MFS Design in Appstore-enabled Smart Featurephones for Low-literate, Marginalized Communities

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ABSTRACT

Mobile Financial Services (MFS) has gained significant popularity during the COVID-19 pandemic, especially among marginalized and low-income, low-literate communities around the world. Such communities have not been traditionally considered while designing MFS services via smartphone apps or USSD services in featurephones. Financial constraints limit such end-users towards basic featurephones, where recent appstore support has made it possible to deploy app-based MFS solutions beyond USSD. This new featurephone platform is a relatively underexplored area in terms of addressing design issues related to aforementioned end-users while developing MFS solutions. Our work addresses this gap by presenting qualitative findings on barriers to technology access focused on MFS solutions in marginal communities. We present a prototype non-USSD, app-based solution on an appstore-supported featurephone platform designed via a human-centered approach. This work has the potential to increase the financial inclusivity of marginalized communities in cashless MFS transactions via low-cost, appstore-enabled featurephones.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Accessibility**.

KEYWORDS

Finance/Money, User Experience Design, HCI for Development, Mobile Devices: Phones/Tablets

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1 INTRODUCTION

Technology has played a major impact in improving the lives of low-literate, low-income marginal communities [68]. Recent advancements in mobile network connectivity and decreasing cost of mobile communications devices have made it possible for marginal communities in different countries to afford and adapt to the usage of mobile phones and phone-based services in their daily lives [55]. The wide use of mobile phones has fueled socio-economic advancement via mobile phone-based services such as Mobile Financial Services (MFS), Remote Education, Online Shopping & Mobile Internet in densely populated, low-resource countries like Bangladesh [55]. Financial Technology such as Mobile Financial Services (MFS) – easily accessible through mobile phones via mobile wallets and mobile banking have taken the socio-economic advancement of the marginal communities further [6, 32, 33] than any other mobile-based services. *Mobile banking* entails the use of a mobile phone to access traditional banking services and carry out financial transactions, whereas *Mobile Money (or Mobile Payment / Mobile Wallet)* is a mobile-based transactional service operated under financial regulations (but outside of traditional banking structure) which allows digital currency to be transferred electronically via mobile networks [2]. The recent COVID-19 pandemic (2020-2022) forced authorities around the world to impose regional lockdowns to maintain Quarantine. This forced the general populace to rely more on mobile phone-based services to meet their daily needs. During this period, Mobile Wallets and Mobile Financial Services usage have significantly increased [11, 12] due to their cashless nature and have been shown to positively impact communities around the world in many ways [32].

Among marginal communities with low or limited literacy, the technology access and usage journeys for mobile financial services are very different compared to mobile users with a higher level of literacy [7]. There are intuitions, imaginations, and the addition of support networks among such communities regarding technology usage. Contemporary research has shown [61, 62] that the basic barriers are amplified when marginal communities access digital platforms. These barriers have shown to be exacerbated among marginal users when it comes to finance-related technologies [6,

32, 33]. Research clearly shows a gap between Mobile Financial Services designers and marginal end-users of such services.

Taking these marginal communities into account during the design process of mobile financial services has a two-fold effect – a) Increasing accessibility and acceptance of MFS among an often neglected but large community of end-users & b) Increasing penetration of an MFS among end-users resulting in larger revenue and market share. Hence, addressing such a gap in interface design in financial technology adds great value to end-users and service providers.

The present trait of financial services provided through mobile devices can be divided along the mobile devices' functionality - Smartphones & Featurephones. Traditionally, smartphones are mostly touchscreen devices with a wide range of functionalities besides basic phone calls and Short Messaging Services (SMS), and most importantly - appstore services allowing independent developers outside the hardware manufacturer ecosystem to develop mobile services and content. Compared to Smartphones - Featurephones are mostly button-based phones with a limited range of functionality beyond call and text services, which are considerably more affordable than Smartphones. Currently, a preferred method of using MFS services on Smartphones is downloadable mobile applications, compared to mobile web applications. The availability of smartphone appstores has made it easier for MFS providers to develop and deploy mobile apps on smartphones. Until very recently - Featurephones were limited by a lack of appstore facilities besides limited device functionality. This forced the MFS service providers to extend their services through Unstructured Supplementary Service Data (USSD) transactions as pre-loading apps on these featurephones were not possible for third-party developers outside the device manufacturer ecosystem.

App-based mobile wallet services in smartphones are simple but do require some level of literacy, which is mostly not present among marginal communities. Exploration of different smartphone-based MFS has shown that most money transactions require between seven to nine consecutive steps to conduct money transactions. The number of steps involved makes it hard to memorize for low-literate end-users, resulting in a frustrating experience. USSD-based MFS transaction steps in featurephones have also been found to be verbose and require a similar number of steps as smartphone mobile wallets.

Recent advancements in Featurephone operating systems such as KaiOS have made it possible to integrate appstore functionality in these button-based, low-functionality, and low-cost featurephones. This has enabled developers outside device manufacturer ecosystems to develop additional content, applications, and features for featurephones - allowing MFS providers to relaunch their services on these low-end, low-cost phones with updated functionalities beyond USSD. This has allowed extending better MFS support in a more affordable mobile phone solution for low-income, low-literate marginal communities across the world. However, most MFS interface design research for improving the marginal, low-literate community's MFS experience has focused on traditional touchscreen-based smartphones due to the add-on Appstore support – not addressing the needs of low-literate end-users being able to afford only featurephones.

This research work addresses the aforementioned gap of MFS interface design in affordable app-store-supported featurephones. This paper explored design considerations for a mobile wallet app (that is easy to use among the marginal, low-literate community) on a button-based featurephone. Bangladesh, as a representative population, was focused on this research due to its overall population size & density, marginal community size, and mobile usage penetration. This research is divided into four phases, challenges in technology, and fintech access among low-literate and marginal community end-users were explored to elicit the target end-user needs and expectations. Then a human-centered design approach was used to prototype a non-USSD, app-based fintech solution in KaiOS-based featurephone / buttonphone platform as a proof of concept.

In the first phase, obstacles to using financial technologies were examined by conducting focus group discussions. Based on the findings from the first phase of this research, particular design challenges were looked into, which arose when developing personas in the second phase. Consequently, in the third phase, specific difficulties that individuals with low-literacy ran into while using Featurephones for tasks beyond calls and text messages were explored. Then, an MFS prototype on KaiOS Featurephone based on the observations from the third phase was developed - and the prototype app was tested out with low-literate users based in urban settings.

This research provides a close understanding of the challenges and barriers in mobile technology interaction among marginal and low-literate communities with a specific focus on fintech applications and presents design findings on improving MFS app-based solutions for appstore-supported featurephones, a relatively unexplored area in ICTD and HCIxD. The observations and findings from this research work have the potential to influence the design and deployment of mobile services for the app-supported featurephone segment and provide marginal communities with a more affordable gateway to the panoply of digital services available within their country.

2 RELATED WORK

2.1 UIs For Low-literate Users

Although user interface design for mobile and web has advanced significantly [63, 67], improvements tailored to low-literate users have not yet been fully addressed [63]. The target users of traditional UI designs and non-literate users are considerably different because of the strong correlation of illiteracy with poverty [19]. Additionally, typical interfaces are made for the developed world and those may not succeed in providing the best user experience for low-literate people in developing countries [22, 71].

The majority of studies in this field acknowledge that mobile user interfaces should be designed differently for low-literate users than they are for literate ones [17, 24, 48]. However, other claims point out the difficulties of textual interface for illiterate users [45]. The majority of these studies are ethnographic [25, 44, 48, 50] - highlighting the usability barrier for low-literate users. These studies also present design ideas in the form of general design guidelines as well as features that essentially contributed towards forming effective frameworks in low-literacy designs.

Huenernfauth [30] proposed design recommendations for non-literate users. Medhi et al. [50] found that textual interfaces are inaccessible to low-literate users and are challenging for beginner users to operate accurately in the context of mobile banking. A study with Self Help Groups in rural India identified that the majority of the people have numeric literacy, but the use of representational images was most helpful in navigation [26]. Several studies have mentioned replacing text with graphics [26, 46, 56]. Additionally, several studies by Medhi et. al. [49, 50] identified that low-literates have trouble with scrolling, understanding softkey functionalities, technical language comprehension, and difficulties in hierarchical navigation. They suggest employing these features as minimally as possible while focusing on voice and graphical instructions. Similar to Medhi et al. - Jackson et al. [7] also found out that short voice-based instructions have a higher chance of being understandable, while lengthy voice instructions end in partial results most of the time. Their work suggests developing unique solutions for each level of literacy; combining voice and text-based solutions for semi-literate end users and voice-heavy solutions for low-literate users.

Chaudry et al. [17] worked on mobile interface design in Smartphones for low-literate populations and observed user preference for larger or medium-sized widgets. The participants in the study preferred and performed well with radio buttons, possibly due to the feedback mechanism built into their designs (dot for a point click). Their findings encourage designers to create larger widgets that let users visualize interactions.

Belay et al. [14] found that the present mobile UI design (in Smartphones) follows traditional app development processes which overlook the user base with technical (bandwidth, connection stability) and economic (device capability, connection cost) issues. Most non-app-based mobile services rely on short messages and Unstructured Supplementary Service Data (USSD), which low-literate users cannot use. The study argued that limited mobile infrastructure and communication technologies hampered app development. It also argued that communication bandwidth could be a problem if audio or multimedia applications aren't designed for low-literate users.

Parikh et al. [56] described the interface design features necessary for managing financial institutions in rural India. The researchers highlighted several key points while designing interfaces for low-literate users and recommended a linear navigation structure. Mehra et al. designed Prayana[52], an intermediated android phone-based app for financial management in a resource-constrained setting. They intended to have minimum text except for numbers, to leverage visual representations and colors, and to reduce textual data entry because they were designed for a multitude of literacies. They also aimed at minimizing the necessity for scrolling, as well as building minimum hierarchies and a simple workflow.

Prayana was followed by another financial management app, SalaPrayana [66], a smartphone application for auto rickshaw drivers. The researchers wanted to communicate sophisticated financial information to drivers with mixed literacies in low-resource settings when building the application. As a result, they relied largely on visual components and colors but were unable to achieve a text-free design. They developed the application with a shallow depth in the hierarchy to ease navigation. They achieved part of their goal, as the app appears to be relatively useful for literate drivers, and at least some information may be valuable for illiterate drivers.

Aside from contextual factors and the generalizability of the research approach, the majority of these works present usability challenges and design recommendations which can be summarized as:

- Text should be reduced in favor of Graphical Widgets.
- Numerical digits should be used when possible as they are usually understandable.
- Scrolling should be avoided as is an issue for most users.
- Softkey mappings should be minimized.
- Complex hierarchies should be avoided in favor of Linear navigation.
- Help sections and live training options should be considered to familiarize the user base with the interface.

However, most UI research work for low-literate users focuses on either Smartphones with App support or USSD/SMS based Featurephones. Almost no exploration has been done in UI research for low-literate users on featurephones with appstore support. These advanced featurephones support more graphical widget options, and third-party supported development compared to older featurephones while retaining the button-based navigation interactions. Also, due to the hardware limitations compared to smartphones such as screen size and unavailability (in most cases) of touch interactions - the nature of graphical widgets is considerably different compared to smartphones. As such, UI/UX research into these new featurephone UI with respect to marginal communities holds considerable value for both MFS and other mobile service providers and low-literate user segments with limited financial means.

2.2 Emergence of MFS in Developing Countries

Although the number of banks and branches has risen significantly enabling banking services accessible in both urban and rural areas [21, 37], the number of banking centers opened by the financial institutions may not always indicate an improved financial inclusion [43]. In such cases, Mobile Financial Services have significant contributions in promoting financial inclusion for developing countries such as Bangladesh where a substantial number of people are unbanked [57]. In Bangladesh, 57% of its 150 million people own a cellphone, but only 13% have a bank account. [27]

Medhi et al. [47] explored differences in the adoption and use of existing mobile banking services by low-literate, low-income individuals across nations, as well as the factors that contribute to this. Variations existed along several dimensions, including household type, key service adopted, the pace of uptake, frequency of usage, and ease of use.

Apart from conventional banking services, MFS in developing countries can surpass demographic and geographic limitations through its network effect, low cost, and increased transparency [59]. In Bangladesh, the use of MFS in 2022 has boomed rising 30.34% in the number of transactions compared to last year [13]. In Kenya, many of its financial inclusion successes may be traced back to the country's success in promoting mobile banking. Primarily because of M-PESA [57], adults who use formal financial services nearly tripled, from 26.7 percent to 75.3 percent, while adults who

are completely excluded from formal financial services declined by more than half, from 41.3 percent to 17.4 percent. M-PESA sales were Safaricom's (its parent group) greatest single source of revenue in the most recent fiscal year, which concluded in March 2021, surpassing voice revenues. M-Pesa revenue currently accounts for 31% of total group revenues, up from 21% five years [60] ago. Within 18 months of the inception of Zimbabwe's first mobile money service, EcoCash, had 2.3M customer registrations (corresponding to 31% of Zimbabwe's adult population), 1M of whom were active, and a yearly transaction volume equal to 22% of the nation's GDP. [38]

2.3 The Potential of Appstore Supported Featurephone to Reduce Accessibility Barriers

Several prior works have explored the potential of KaiOS, an appstore-supported featurephone Operating System to diminish accessibility barriers for the unbanked and offline population. KaiOS strives to bridge the digital divide by removing one of the most significant barriers to internet access: *the cost of devices and data* [39]. With its present availability in both emerging and developed nations, billions of new users will gain access to the mobile internet with very minimal device and data costs. With pricing as low as 17 USD [69] per device, these phones solve the affordability barriers of the previously unconnected customers to connect to the internet.

KaiOS has already connected 140 million people through smart featurephones in collaboration with partners, and the average cost of devices and data is rapidly decreasing around the world. [18]. JioPhone, a KaiOS-powered smart featurephone, grew its rural subscriber base in India to 128 million from 62 million, giving it a rural market share of 25.05% versus 12.14% in June 2019 [58]. Most of these buyers are first-time internet users in the low-income segment, without the means to afford the device and data cost of smartphones [31, 34].

The basic featurephone cannot support most internet data-based mobile services and relies on USSD/Text messages for providing such services. In terms of MFS - accessing Mobile Wallets or Mobile Banking via USSD/Text message is cumbersome and has very low acceptance among end-users. A study undertaken by the KaiOS development team [40] shows the preference for mobile wallets over mobile banking in emerging economies due to accessibility and trust issues and underscore the necessity of internet connections to use mobile money services for a better user experience. They show that Mobile Wallet and MFS resulted in increased financial inclusion of a large marginal population segment in Low-to-Middle Income Countries (LMIC) in Africa, South Asia, Latin America, and Oceania. Recognizing the potential of an appstore eco-system in Featurephone segment to provide ultra-low income communities with cashless financial inclusivity - the developers of KaiOS are officially partnering up with MFS providers [41] in various countries to extend country-specific MFS services to local end-users. This enables the ultra-low income communities across different countries to go beyond cash-based transactions and access cashless banking, develop personal savings and manage business funds and perform monetary transactions across great physical distances - resulting in increasing financial inclusion by creating opportunities for the unbanked population.

With the growing popularity of Smart Featurephones with appstore support in developing nations and its potential to provide low-income end users MFS inclusivity - addressing the needs of low-literate users becomes of paramount importance due to major overlap between low-income and low-literate end-users. As Section 2.1 illustrates - this area of UI design for MFS in Smart Featurephones is relatively unexplored. In this paper, novel aspects of the Smart Featurephone using KaiOS were focused on as a platform to address how marginal community users interact with smart featurephones and how the MFS applications should be designed to better facilitate the low-literate end-users.

3 METHODOLOGY

The study considered various groups of participants throughout a year initiated in December 2020. The study took place over several phases, as discussed here.

3.1 Recruitment

The researchers recruited participants through two primary methods: purposive sampling and snowball sampling. They primarily communicated with them in person, over email, or via telephone, explaining to them the goals and ethics of the study. Once the participant agreed to take part in the study, they settled on a time and venue for an in-person interview at the convenience of the participant. The only exception was the design sprint, where virtual meetings were held after a Google Calendar invite was sent out to the participants. The places of the interviews were the participants' residences, workplaces, and local tea stalls. More details of the individual recruitment process are discussed in the study phases.

3.2 Participant Demographics

This section describes the demographics of the participants for each phase. An overview of participant demographics is also shown in Table 1. All of our participants in Phase I, III, and IV except Phase II belonged to the working class and included construction workers, RMG workers, vegetable sellers, household workers, rickshaw-pullers, security guards, and tailors, who had limited literacy with no design experience and technical background. The only exception was Phase II, where all participants were highly educated professionals. In our paper, we refer to individuals with limited literacy skills as low-literates who have difficulty reading, writing, or understanding short, simple messages. This group includes both illiterate people who cannot read, write, or understand basic messages, as well as semi-literate people who struggle with these skills [7].

As our research targeted low-literate people, study phases I, III, and IV did not necessitate recruiting participants with prior design experience and technical skills. Only phase II required the participants to be from industry or academia and have experience designing for accessibility or technical skills demonstrating considerable prior knowledge of fintech applications.

3.2.1 Phase I. The study explored N = 86 participants (Male = 21, Female = 63, Transgender = 2) in urban, rural, and semi-urban regions of the Dhaka Division of Bangladesh. The study region included the urban region of Dhaka city (54 participants), a semi-urban region of Narayanganj city (11 participants), a semi-urban

Table 1: Demographics of Participants

Study Phase	No. of Participants	Gender	Age Range	Type of Area	Profession
I	86	Male (21) Female (63) Transgender (2)	18-29 (25), 30-39 (38), 40-49 (14), 50+ (9)	Urban, Semi-urban, Rural	Professional Driver, Household worker, Vegetable seller, RMG Worker, Rickshaw puller
II	16	Male (11) Female (5)	18-29 (11), 30-39 (5)	Urban, Semi-urban	Researcher, Professional
III	10	Male (6), Female (4)	18-29 (7), 30-39 (3)	Urban, Semi-urban	Construction worker, Household Worker, Cleaner
IV - Initial	5	Male (5)	18-29 (3) 30-39 (2)	Urban, Semi-urban	Construction worker, Cleaner
IV - Final	23	Male (11) Female (12)	18-29 (15) 30-39 (8)	Urban, Semi-urban	Construction worker, Rickshaw puller, Security guard, RMG Worker, Tailor

region of Tangail city (11 participants), and a rural area (10 participants) covering the Balla union of Tangail district. Among the participants, there were thirty-six low-literate participants, the majority (30) being women, including the transgender participants identifying themselves as women. The remaining participants had varying literacy levels, with some demonstrating good reading skills but limited writing abilities.

3.2.2 Phase II. N = 16 participants (Male = 11, Female = 5) from diverse backgrounds came together for the design sprint phase, including researchers and professionals from academia and industry. Thirteen participants joined from urban Dhaka, one joined from the USA, and two others joined from Tangail and Cumilla. Eleven participants had prior design experience and technical skills. Five participants did not have prior design experience or a technical degree; however, they had the necessary technical skills, i.e., they demonstrated considerable prior knowledge of fintech applications. None of the participants in this phase overlapped with any other phases.

3.2.3 Phase III. The study included N = 10 (Male = 6, Female = 4) low-literate participants - five from urban Dhaka and five from the semi-urban Narayanganj area. Seven participants were identified as semi-literate, one as illiterate, and the remaining two demonstrated good reading literacy. All participants were new and active users of button phones.

3.2.4 Phase IV. Phase IV involved testing two application prototypes. All participants for both testing sessions were active button phone users. N = 5 (Male = 5) urban and semi-urban low-literate users participated in the initial prototype testing, including two illiterate users from Phase III and three other new participants identified as semi-literate. Three participants were from semi-urban Narayanganj, and two were from urban Dhaka.

For the final prototype testing, N = 23 (Male = 11, Female = 12) participants from Dhaka (13 participants) and Narayanganj (10 participants) participated. Four participants also attended the initial prototype testing of this phase, while the remaining participants were new. Six participants were illiterate, and twelve were identified as semi-literate. The remaining participants had varying levels of reading and writing skills.

3.3 Procedure

We interviewed the participants in their local language (Bangla). We took explicit consent from the participants to audio record the interviews and take pictures and notes. The participants were explained how the audio recordings, photos, and notes would be used in our research. The interviews were audio-recorded after receiving informed consent from the participants, and field notes and memos were taken along with that. On average, each interview took between 20 and 30 minutes. Following the interview, participants were compensated with a mobile recharge of BDT 100 (about USD 1.00), except the participants of the design sprint. Further details of the individual procedures are discussed in the study phases.

3.4 Data Analysis

Our data consisted of field notes and audio recordings from the interviews. Before conducting the analysis, the audio recordings were transcribed and translated from Bangla to English. Along with collecting the data, we formulated memos to explore potential themes arising from the data [16]. The data were subsequently analyzed using inductive thematic analysis [53]. The two authors went through the data three times to find the initial set of codes. The authors then did multiple rounds of open coding in the "ATLAS.ti" software, extensively discussing and refining the codes. Finally, twenty-eight refined codes were found, which were categorized into six high-level themes as discussed in section 4.1. This follows the same practice in similar qualitative HCI research [28]. The same data analysis method applies to the rest of the study phases.

3.5 Study Phases

This section discusses the various phases of the study required through the design and development process.

3.5.1 Phase I, Understanding the Challenges of Low-literate Users. The goal of this phase was to explore barriers to using financial technologies that took place from December 2020 to March 2021. The participants were recruited through purposive sampling by contacting local key informants who were familiar with the regional context and participants. This study included fifteen focus group discussions, each being more than an hour long where the discussion took place in Bangla. The conversations were around technology familiarity, focusing on fintech where the participants added the COVID-19-related situation. This study's outcome was identifying pain points marginalized groups have experienced using technology and fintech.

3.5.2 Phase II, Design Sprint. The goal of this phase was to explore the specific design challenges of creating a persona based on the research that took place in Phase I (Section 3.2.1 & 3.5.1). This phase included a week-long design sprint taking place in the Third week of April 2021. The participants were recruited based on their interest in the ongoing study for inclusive technology design, where

an email-based call was sent out. The sprint took place virtually, where COVID-19 was evident in the country. The outcome of this study was to consolidate the attention on low-literate user groups in their technology and fintech usage.

3.5.3 Phase III, A Design Probe for Featurephones. The goal of this study was to explore specific challenges low-literate participants faced in featurephone usage. The participants were recruited using snowball sampling. In this phase, the participants were engaged in sharing and exploring their phone usage experiences with the researchers in individual one-to-one sessions. The study was divided into two sessions, each taking more than twenty minutes. The outcome of this study was a set of requirements and a better understanding of user interface-related features that are desirable and understandable by this user group. Additionally, three design guidelines were formulated from the findings of this phase, as discussed in section 4.4. These were followed in the prototype development phase (section 4.5).

3.5.4 Phase IV, Prototype Development and Testing. In this phase, initially, urban low-literate users participated in testing the initial prototype. Once the users provided feedback about the initial prototype, the user interface of the application was modified and a follow-up study was conducted. For the final prototype design, six 10-15 minute sessions were conducted. These sessions included a group of participants where 1-4 participants joined per session. They were recruited with the help of a local contact person of the researchers. They were provided with a Nokia 2720 Flip Phone - a KaiOS-powered Smart Featurephone for using the app. The goal of this study was to test the application designed considering the study findings and find out the future directions of the work.

3.6 Research Ethics and Safety Protocols

This research was Institutional Review Board (IRB) approved. All the participants were adults and gave informed consent after they were explained the research purpose and goals.

The majority of the study taking place during the COVID-19 pandemic required strict safety measures to be maintained as directed by WHO [70] and Ministry of Health [20] where social distancing was maintained, masks were required with mandatory hand washing protocols.

3.6.1 Self Disclosure. Franekber [23] recommends the disclosure of the background and positionality of the researchers so that the readers understand the lenses used. The researchers in this study were born and raised in Bangladesh.

4 STUDY, DESIGN, AND EXPERIMENT

4.1 Understanding the Challenges of Low-literate Users

In the first phase of this research work - a pilot study was conducted to explore the role of MFS on low-literate communities. The definition of low-literate people is the same as discussed in section 3.2. The study took place from December 2020 to March 2021, right before the first lockdown of the COVID-19 pandemic. The qualitative study considered multiple focus group discussions with participants of the same socio-economic category to discuss their current financial and technological activities through a semi-structured personal story-sharing process.

To conduct the study, two researchers transcribed and translated the audio interviews, as well as the field notes and memos, into English. The transcription underwent thematic analysis [15], with the data being reviewed three times to identify and cluster patterns or codes. The researchers analyzed the transcripts of multiple interviews independently, developing codes, comparing them, and iterating with more interviews until a consistent codebook [8] was established. Finally, the researchers categorized and grouped their codes into six high-level themes based on the repeated review of the data. These themes represent a set of common tensions and challenges that the study participants faced in using mobile financial services, as discussed in section 4.1.1 through section 4.1.6.

4.1.1 Mobile Financial Services Use Case among Existing Users. Different individuals use MFS products for different purposes. The participants, through the pilot study, showed the importance of MFS in their lives to attain different objectives. For example, a significant number of Ready Made Garment (RMG) workers, professional drivers, construction workers, and household workers - low-income community members in Bangladesh traditionally receiving cash salaries started receiving their salaries through mobile wallets during the COVID-19 pandemic. This shift in the monetary instruments was to avoid physical cash to curb the spread of the virus. MFS allowed seamless transactions, which were specifically desirable for marginal communities who had to face social prejudice otherwise. For example, a participant from the transgender community shared how she was able to support her niece through a seamless money transaction where her visit to her relatives was prohibited. The niece asked for money as she did not have any food for the last two days. In her words: "*I could send her the money immediately*".

During the study, some of the participants acknowledged that they started receiving their salaries using MFS services. Some participants indicated that they use it in emergencies, businesses, or while sending money to their homes. Regarding the frequency of the usage, some participants informed us that they use it regularly, i.e., every month and sometimes twice or thrice a day. Some participants indicated that they use it whenever they need to send money but want to avoid physical travel across large distances, reflecting their reliance on MFS products.

4.1.2 Preference of Payment Method among Existing Users. The participants shared their preferred MFS platforms and their reasons behind choosing them. The majority of the participants revealed that they use Rocket [36] MFS service due to zero cost associated with sending money. They also revealed that the physical existence of DBBL bank associated with Rocket service, and the widespread bank branch network across Bangladesh resulting in the availability of bank branches near their homes is another key factor in choosing this service. Many participants indicated that they use bKash [36] MFS because of the abundance of bKash agents (independent licensed contractors authorized to provide in-person services) adjacent to their homes. Some participants reported that they are planning to switch from bKash to Nagad [36] MFS as the latter incurs a lesser fee compared to bKash. The responses indicate users

are likely to stick to the products with agents/locations close to their residence and a lesser fee.

4.1.3 Device Use Case. Most participants acknowledged the primary usage of the device to receive calls and texts. A considerable number of participants revealed using a mobile device for listening to music and radio. Some respondents acknowledged using the device to send money using mobile wallets.

4.1.4 Accessibility Barriers to Device Use. The participants in the study shared their accessibility barriers while using mobile devices and MFS services in their current state. Most importantly, the study revealed the eagerness of participants who wanted to use MFS but had to depend on others due to their limited literacy. Some participants acknowledged their dependency on their colleagues, relatives, or shopkeepers to use mobile phones. One RMG worker shared how she was embarrassed when she had to ask for help during an emergency money transaction in the middle of the night. The person helping her was annoyed and asked her to learn the method herself the next time. She was motivated to learn, in her words: "*I tried over and over but forgot it all*". She was not able to remember all the steps for money transfer for her literacy problems. Similar experiences were shared by rural participants struggling to remember the process. Several participants with limited literacy indicated difficulty recognizing letters on the device because of low-literacy. Additionally, during our research, it was found that several mobile devices do not support Bangla as the device language. The users of those devices memorize the activity flow and words to perform tasks which often results in errors.

4.1.5 Knowledge of MFS among the Users. During the study, participants displayed a varying level of knowledge and familiarity with MFS in general, and the features/benefits available in different MFS products. Some respondents indicated they know MFS as "*Sending money with bKash*". Many of our participants informed us that they are aware that MFS products provide interest/profit [29] on the money kept in their accounts. Some respondents let us know that they are unaware of any such benefits.

4.1.6 Unwillingness to Use MFS- Lack of Trust. Many participants displayed a lack of trust as a force for their unwillingness to use an MFS product. Some respondents indicated that their distrust in keeping money in an MFS account stems from the belief that MFS providers unnecessarily or abruptly charge their users or have additional cuts. Some participants let us know that their lack of trust derived from the experience of "*bKash frauds/scammers*" [10] who call bKash users in disguise as bKash officials and ask for money. The responses reflect the commonalities for the lack of trust among users: perception of unnecessary charges and scammers.

The discussions revealed the requirement for design specifications addressing marginal communities along with the fact that the majority of these communities use featurephones or basic phones that are not smartphones, often without access to the internet. Moreover, the communities relied on their own methods to address their limited literacy or lack of literacy for regular phone usage. There was a clear requirement to explore further and find solutions to make money transfer processes easier.

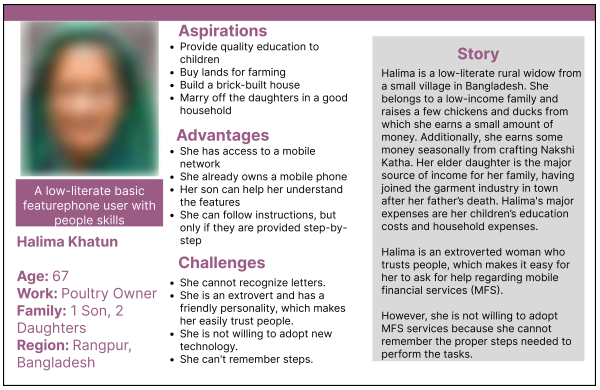
4.2 Design Sprint

These requirements guided us towards conducting a design sprint consisting of researchers and professionals from the industry and academia. The participants were divided into three groups. The individual groups were representative of the marginal communities of consideration - which included low-literate communities, communities facing social prejudice (e.g., transgender, indigenous community), and visually impaired communities. The design sprint took place online to limit in-person contact, considering the rise in the number of COVID-19 cases. The week-long sprint was divided into five phases and was conducted within a week (5 working days).

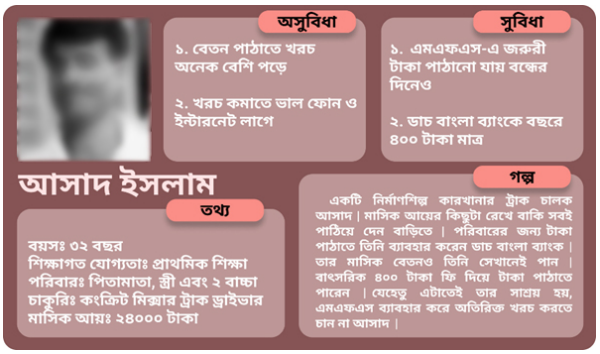
4.2.1 Day 1 - understand and define. The first day started with discussing the target user base in each group. Each group studied the target community's background, discussed the common issues, and tried to understand their challenges. After initially defining the problems, the groups mapped the initial sketch of what the possible solution could be - this helped the groups to stick to the idea and choose a realistic goal within the defined challenge.

4.2.2 Day 2 - ideate. On Day 2, during the ideation phase, participants in each group were tasked with selecting a persona from the Phase-I study (Section 3.2.1 & 3.5.1) or imagining a new one, to ensure that the personas together represented a diverse group in terms of age, gender, profession, income level, and family members. The participants gathered necessary information about their selected personas from the Phase-I study findings and worked on exploring their possible advantages, disadvantages, and barriers to adopting technology. This process led to the development of possible stories for the personas. Figure 1 shows some of the persona designs created during this phase.

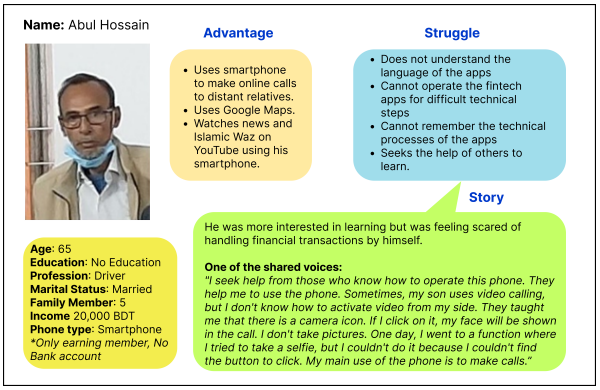
4.2.3 Day 3 - decide. On Day 3, the participants focused on decision-making by considering different personas who face technology usage challenges in rural and urban regions. For instance, one persona was a rural mother whose family members work in the city and support her financially (Figure 1a), inspired by a garment worker from our Phase I study (Section 3.2.1 & 3.5.1) who regularly sends money to her mother. Other personas included an indigenous community member who faces social barriers and cannot operate mobile phones using their local language and a professional driver who sends money to his family through banks to avoid fees (Figure 1b). During this phase, the participants discussed how symbols could improve the accessibility of featurephones and how to design a minimalistic activity flow. The discussions led the participants to develop flowcharts for performing different functionalities using MFS. These flowcharts were organized by the available task options, task steps for each option, feelings users might feel while performing a task, and possible ways to improve the steps. For example, if a user wants to perform a transaction using MFS (Figure 2), there are two options available, Personal Account Operation or Agent Banking. Using Personal Account Operation, the user must login by providing a PIN, select the Send Money option, input the recipient's number & amount, confirm by entering the PIN, and then tap Send. Using Agent Banking, the user must visit an agent shop, provide the recipient's number, pay to the agent in cash, and then get confirmation of the transaction from the agent. The process of performing these tasks can create mixed feelings among different users based



(a) Persona of a rural mother



(b) Persona of a professional driver



(c) Persona of an urban driver

Figure 1: User Persona Designs

on factors such as the issues they face, their frequency of use, and their level of literacy. Challenges and complexities like these were presented by the participants through different flowcharts in this session and some recommendations were made that might facilitate the user in performing these tasks. Table 2 illustrates the variations in steps, feelings, and ways of improvement for each persona.

4.2.4 Day 4 - prototype. The participants designed prototypes in groups during this phase considering the flowcharts and persona designs developed on Day-2 and Day-3 (Section 4.2.2 & 4.2.3). The

Table 2: Uncovering Diverse Perspectives: Exploring Task Variations, Emotional Responses, and Improvement Opportunities across Personas

Task Execution Insights	Task Options (Cash In/ Cash Out)				
Steps	1. Ask for a break 2. Go to an agent 3. Stand in a queue	1. Ask for a break 2. Go to an agent 3. Get agent's number	1. Share the number with a family members 2. Ask MFS agent 3. Get the proof of Cash In	1. Find out who can fix the issue with Login 2. Fix the issue 3. Get the work done by someone else	1. Find out if it is a fraud 2. Not sure where to ask and verify 3. Follow up with a complaint
Feelings	1. Annoyed 2. Anxious 3. Tired	1. Worried 2. Tired 3. Fear of making mistakes	1. Fear of making mistakes 2. Anxious 3. Satisfaction	1. Annoyed 2. Anxious 3. Tired	1. Fear 2. Anger 3. Frustration
Possible ways to improve the Task	1. Reduce dependency on others	1. Getting a personalized service	1. Reduce the service time	1. One stop service	1. Education and awareness on possible fraud cases 2. Video tutorials

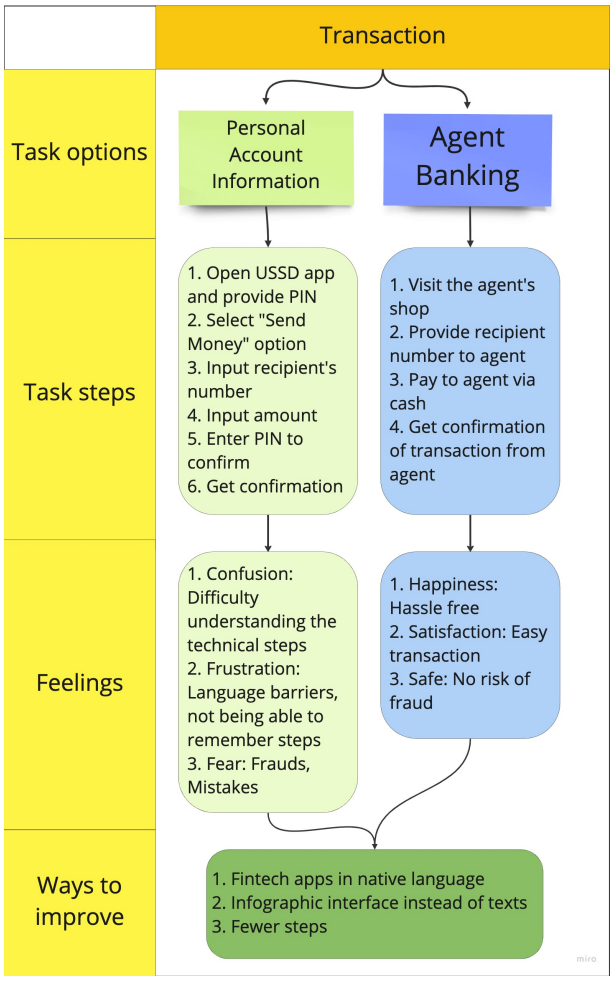


Figure 2: From Start to Finish: Navigating Transactional Tasks with User Experience and Identifying Opportunities for Improvement

participants used different tools and applications to design the prototype e.g., Figma, Adobe XD, Microsoft Paint, Keynote, etc. Their prototype consisted of probable design solutions for people with varied socio-economic statuses and literacy levels. For example, participant P1 suggested adding a complete visual representation and a voice-based approach for low-literate people who recognize symbols only. Another participant, P2, suggested designs with visuals of the amount of money. This way, the users can count their money in real-time from the system and calculate the amount of money they will exchange. He suggested the designs for people who can read Bangla only. Participants P3, P4, and P5 took a more written approach to the designs. The minimalist applications showed carrying out easy steps of transactions in Bangla. Lastly, P6 suggested simplifying designs for the low-literate community.

4.2.5 Day 5 - test, validate and learn. At the end of the week, the participants joined an online video call to present their prototypes in groups. Each group presented its prototypes while other groups scrutinized the designs, pointing out the strengths and weaknesses of each prototype. Some of the prototype designs are presented in Fig. 3. During this phase; the researchers also identified the variations of icons, layouts, and symbols across different platforms - which brought up the conversation of app-store-enabled KaiOS featurephones.

However, on the last day, the discussion with the researchers and participants based on the pilot study and the design prototypes made in the design sprint revealed an immediate requirement to address low-literate communities initially, as these communities have initiated MFS usage. Hence, we designed a study to identify the challenges faced by button phone users and better understand the design space. The rest of the paper discusses the work undertaken in this research, focusing only on low-literate communities.

4.3 A Design Probe for Featurephones

Section 2.1 illustrates that textual interfaces are inaccessible to low-literate users, and they face troubles while scrolling, understanding softkey functionalities, and difficulties in hierarchical navigation. Some studies also suggest using representational images in navigation and replacing texts with graphics as much as possible, keeping the interface simple. Additionally, our studies in Phase I (Section 4.1) reinforce the previous works that low-literate users depend on others to use mobile phones due to their limited literacy and face difficulty recognizing letters and memorizing the activity flow and keywords to perform tasks.

These facts inspired us to explore the icons, screen layout, keypad interactions, and activities of low-literate users in featurephones. We designed two tasks to better understand the featurephone design space: Task 1 - Interpreting icons and Task 2 - Performing activities. Both tasks were divided into three levels - basic, intermediate, and advanced. The division was made by comparing basic non-feature and featurephones' functions. The basic level included icons and activities of apps in every phone, for example, Call, Messaging, Contacts, and Call logs [5]. The intermediate level included apps that do not require internet connectivity and are usually found in featurephones with lower capacity. The advanced level included comparatively complex apps in both activity and operation hierarchy.

(a) Design 1: Login (b) Design 1: Home

(c) Design 1: Send Money (d) Design 1: Confirmation

(e) Design 1: Success (f) Design 2: Login

(g) Design 2: Home (h) Design 2: Balance

Figure 3: Various Designs Proposed in the Design Sprint

All the participants in this phase were active button phone users. Half of them had experience using built-in mobile apps, e.g., Call,

Messaging, To-do list, Calculator, Radio, etc., while the rest of the participants had no prior experience, and their mobile usage was limited to phone calls (Incoming and outgoing) only. The sessions were conducted at their workplace to encourage participants to think and perform the tasks comfortably. The participants performed the tasks in two one-to-one sessions, each lasting 20-25 minutes. The discussion was conducted in the participants' local language (Bangla) and was audio-recorded with their consent. Additionally, one researcher was constantly noting down their non-verbal cues, particularly the hand gestures of the participants for each response, to interpret the feedback better. For both Task-1 and Task-2, the researcher prompted participants with clarifying questions about their perception and performance. The observational notes, interview feedback, and audio recordings were analyzed to derive qualitative insights. The extracted insights were used to generate an effective user experience-based solution.

4.3.1 Task 1 - Interpreting icons. Icon creates the first impression of an app among users, and its design plays a crucial role in triggering the interest of users [35]. The objective of this task was to identify how the users perceive the app icons and generate qualitative insights that could help us design accessible graphical icons and symbols. Twenty-seven app icons were color printed on A4-sized papers and presented to the participants. Participants had to provide verbal explanations of what they understood by observing those icons.

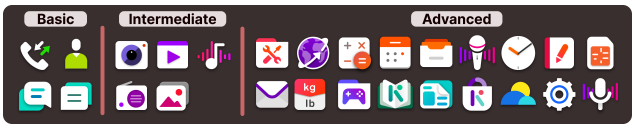


Figure 4: Featurephone App Icons Used in the Study © Kai OS Technologies [4]

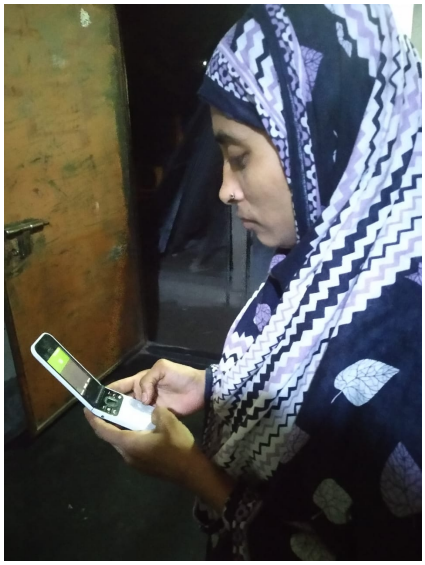
Figure 5: User Interpretation of App Icons (App icons are on the left © Kai OS Technologies [4], and their real-world representation perceived by the users are on the right)

4.3.2 Task 1 - Findings. The findings of this task broadly concern the graphics of the featurephones and can be grouped into a single category, Graphical Icons.

Graphical Icons - Icons and logos are alternatively used in button phones to indicate activities to users in a simplistic manner. These graphical objects play a crucial role in user experience. Although icons are supposed to convey a meaningful message to the users, it was found that many of the icons are used as pointers for some activities, as presented in Fig. 5. Six of the ten participants did not know the implicit meaning of the *Contacts* icon, and five of them failed to enunciate the *Music* and *Gallery* icon. One of the participants described the *Contacts* icon by saying, "*This is a picture of an invisible man; clicking it shows the numbers saved in this phone*". When asked about their recommendations about the icon, the participant pointed to the icon of the *Notes* to be used as the *Contacts* icon. "*Something that saves the number should have the picture of numbers or notes; why should it have a picture of people*", said one of the participants. None of the participants were found to be familiar with music note icons. A participant, without having any clue about the musical note icon of the *Music* app, questioned, "*Why do I need to select the picture of a spoon to listen to music? - there should be a picture of a sound box instead of this*". The participant compared the music note of *Music Store* with spoons (Figure 5a); they described the picture as two spoons joined with a metal rod at the top (Figure 5b). The responses were slightly different for different devices, as these devices run on different operating systems. Though some were unsure about icon meanings, it was observed that they tend to memorize these icon images to perform certain tasks.

4.3.3 Task 2 - Performing activities. This was a hands-on session where participants demonstrated their ability to perform various activities within mobile apps live in front of the researchers. Thirty-five sub-tasks were created for three levels of activities. Only built-in, pre-installed (apps installed by device manufacturers) and a few network operator-specific USSD apps were chosen for this task. The researchers went through each app and analyzed all possible general operations of those apps, which were then listed as sub-tasks. Participants had to pass the successive levels to advance to the next levels, e.g., a participant would need to pass at least half of the sub-tasks of the basic level to proceed to the intermediate level. The basic level included making calls, saving a contact in the phonebook, sending a text message, etc. The intermediate level was limited to Radio, Music, Videos, etc. The Advanced level activities included using the calculator, scheduling an alarm, and using MFS

(a) A Male Participant Performing an Activity



(b) A Female Participant Performing an Activity

Figure 6: Participants Performing Different Activities on featurephones.

account balance using USSD. The tasks were performed with two featurephones, a phone which the participant was currently using and the other one provided by the researchers. Two different devices were used to measure the difference factor in usage between the two devices. Participants had to perform the activities on their own. The researchers guided participants at different stages with hints upon request in performing the functionalities with which they were unfamiliar. The researchers closely monitored their activities and noted the duration and finger movements for each task.

Table 3: Different Tasks Designed for Participants.

Category	Interacting App	Activity
Basic	Call	Dial a number using keypads and make a call.
		Select a number from contacts and make a call.
		Receive a call and switch it to the loudspeaker.
		Navigate to call history and distinguish incoming and outgoing calls.
		Navigate to call history and read call details (Duration, time, call type).
		Dial the mobile phone operator code to check airtime balance
	Message	Navigate to messages and read one
		Type and send a message to a number
	Contacts	Navigate to contacts and find a contact from the list
		Search for a contact using the search bar in the Contacts app
		Save a number in the contacts
Intermediate	Radio	Navigate and play the radio
		Change channels using the D-pads
	Camera	Take a picture
		Use zoom in and zoom out in the Camera app
		Record a video
	Gallery	Navigate and view photos
	Video	Navigate and view videos
	Music	Play music loaded into phones storage
Advanced	File Manager	Navigate to downloads/wallpaper folder
	Clock	Set a different time
		View clock and set an alarm
		Choose time format between 12 and 24 hours
	Calculator	Derive the sum of two numbers
	Browser	Open browser and navigate to a webpage
	Calendar	Open calendar and check dates
	Mail	Open and check OTPs sent in email
	Notes	Take a note
	Sim Toolkit	Navigate to toolkit call forwarding settings
	Weather	Check weather conditions
	Settings	Navigate to settings and control display settings
	Audio Recorder	Start recorder and play the recorded audio
	Unit Converter	Convert cm to inch or vice versa
	Facebook	Open Facebook and browse feed
	Whatsapp	Open Whatsapp and make a call

4.3.4 Task 2 - Findings. The findings of Task 2 can be grouped into the following categories :

(1) Keypad Choices
(2) D-pad Preferences

These categories are discussed in detail below:

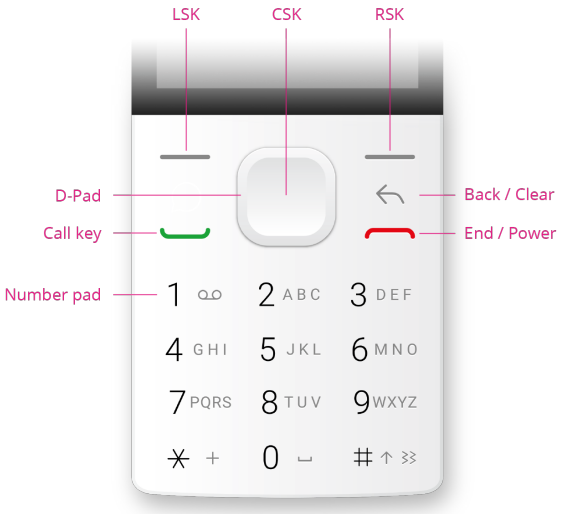


Figure 7: Featurephone Keypad Representation © Kai OS Technologies [4]

Figure 8: D-pad with Direction Signs - Model Doro 7050 © Doro AB[3]

(1) Keypad Choices:
A user's first interaction point in a button phone is its keypad. Every participant held the phone and instinctively pressed the keys with their thumb to perform activities. A few of the tasks had a couple of keys that did the same function for a particular application; it was observed that participants inherently chose the keys which are easy to reach by their thumb. When asked about key preferences, none of them mentioned any key preferences. In most cases, the stable position of the thumb was at the *Center* softkey (CSK). The participants tend to press buttons within 0.5-0.75 cm (1cm for Qwerty phones) from the *Center* softkey. Some of the participants assumed the *Call key* (Green) and *End/ Power* (Red) buttons as softkeys (selector buttons that represent the bottom-most left and right on the screen) (Figure 7) in case of performing tasks that were new to them. For example, when selecting *Back* and *Channels* in the phone **Radio** app, some participants tried to use the Green and Red buttons for the tasks. One of the participants said, *I thought Green means yes, and Red means no in phones - that's how we tell the mobile if we want to take a call or reject*". Four of the participants had the same conception of those two colored buttons. When testing with different devices, it was found that highlight selection on phones which had directions printed on D-pad was easier as the participants could easily understand the directions. Participants preferred mobile devices like Doro-7050 (Figure 8), which has directions indicated on D-pads.
(2) D-pad Preferences: D-Pads are common in all models of both basic and smart featurephones. *Up*, *Down*, *Left*, *Right* - these four keys are collectively called D-Pads in button phones. These buttons are used to move the highlights on items in a list or grids, switch tabs, and as cursors in some applications. Three of the participants were seen to be reluctant to use the *Left & Right* D-pads. These observations were made when they moved the highlight on apps from the App Menu without using the *Left & Right* D-pads. Similar observations were made when they were unable to switch radio channels and had no clue about browsing gallery pictures using the *Left & Right* D-pads. A participant mentioned, "*I use Up and Down keys to navigate call histories as well as the menu; I know these are some keys (Right and Left D-pads), but it has no use to me.*" Similar explanations were provided by the other two participants. Additionally, four participants were seen to be preferring the use of *Left* softkey for deleting letters one by one instead of using *Left & Right* D-pads to move the blinking cursor for text corrections. These issues prevailed for participants whose phone usage was limited to making and receiving phone calls.

4.4 Design Guidelines

The probe sessions enabled us to identify the key issues of low-literate users in using button phones. The study refined our goals and provided us with finite directions. Based on the directions, three design guidelines were formulated and followed in the prototype development process.

4.4.1 D1: Less key involvement, fewer navigation errors. Activity navigation is best when it is well connected with the display and the keys. Several studies suggest keeping the navigation as linear as possible [24, 49, 50]. Our probe study takes this recommendation forward by identifying that low-literate users' navigation (linear) using D-pads is complex compared to apps with simple softkey interaction. The softkeys are the top-left and top-right keys located right below the display. They represent the soft highlight at the bottom of the screen (Figure 8). It is also found that colored keys which are used to accept and reject phone calls, i.e. Call key (Green) & End/ Power key (Red) are assumed as decision-making keys by the low-literate users when interacting with apps - which is a novel finding in the design space of featurephones and has the potential to replace the use of other keys, ultimately reducing key involvement.

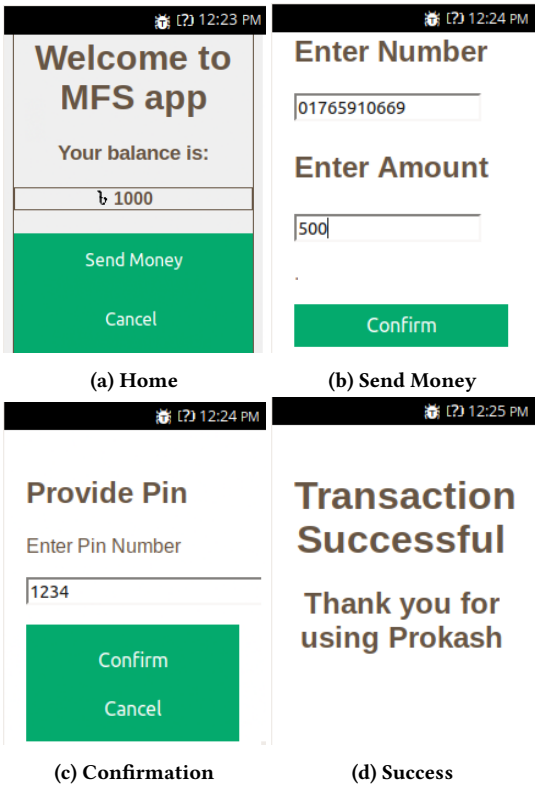
4.4.2 D2: Vertical scroll, minimum D-pad involvement. D-pads are deemed very useful in switching highlights, especially the *Up & Down* keys. But the participants in the probe session demonstrated that apps which used the *Left & Right* D-pads (e.g., switching radio channels, browsing gallery pictures) were tricky to operate. Additionally, the participants were found to prefer softkeys over *Left & Right* D-pads. These findings suggest that apps should be designed with minimal D-pad involvement - Scrolling views should be vertical, and left-right D-pads should not be used unless it can't be avoided.

4.4.3 D3: Task-relevant icons, guided towards activity completion. Icons are the first impression in apps. Although icons are well-designed for most apps, their meaning and indications vary depending on the geography, culture, and the user's literacy level. An ideal icon should enable users without any prior experience to get a fundamental idea of the concerned activity. Prior studies suggested using fewer texts and graphics and visual representations as much as possible [26, 46, 52, 56]. Our work in the probe session strengthens previous works and takes one step further by analyzing the perceived value of low-literate users for different icons in featurephones. It explores the fact that low-literate users

often try to relate icons with their surroundings - and validates the fact that graphical objects for low-literate communities need to be designed differently from the regular ones in such a way that users can relate the activity with their surroundings, and get a message which could guide or provide a hint towards the next step of an activity.

4.5 Prototype Development and Testing

After formulating a clear design guideline from previous works and our findings, we attempted to develop a KaiOS-based application prototype. In our first attempt at KaiOS development, we faced a major roadblock in integrating the Bangla language. KaiOS was an emerging platform with limited developer support and community resources. These blockers convinced us to reconsider developing the app without local language support and reduced number of features - which led us to build our first application prototype. But as our study on the first prototype suggested that local language support is a crucial requirement, we started working on the app again and built a new prototype. The details about both prototypes are described below.



(a) Home **(b) Send Money**

(c) Confirmation **(d) Success**

Figure 9: First Application Prototype Screenshots

4.5.1 First Application Prototype. The initial version of the developed KaiOS Smart Featurephone app focused on the derived functionalities from the design sessions and focused less on the aesthetics of the application. Figure 9 shows a snapshot of the first prototype. A major roadblock to developing the prototype was integrating local language support (Bangla) into the app. Initially, it was thought that local language support was necessary for this app since the target user base is from a low-literate background and the local (Bangla) language is more accessible than English. However, considering the difficulty of integrating the local language support, the language was initially limited to English. A user study was conducted to identify the extent to which the users can understand the app functionalities without local language support. The researchers recruited five participants through purposive sampling. The sessions were conducted as one-to-one interviews; each lasted for about six to eight minutes. The participants were briefed about the purpose and objective of the study before the study and were provided a KaiOS-powered mobile device for testing the prototype app. The sessions were audio recorded with their consent and were later transcribed to analyze the relevant findings.

The findings in this short study concluded that only participants with sufficient exposure to technological devices could understand the app functionalities in English, and the rest of the participants seemed to struggle while navigating through the app.

The next iteration of the prototype app (Figure 10) integrated local (Bangla) language support and underwent significant design changes to cater to the needs of the target user group. Afterward, a user study on the new prototype was conducted. The study result showed that users are better off using updated application versions with local language support than only English Language support, as the end-users understand the functionalities better and gain more trust.

4.5.2 Final Application Prototype. Figure 10 highlights the prototype app with local language (Bangla) support, illustrating the simplicity of the derived design. The app, named *Prokash*, has six screens (activities) in total:

- *Login* screen (Figure 10a)
- *Statements* screen (Figure 10b)
- *Input Number* screen (Figure 10c)
- *Input Amount* screen (Figure 10d)
- *Confirmation* screen (Figure 10e)
- *Status* screen (Figure 10f)

An overview of the design rationale for the app is described below.

(1) *Activity Selection and Navigation Using Left and Right softkeys, Up and Down D-pads*: All of the screens require the use of *Left & Right* softkeys to navigate in between activities. The use of the *Center* softkey is disabled in the app. The user can exit the app directly using the *End/ Power* key. On the D-pad, only the *Up & Down* keys are functional, enabling vertical highlight switching. The use of *Left & Right* keys in D-pad is disabled in the app to avoid complexity for users.
(2) *Rightward Navigation*: Throughout the whole design, the *Green* and *Red* colors on keys have been considered as decision-making keys. This design consideration was adopted to provide a rightward navigation experience where the *Green Right* softkey would always indicate moving forward, and the *Red Left* softkey would indicate going back. This color scheme was chosen as the discussion from the participants in various study phases revealed the target end-user mental

Figure 10: Final Application Prototype

model of associating *Green* color with *Accept* and *Red* color with *Reject* choices.

(3) *Graphical Icons*: Graphical icons were used throughout the app to aid low-literate users in remembering the icons as a mnemonic for providing inputs. For example, a graphical image of a button phone was used where users needed to input the mobile number of the recipient, and a money icon was used to represent the transfer amount. In the header section, several icons have been used to help the users remember the flow of the app. Additionally, *Cash In* and *Cash Out* have been indicated with inwards and outwards arrows similar to the incoming and outgoing call arrows (action icons) of basic and featurephones, as our findings suggest that low-literate users are familiar with call log action icons.

(4) *Use of Mixed Numeric Values*: Both Bangla and English numbers have been used in the app to make it more accessible. As the previous studies suggest, numeric literacy is more common among low-literate users [7], and our study indicated that low-literate users are comfortable typing numbers in English, but they do the calculation of their expenses in the local language (Bangla). Hence, we used Bangla numbers in the *Statements* screen (Figure 10b) and English for typing phone numbers in the *Input Number* screen (Figure 10c).

A study was conducted with end-users from the targeted marginal communities to evaluate the prototype to determine if they could effectively use it. Twenty-three participants were recruited for the study through snowball sampling. The study included six focus group discussions where 1-4 participants joined the sessions. They were provided with Nokia 2720 Flip featurephones running KaiOS with appstore support for running the target prototype app. These sessions were audio-recorded with participant consent. At the start of the session, participants were given a brief idea and a hands-on demo of the app, including using different features. In addition to the audio recordings, a study coordinator took observational notes. At the end of the hands-on sessions, participants did a verbal walk-through of each feature and reported their experience.

4.5.3 Findings. The observational notes, discussion feedback, and audio recordings were analyzed and then grouped as follows:

(1) *Simple Screen Navigation Using Softkeys*: All participants found the app relatively easy to use after watching a hands-on demo - which validates prior works' recommendations of incorporating audio instructions [7, 46]. As mentioned by a participant, he used to rely on someone else to send money from his family. However, he is confident that he can do it independently after being trained on how to do it. The softkey names guided the participants very well, except for a few. Most participants couldn't understand the meaning of *Home*, which could be pressed using the the *Right* softkey in the *Success* screen (Figure 10f). But all of them could exit the app by pressing *Home* when the researcher described it. Therefore, an in-app product demo can be suggested to be incorporated into the app to increase user engagement and satisfaction.

(2) *Understanding Technical Terms*: Nine participants understood the English terms, which are very popular among MFS users. Terms such as *Balance*, *Cash-in*, *Cash-out*, *Contact*, and *PIN* are popular among the existing MFS apps in the country. However, some participants found some of the terms hard to relate to. Some of the participants needed extra guidance when performing activities involving these terms, e.g., a participant needed an explanation of the term *PIN*. A *PIN* is also used interchangeably with the term *Secret Number*. It was found that many preferred the term *Secret Number* instead of *PIN* and *Password* because it was made familiar to them by existing MFS providers through mass advertising.

One of the participants said, *"TV advertisements suggest not to share the Secret Number"*.

(3) *Non-scrollable*: This was the only criterion where the app looked most useful. scrolling was disabled. All of the participants used *Up & Down* D-pads for switching highlights between input fields. The simple interface enabled the *Right & Left* D-pads only to be used to move the blinking cursor inside the input fields. As the app was designed to fit the entire layout within the phone display, no horizontal or vertical scrolls were needed. When asked about other scrollable apps, the participants seemed to like the design. One of them said, "*Yes, it is easy to use without the scrolls; I don't like to use those (Right and Left D-pad) keys as it scrolls to different levels for different apps*".

(4) *Know Your Customer (KYC) verification*: This was not implemented in the developed app and fell beyond the capability of some button phones (e.g., phones which don't have a camera). However, the participants asked us how they would register on the app. In one session, a participant who is an existing user of MFS suggested that the system should not require a National ID Card for signing up, given he has been unable to open an account of his own in a renowned MFS app. This reflects such requirements that create accessibility barriers for individuals.

(5) *Screen and session timeouts*: Screen timeouts were another concerning factor for the participants when using the app. They seemed to hurry in giving input, fearing session and screen timeouts. The prototype app didn't override the screen timeout defaults; hence, the users could perform the tasks set on their device (30 seconds on the device where the study was conducted). However, session timeouts were not integrated. Usually, session timeout is a security measure that automatically logs out the users after a certain period of inactivity. A participant recommended removing the session timeout to increase satisfaction.

(6) *Pricing Strategies*: Although pricing strategies fall beyond the scope of this study, it is worth mentioning that many participants recommended that the pricing should be lower than the existing products in the market to increase user engagement.

5 DISCUSSION AND FUTURE WORK

As Toyama [68] suggests - technology as a medium has the potential to empower marginal communities. Mobile Financial Services (MFS) - an already popular concept in developing countries [9, 40] around the world saw a great surge and opportunity during the COVID-19 pandemic. People across different communities - regardless of financial or literary status were forced to adopt digital transactions to limit the spread of the virus through currency note transactions. It enabled people to transfer money across great distances without physical travel to support business transactions or family needs. In developing countries where low-income/low-literate and marginalized communities have great barriers (such as bureaucratic processes, credit-worthiness, cost, and general mistrust) [40, 72] to access traditional banking services and credit cards - MFS has offered a great alternative to provide financial inclusion to these end-user segments. The extended pandemic period forced most non-marginalized end-user segments to learn to adapt to MFS usage. However, this study suggests that low-literate and marginalized communities had difficulties adapting to MFS due to device cost and design considerations. The study revealed the necessity of an easy-to-understand and easy-to-operate MFS interface for the low-literate participants while keeping the device and data costs within an affordable range for marginalized communities.

Contemporary research has shown how communities under consideration manage in unique ways to remember and access technology [7, 8, 65]. There are innovative solutions to support the community by showing the usage of symbols [64], voice [50], audio-visual interface [51], etc. The studies show diverse ways to increase technology access and engagement where the requirements must be human-centered. This research focuses on fintech operations for low-literate communities and evolved through a design and development process using the such human-centered intervention.

The current fintech services have evolved positively, showing a high penetration rate locally (in Bangladesh) and globally [11, 12]. In Bangladesh - the services are facilitated by a great distribution of agent shops across the country [13]. The question may arise whether the existing working system should be enhanced. The initial study on 86 participants shows how fintech has opened up opportunities for many while the fintech operational dependencies on agents, family members, or others have hampered the process. Technology here is an enabler towards empowerment, while the indirect mode of access might instill self-doubt and insecurity in its users, particularly for users who have been marginalized from technology usage, such as women [61, 62]. The improved design in the local (Bangla) language has the potential to provide the community under consideration with an easy-to-operate interface in affordable featurephones. Independent technology access is expected to support the empowerment of marginalized communities in a positive direction.

Current non-KaiOS featurephone solutions are mostly USSD based as most device manufacturers have not enabled application marketplaces. KaiOS has provided a breakthrough in this domain by providing marketplace support where independent applications can be deployed for users. This opened up opportunities for many to explore the area of user-friendly interfaces in low-cost featurephones. This work is one of them; the concept of the KaiOS marketplace was leveraged, and the possibility of financial applications for low-literate communities was studied. Future work can look at ways to develop applications with much more assistive technologies (e.g., voice instruction, in-app tutorial, hands-on training).

This work did not focus on design aspects other than a simple financial app. However, we believe there is an opportunity to explore more context-specific findings in other domains relating to the mobile use of low-literate communities. For example, music, agriculture, education, etc., each of these domains can bring new complexities along with their utilities for the low-literate communities. The socially and locally acceptable design, as presented in the South Asian context, often provides design recommendations covering various areas of interest. There have been design propositions specifically designed for communities [26, 46, 56] where regional context is taken into account. The studies have provided design guidelines for communities of interest. The generic design

framework [30] is helpful for a high-level view of a solution approach, while the actual design and development require the close engagement of the users.

Although our findings are based on studies conducted in Bangladesh, these can be scaled or applicable to other marginalized communities around the world as well. Appstore-supported smart featurephones, eg. KaiOS phones, are available and quite popular in regions like Africa where the literacy rate is low [54]. With local language support, these phones are impacting the lives of these underrepresented populations by helping with everything from their digital literacy to health [42]. Our design approach can be followed to develop a mobile financial services app for other marginalized communities taking regional context [1] into account, to bring them under the umbrella of financial inclusion.

The suitability of the KaiOS default theme for low-literate users through icon, image, and activity tests was explored in this work. However, this work did not focus on improving or building a new theme for low-literate users for now. For example, this work identified that *Settings* icon in KaiOS is often interpreted as a *Tractor wheel* by the participants, but a more suitable icon to interpret device settings as *Settings* was not identified through this study. These mobile systems and services are often designed without incorporating the voices of marginalized communities using technology in non-traditional ways. Future work can explore designing operating systems or building themes on top of it to enable marginalized communities to access mobile applications with ease and ensure social justice in the technology space.

6 CONCLUSION

Mobile Financial Services has enabled cashless transactions and fueled economic growth. However, as the number of services is increasing, traditional money transfers are becoming obsolete. This brings forth a new challenge for the low-literate communities within a country. Prior research has identified these issues in their regional context and provided many recommendations and solutions. This research demonstrated the potential of Smart Featurephones with appstore support in promoting financial inclusion within a country. We explored the design space of featurephones in the context of MFS and provide some design recommendations for button-phone-based applications to march toward financial inclusion for marginalized communities. Although this work is in no way exhaustive - we believe that this research has the potential to elicit design considerations for marginalized communities to provide them with essential mobile services, including and beyond digital money, while lowering the financial burden of accessing such digital services.

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APPENDIX

A LABELING OF EACH FUNCTION IN THE ENGLISH LANGUAGE FOR THE LOCAL (BANGLA) VERSION OF THE PROTOTYPE MADE IN THE DESIGN SPRINT

(a) Design 1: Login (b) Design 1: Home

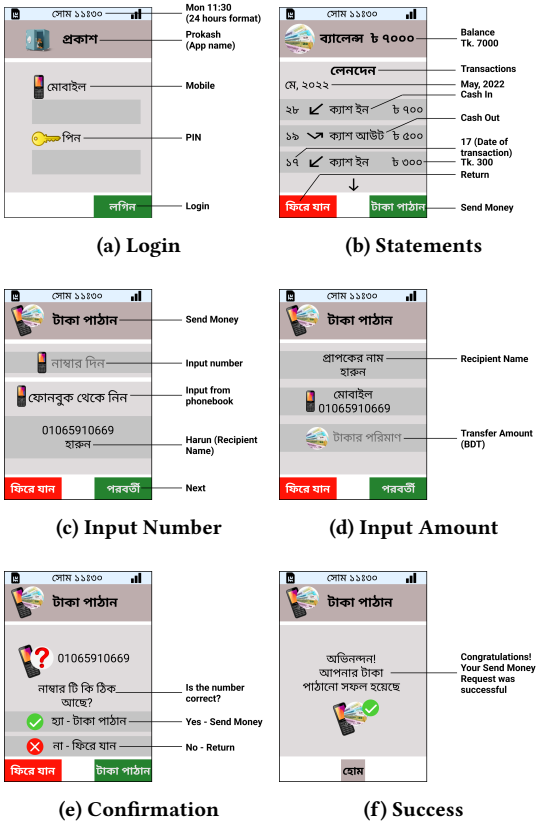
(c) Design 1: Send Money (d) Design 1: Confirmation

(e) Design 1: Success (f) Design 2: Login

(g) Design 2: Home (h) Design 2: Balance

Figure 11: English Translation for the Local (Bangla) Version of the Prototype Made in the Design Sprint

B LABELING OF EACH FUNCTION IN THE ENGLISH LANGUAGE FOR THE LOCAL (BANGLA) VERSION OF THE FINAL APP



(a) Login (b) Statements

(c) Input Number (d) Input Amount

(e) Confirmation (f) Success

Figure 12: English Translation for the Local (Bangla) Version of the Final App

C LABELING OF THE PERSONA IN THE ENGLISH LANGUAGE

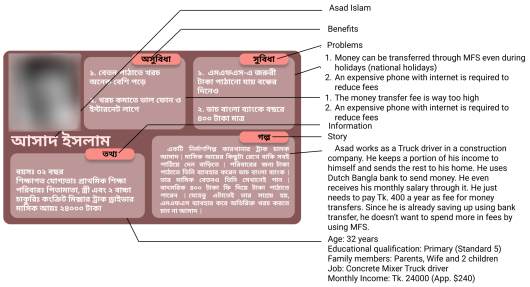


Figure 13: English Translation for the Persona Design Done in Bangla