3.72	3.35 – 4.09	0.94	4	2	3
R_8: I found the system very awkward to use.	1.48	1.14 – 1.82	0.87	1	1	5
R_9: I felt very confident using the system.	3.88	3.55 – 4.21	0.83	4	3	5
R_{10}: I needed to learn a lot of things before I could get going with this system.	1.76	1.24 – 1.88	0.82	1	1	3

Equation 4 was used to calculate the SUS score by substituting the "Rx" with the corresponding value of the "mean" scores for each question.

$$\textit{The SUS Score} = [(R_1-1) + (5-R_2) + (R_3-1) + (5-R_4) + (R_5-1) + (5-R_6) + (R_7-1) + (5-R_8) + (R_9-1) + (5-R_{10}) \times 2.5] \quad (5)$$

$$= [(3.96-1) + (5-1.68) + (4.12-1) + (5-1.56) + (3.76-1) + (5-1.16) + (3.72-1) + (5-1.48) + (3.88-1) + (5-1.76) \times 2.5]$$

$$= 79.5$$

Equation 5. Calculating the SUS score. Source: (Oktaviani et al., 2022).

Table 7: Summary of the SUS score for the SIM UI.

Mean	Standard Deviation	Min	Max	SUS Score
2.688	0.815	1.8	3.2	79.5

The best-graded questions were $\mathbf{R_6}$ and $\mathbf{R_8}$, indicating that users found the prototype consistent and streamlined. Specifically, forty-eight (48) participants (96%) disagreed that there was too much inconsistency or that the system was cumbersome. Most users found the system easy to use and required little effort to learn its features. This is evidenced by forty-two (42) participants (84%) who agreed that the system was easy to use, with a mean rating of 4.12. Additionally, thirty (30) participants (60%) agreed they felt confident using the system, with a mean rating of 3.88.

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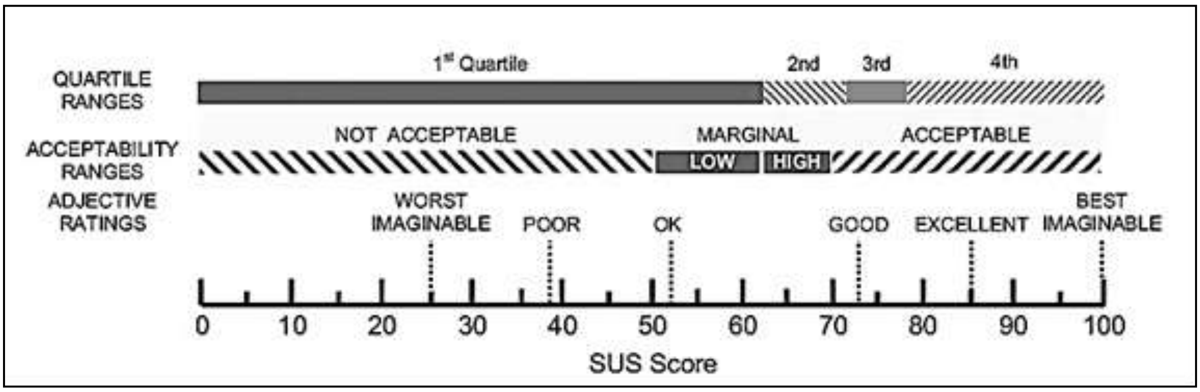
Only ten (10) participants (20%) agreed that they would need the support of a technical person to use the system. In comparison, forty (40) participants (80%) disagreed, indicating they did not need to learn a lot before getting started, with a mean rating of 1.76. Thirty-six (36) participants (72%) expressed that they would like to use the system frequently, giving it a mean rating of 3.96. Moreover, thirty-two (32) participants (64%) agreed that the various functions in the system were well integrated (mean rating of 3.76). However, some users expressed concerns about the system's complexity, noting that it may require technical assistance and additional learning to use effectively. Considering that the average SUS score is typically set at 68, the score of 79.5 in this study corresponds to an adjective rating of "*excellent*" based on the scale provided in Figure 11 (Bangor et al., 2009; Lewis, 2018). This indicates that the participants were delighted with the SIM UI for accessing VAS.

Figure 11: System usability scale ratings



Source: Lewis (2018)

COMPARATIVE ANALYSIS

As previously outlined, the criteria for selecting the two countries are the cases of its two leading MNOs (Vodacom and Safaricom), who embraced different VAS technologies for basic phones (Bolarinwa, 2021; Leon, 2022). However, the insights gathered from the user interviews revealed a more complex picture in terms of usability for the target demographic. This nuanced understanding formed the basis for the comparative analysis, structured into three main sections: *comparison, reflection on learning,* and *impact on practice (recommendations).*

Comparison

The preliminary findings illustrated in Table 8 from our comparative analysis reveal that both the Tanzanian-based and Kenyan-based operators use USSD for their VAS, contrary to the findings of previous studies (Bolarinwa, 2021; Foster, 2021). This part of the analysis emphasises notable differences in technology choices and their impact on usability, accompanied by rationales for these differences.

Table 8: Similarities and differences from comparative analysis

Criteria	Kenyan-Based Telco 1	Tanzania-Based Telco 2	Explanation
Primary Technology for VAS	Dominantly uses STK for mobile financial services (MFS) but prefers USSD for all other VAS.	It primarily uses USSD for all its VAS services, including MFS.	Telco 1 TK for its superior security in financial transactions, whereas Telco 2 uses USSD for its flexibility and ease of management, reflecting different strategic priorities based on customer and service needs.
		USSD is less secure; PINs are	Telco 1 uses STK to secure sensitive operations like payments, ensuring PINs

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Criteria	Kenyan-Based Telco 1	Tanzania-Based Telco 2	Explanation
	STK is more secure as PINs are protected directly on the handset	entered in plain text.	are safe from shoulder surfing. At the same time, Telco 2 accepts the lower security of USSD for its broader accessibility and ease of use.
User Interface	STK is considered more user-friendly but less flexible	USSD is seen as more straightforward for users	Telco 1's choice of STK reflects a trade-off between enhanced user-friendliness and higher operational costs, while Telco 2 prioritises USSD's simplicity and user familiarity despite its less intuitive nature.
Cost and Maintenance	STK has a higher cost due to scheduled updates needed for STK across all handsets	USSD has a lower cost with server-based updates for USSD	The higher operational costs for STK are due to its need for manual device updates. In contrast, USSD's server-side updates reduce maintenance efforts, influencing each telco's technology choice based on cost management preferences.
Challenges and Limitations	Switching between USSD and STK can affect usability due to inconsistent interfaces.	Complexity of USSD menus can hinder user experience	Both telcos acknowledge usability issues but choose different approaches: Telco 1's dual use of STK and USSD creates interface inconsistencies, while Telco 2's reliance on USSD, the hierarchical structure of USSD, can complicate navigation, resulting in complexity.
Future Plans	Improving smartphone apps and transitioning users to feature-rich applications	Uncertain about adopting STK, focusing on enhancing USSD and smartphone apps	Both telcos are investing in improving smartphone apps, indicating a shift towards feature-rich applications, although Telco 2 remains undecided about adopting STK.

Reflection on Learning

Through this comparative analysis, we learned that security concerns, user preferences, cost, usability considerations, and strategic priorities influence the VAS technology choice in basic phones. This broader perspective contrasts with previous studies and reports, which offered only a limited view of the reasons behind the technological choices between the two telcos (Blechman, 2016; Bolarinwa, 2021; Nyaketcho, 2014; Paelo, 2019; Robb & Vilakazi, 2016; Rowan & Mazer, 2016). The Kenyan operator, however, chooses explicitly STK for financial services due to security concerns despite acknowledging that such variability may impede usability, particularly when users have to switch between USSD and STK for different services. Conversely, the Tanzanian-based operator's preference for USSD highlights a focus on simplicity, ease of maintenance, and catering to a broader customer base accustomed to USSD. Additionally, neither of the providers expressed a specific technology poised to replace USSD and STK. This variability will persist in the foreseeable future, even though its impact on usability remains significant.

Impact on Practice (Recommendations)

Both providers acknowledged the limitations of text-based menus, particularly menu complexity and lengthy customer journeys. Improvements like the proposed SIM UI offer promise to enhance the usability. In particular, search functionality, the USSD catalogue, and favourite features were applauded by both operators for their ingenuity in shortening the customer journey, suggesting potential consideration by both operators in their future feature

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developments. As a result of this understanding, several methods that telcos could use to implement our solution are recommended:

- A user-centred design framework tailored to guide the redesign and adoption of the SIM UI prototype by involving the ultimate users is needed. Incorporating novice users and iterative design processes into the workflow would create intuitive interfaces and uncover critical problems that might be overlooked. Consequently, successfully piloting this prototype in a real-world context validates the framework, allowing practitioners to adopt it in similar VAS contexts.

- Interface standardisation. We can overcome the differences between USSD and STK protocols by establishing standard UI elements like in the SIM UI prototype, providing a more consistent user experience regardless of the underlying technology. In light of this, industry-wide efforts are needed among various stakeholders in the VAS ecosystem. This collaboration could involve hackathons, innovation challenges, knowledge-sharing platforms, and open-source frameworks to develop standardised protocols and APIs (application programming interfaces) for interoperability. Such efforts would ensure consistency and user familiarity across VAS providers.

CONCLUSION

Usability is critical to the success of a product because it ensures that users can interact with it effectively and effortlessly. It drives user satisfaction, cultivates loyalty, and distinguishes a product from its competitors, making it an essential aspect of product design and development (Issa & Isaias, 2022; Marcus & Wang, 2018). In the rapidly evolving telecom landscape, where the focus is predominantly on smartphone technologies, enhancing the usability of menus on basic phones presents an untapped opportunity for inclusivity across the digital divide. Motivated by the relative lack of studies on the usability of VAS on basic phones, this paper endeavours to bridge this knowledge gap and challenge the prevailing norm.

The aim was to develop a text-based, menu-driven prototype to enhance the usability of VAS. The prototype was subjected to an expert evaluation before end-user validation, during which necessary refinements were made. The end-user validation yielded promising results, attaining an average ease-of-use rating of 85.8%, with 90.5% of participants deeming the menu intuitive and conducive to easy service discovery. These favourable outcomes, with a satisfaction index of 79.5%, suggest that the SIM UI was not only user-friendly, as evidenced by the elevated user satisfaction, but also more efficient, owing to a streamlined menu structure that facilitated a shorter user journey and expedited information retrieval.

Practical Contribution

The contribution of this paper is a practical, *one-size-fits-all* prototype (Figure 4), providing a dynamic toolkit for developers and service providers to tailor VAS offerings, particularly to regions with distinct informational requirements and diverse technological preferences. For instance, given the increased demand for mobile transactional and informational services in the region, providers could tailor the SIM UI prototype to cater to users' platform needs as follows:

- Quick-access menu option. By incorporating the quick-access menu from the prototype for commonly performed actions such as sending money, checking balances, and paying bills. The favourite menu would serve as personalised shortcuts, significantly reducing the time and effort required for routine transactions.

- USSD service catalogue. Considering the prevalence of the USSD service codes currently used for various services, operators could integrate a catalogue menu from the prototype to streamline access, thereby minimising the cognitive load on users who must remember and navigate different codes.

- Search functionality. A robust search feature would allow users to quickly find specific services within the platform, shortening the customer journey and enhancing overall usability.
- Bundled menu approach. Adopting the prototype's menu structure could consolidate multiple services under a single interface, eliminating the need for users to switch between different platforms or services, as is commonly observed in this region.

Future Works

Future studies could explore how to incorporate user-generated content into the VAS mainstream. Users could contribute information and tips relevant to their communities, such as local market updates or best agricultural practices, even in their native languages. Here, blockchain can provide a secure and transparent platform for users to share and access information. By incorporating blockchain tokens as incentives, users can be rewarded for their contributions, encouraging participation and enriching the content pool. This has the potential to directly address the community's needs and create a more user-centric VAS ecosystem that benefits both users and service providers.

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