# USABILITY AND ACCESSIBILITY ASSESSMENT OF MOBILE FINANCIAL SERVICE APPLICATIONS IN BANGLADESH

**MD LUTFUL KABIR**

**M.Sc. Engineering THESIS**


**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**
**MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY**
**DHAKA, BANGLADESH**

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**MD LUTFUL KABIR (SN. 0420140014)**

**A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Computer Science and Engineering**


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By

MD LUTFUL KABIR (SN. 0420140014)

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# USABILITY AND ACCESSIBILITY ASSESSMENT OF MOBILE FINANCIAL SERVICE APPLICATIONS IN BANGLADESH

## DECLARATION

I hereby declare that the study reported in this thesis entitled as above is my own original work and has not been submitted before anywhere for any degree or other purposes. Further I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged and/or cited in the reference section.

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## ABSTRACT

Mobile Financial Service (MFS) refers to the use of mobile phones to access and execute financial transactions. In recent times, the rapid proliferation of information technology in daily life has led to a significant increase in the use of MFS applications in Bangladesh. Consequently, it is essential for MFS applications to be highly usable and comprehensible to all types of users. However, only a limited number of existing studies have focused on designing, developing, and evaluating MFS applications to enhance their usability, intuitiveness, understandability, and accessibility, particularly within the context of Bangladesh. Therefore, the objectives of this research are twofold: firstly, to evaluate the usability and accessibility of major MFS applications commonly used in Bangladesh, and secondly, to explore the applicability of design principles for enhancing the user interfaces (UIs) of MFS applications. To achieve these objectives, the usability of three MFS applications (bKash, Nagad, and Rocket) used extensively in Bangladesh was evaluated through heuristic evaluation, semiotic evaluation, and empirical studies. The outcomes of the usability evaluation revealed numerous usability issues for each application, provided detailed insights into the intuitiveness of various interface elements, and highlighted usability concerns from the users' perspective in terms of effectiveness, efficiency, and satisfaction. Additionally, an accessibility evaluation was conducted following the Web Content Accessibility Guidelines (WCAG 2.1), which identified several accessibility problems. Subsequently, a set of design considerations were proposed and a prototypical solution was developed based on these considerations. Finally, a comparative user study was undertaken to assess the usability and accessibility of the selected MFS applications and the developed prototypical UIs using the System Usability Scale (SUS) approach. The SUS evaluation demonstrated that the proposed design solutions offered improved usability and accessibility compared to existing MFS applications.

# সারসংক্ষেপ

Mobile Financial Service (মোবাইল আর্থিক সেবা) সংক্ষেপে MFS (এমএফএস) দ্বারা আর্থিক লেনদেন অ্যাক্সেস এবং সম্পাদনের জন্য মোবাইল ফোনের ব্যবহারকে বোঝায়। সাম্প্রতিক সময়ে আমাদের দৈনন্দিন জীবনে তথ্য প্রযুক্তির ব্যাপক বিস্তারের ফলে বাংলাদেশে এমএফএস অ্যাপ্লিকেশনের ব্যবহার উল্লেখযোগ্যভাবে বৃদ্ধি পেয়েছে। এমতাবস্থায়, সব ধরনের ব্যবহারকারীদের জন্য এমএফএস অ্যাপ্লিকেশনসমূহ অত্যন্ত ব্যবহার উপযোগী এবং বোধগম্য হওয়া অপরিহার্য। উল্লেখ্য যে, খুব সীমিত সংখ্যক বিদ্যমান অধ্যয়ন/গবেষণা এমএফএস অ্যাপ্লিকেশনসমূহের ব্যবহারযোগ্যতা, স্বজ্ঞাততা (Intuitiveness), বোধগম্যতা এবং অ্যাক্সেসযোগ্যতার মানোন্নয়নের জন্য ডিজাইন/নকশা প্রণয়ন, নকশার পরিবৃদ্ধি এবং মূল্যায়নের উপর দৃষ্টি নিবদ্ধ করেছে, বিশেষ করে বাংলাদেশের প্রেক্ষাপটে। অত:পর, এই গবেষণার উদ্দেশ্য মূলত: দুইটিঃ প্রথমত, বাংলাদেশে ব্যবহৃত প্রধান প্রধান এমএফএস অ্যাপ্লিকেশনগুলির Usability (ব্যবহারযোগ্যতা) এবং Accessibility (অ্যাক্সেসযোগ্যতা) মূল্যায়ন করা; এবং দ্বিতীয়ত, এমএফএস অ্যাপ্লিকেশনগুলির ইউজার ইন্টারফেসসমূহ উন্নত করার জন্য ডিজাইন নীতিসমূহের প্রয়োগীয়তা পরীক্ষা-নিরীক্ষা করা। এই উদ্দেশ্যগুলি অর্জনের জন্য, বাংলাদেশে ব্যাপকভাবে ব্যবহৃত তিনটি এমএফএস অ্যাপ্লিকেশনের (বিকাশ, নগদ এবং রকেট) Usability (ব্যবহারযোগ্যতা) Heuristic Evaluation, Semiotic Evaluation এবং User Study Evaluation এর মাধ্যমে মূল্যায়ন করা হয়েছে। Usability Evaluation (ব্যবহারযোগ্যতা মূল্যায়ন) এর ফলাফলসমূহ প্রতিটি অ্যাপ্লিকেশনের জন্য অনেকগুলি ব্যবহারযোগ্যতার সমস্যা চিহ্নিত করেছে, বিভিন্ন ইন্টারফেস উপাদানগুলির স্বজ্ঞাততা সম্পর্কে বিস্তারিত অন্তর্দৃষ্টি প্রদান করেছে; এবং 'কার্যকারিতা', 'দক্ষতা' এবং 'সন্তুষ্টির' বিবেচনায় ব্যবহারকারীদের দৃষ্টিকোণ থেকে ব্যবহারযোগ্যতার উদ্বেগগুলিকে বিশেষভাবে উপস্থাপন করেছে। এছাড়াও, ওয়েব কন্টেন্ট অ্যাক্সেসিবিলিটি নির্দেশিকা (WCAG 2.1) অনুসরণ করে একটি Accessibility Evaluation (অ্যাক্সেসিবিলিটি মূল্যায়ন) করা হয়েছে, যা বেশ কয়েকটি অ্যাক্সেসিবিলিটি সমস্যা চিহ্নিত করেছে। উল্লেখিত মূল্যায়নসমূহের উপর ভিত্তি করে এই গবেষণায় এমএফএস অ্যাপ্লিকেশন তৈরির জন্য এক সেট Design Consideration (নকশা প্রণয়নের জন্য বিবেচ্য বিষয়াবলী) প্রস্তাব করা হয়েছে এবং এই প্রস্তাবিত বিবেচ্য বিষয়াবলীর দিকে লক্ষ্য রেখে একটি প্রোটোটিপিকাল সমাধান তৈরি করা হয়েছে। অবশেষে, উল্লেখিত এমএফএস অ্যাপ্লিকেশনসমূহ এবং নতুন ডিজাইনকৃত প্রোটোটিপিক্যাল ইউজার ইন্টারফেজসমূহের তুলনামূলক ব্যবহারযোগ্যতা এবং অ্যাক্সেসিবিলিটি মূল্যায়ন করতে System Usability Scale (SUS) মূল্যায়ন পদ্ধতির মাধ্যমে একটি Comparative User Study (তুলনামূলক ব্যবহারকারী গবেষণা) পরিচালনা করা হয়েছে। এই মূল্যায়ন থেকে প্রমাণিত হয়েছে যে, প্রস্তাবিত ডিজাইন সমাধানগুলি বিদ্যমান এমএফএস অ্যাপ্লিকেশনগুলির তুলনায় উন্নত ব্যবহারযোগ্যতা এবং অ্যাক্সেসিবিলিটি প্রদর্শণ করেছে।

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AE | Accessibility Evaluation |
| ACM | Association for Computing Machinery |
| BTRC | Bangladesh Telecommunication Regulatory Commission |
| HCI | Human-Computer Interaction |
| HE | Heuristic Evaluation |
| ICT | Information and Communication Technology |
| MFS | Mobile Financial Service |
| POUR | Perceivability, Operability, Understandable, and Robust |
| SE | Semiotic Evaluation |
| SIM | Subscriber Identity Module |
| SLR | Systematic Literature Review |
| SUS | System Usability Scale |
| UCD | User-Centered Design |
| UI | User Interface |
| USE | User Study Evaluation |
| UX | User Experience |
| W3C | World Wide Web Consortium |
| WAI | Web Accessibility Initiative |
| WCAG | Web Content Accessibility Guidelines |

# CHAPTER 1
# INTRODUCTION

## 1.1 General

This chapter comprises of the thesis background, motivation and problem statement, thesis objectives, research methodology, thesis scope, and organization of the thesis. Firstly, it provides a brief discussion on the thesis background to introduce the thesis topic. Next, it highlights the motivation and problem statement of the thesis. Then, the thesis objectives are presented followed by methodological overview and scope of the thesis. Finally, the organization of the remaining chapters are described.

## 1.2 Thesis Background

Modern technology has become an overarching factor in our everyday life. The prevalence of COVID-19 from December 2019 to May 2023 has further increased the dependency of human race on the benefits of modern technology, particularly, on Information and Communication Technology (ICT). The world has gradually adapted to the changes evolved due to COVID-19. Although many business sectors have suffered seriously due to the impacts of COVID, ICT based business models have witnessed a major growth amidst this pandemic. People across the world have relied more and more on the benefits of ICT for accomplishing their routine jobs remaining at home. In the developing countries where banking facilities are not at everyone's doorstep and internet/online transactions are not that easy and accessible, percentage of educated people is low, people with low income group are afraid to go to the banks, Mobile Financial Services (MFS) have appeared as a blessing for these people which enabled them to do all necessary financial transactions quite easily from their own mobile phones or from a local agent who is available next to their doorsteps.

As per the guideline developed by Mobile Financial Services Working Group (MFSWG) (2013), Mobile Financial Service (MFS) is the use of mobile phones to access financial services and execute financial transactions. MFS is a step forward towards digital banking and cashless transactions encouraged by the Government of Bangladesh. At present, there are thirteen MFS providers in Bangladesh, of which, twelve are linked to Schedule Banks and one is a non-banking financial institution. These are: Rocket linked to Dutch-Bangla Bank Limited, bKash linked to BRAC Bank Limited, MyCash linked to Mercantile Bank Limited, mCash linked to

Islami Bank, Trust Axiata Pay (tap) linked to Trust Bank Limited, FirstPay SureCash linked to First Security Islamic Bank Limited, Upay linked to United Commercial Bank Limited, OK Wallet linked to One Bank Limited, SureCash linked to Rupali Bank, TeleCash linked to South-East Bank Limited, Islamic Wallet linked to Al-Arafa Islami Bank Limited, Tap `n Pay linked to Meghna Bank Limited, Nagad linked to Bangladesh Post Office which is a non-banking financial institution.

The effectiveness of an MFS dependents on few relevant factors as well, like availability of internet service and mobile network in the remote areas of the country, interoperability with different utility services, merchant payment gateways, financial institutions, and other online financial transaction facilities. All these factors are reflected in the operating system of the applications and the UI design of the applications. When a user opens an account in any of the MFS, he/she has to access that specific application for obtaining the desired services.

Usability and accessibility are two important quality aspects of any digital solution. Usability refers to the quality of a user's experience when interacting with products or systems, including websites, software, devices, or applications. Usability is about effectiveness, efficiency and the overall satisfaction of the user. Usability evaluation focuses on how well users can learn and use a product to achieve their goals and how satisfied users are with that process (Rusu et al., 2015).

Accessibility means the quality of being easy to approach, reach, enter, speak with, use, or understand. Mobile accessibility refers to making websites and applications more accessible to people with disabilities when they are using mobile phones and other devices. World Wide Web Consortium (W3C) Web Accessibility Initiative's (WAI) work in this area addresses accessibility issues of people using a broad range of devices to interact with the web, including: phones and tablets. The Web Content Accessibility Guidelines (WCAG) are organized by four main principles, which state that content must be POUR: Perceivable, Operable, Understandable, and Robust (Caldwell et al., 2008).

As of July 2023, approximately 198 million users are registered with 13 MFS providers in Bangladesh, a country with a population of 170 million, as many individuals maintain multiple MFS accounts. Rural people, including a significant number of women, have played a pivotal role in driving the growth of MFS. According to the information of Bangladesh Bank, almost half of the MFS accounts are actively in use (Parvez et al., 2015). In the last ten years, the number of MFS users have increased exponentially, making Bangladesh the largest MFS

market in the world (Dona et al., 2014). As such, the MFS applications in use must be highly usable and accessible so that people with diverse educational, social, and financial backgrounds can easily use and access these applications to receive the services efficiently. At present, out of thirteen MFS providers in Bangladesh, only three MFS companies hold more than ninety percent of the total market share (Parvez et al., 2015). Therefore, assessing the usability and accessibility of the major MFS applications in the context of Bangladesh is of great importance.

### 1.3 Motivation and Problem Statements

In 2011, Bangladesh Bank, the national bank of the country, issued licenses for MFS with a view to bringing the unbanked people into the formal financial sector and lead to a greater financial intermediation and contribution to the national growth. At present, Bangladesh is the largest MFS market in the world. Therefore, assessing the usability and accessibility of the most prominent MFS of Bangladesh is crucial for suggesting the ways to improve their acceptability among the mass population of the country.

Few studies have been conducted on the usability and accessibility of mobile applications in the recent past. For example, Acosta-Vargas et al. (2019) showed that the applications developed for monitoring air quality did not reach an acceptable level of accessibility as recommended by W3C, while Ballantyne et al. (2018) suggests that mobile applications could be accessible at the system level but remain largely inaccessible at the user level due to inaccessible design. Again, a number of studies have been conducted to evaluate the usability and accessibility of different web and mobile applications developed and used in the context of Bangladesh including mobile health, e-government websites, etc (Islam, Rahman and Islam, 2017; Islam et al., 2021; Baowaly and Bhuiyan, 2012). However, little research has been conducted in the context of Bangladesh that explore the usability and accessibility of the existing MFS applications.

Considering the diverse user groups in Bangladesh and for promoting the successful adoption of MFS applications by the varied user groups, the usability and accessibility of such existing applications are required to be assessed and also to explore the effectiveness following the usability and accessibility principles in designing User Interfaces (UIs) of an MFS application in the context of Bangladesh. Therefore, the *problem statements* could be formulated as follows:

- Number of studies have been conducted focusing on web and mobile application usability, with a gap in research on design, usability, and accessibility of financial mobile applications.
- In the context of Bangladesh, very few studies have been conducted on the usability and accessibility analysis of different mobile applications where the focus is mostly on their quality of service, comparison, and differences.
- No prior research investigates usability and accessibility of existing Mobile Financial Services (MFS) applications in Bangladesh in the perspective of UI design.

## 1.4 Thesis Objectives

This research aims to identify the usability and accessibility issues of the major MFS applications in the context of Bangladesh with a view to demonstrating the efficacy of implementing usability and accessibility guidelines in designing the UIs of MFS applications, thereby enhancing the overall usability and accessibility of the MFS applications. Considering the above stated problem statements and expected research outcomes, the objectives of this study are outlined as follows:

- Evaluate the usability of prominent Mobile Financial Services (MFS) applications utilized in Bangladesh.
- Assess the accessibility features of these MFS applications in the context of Bangladesh.
- Explore the practical application of usability, accessibility, and design principles in enhancing the user interfaces (UIs) of MFS applications for improved usability.

## 1.5 Methodological Overview

The key steps followed to carry out this thesis is illustrated in Figure 1.1.

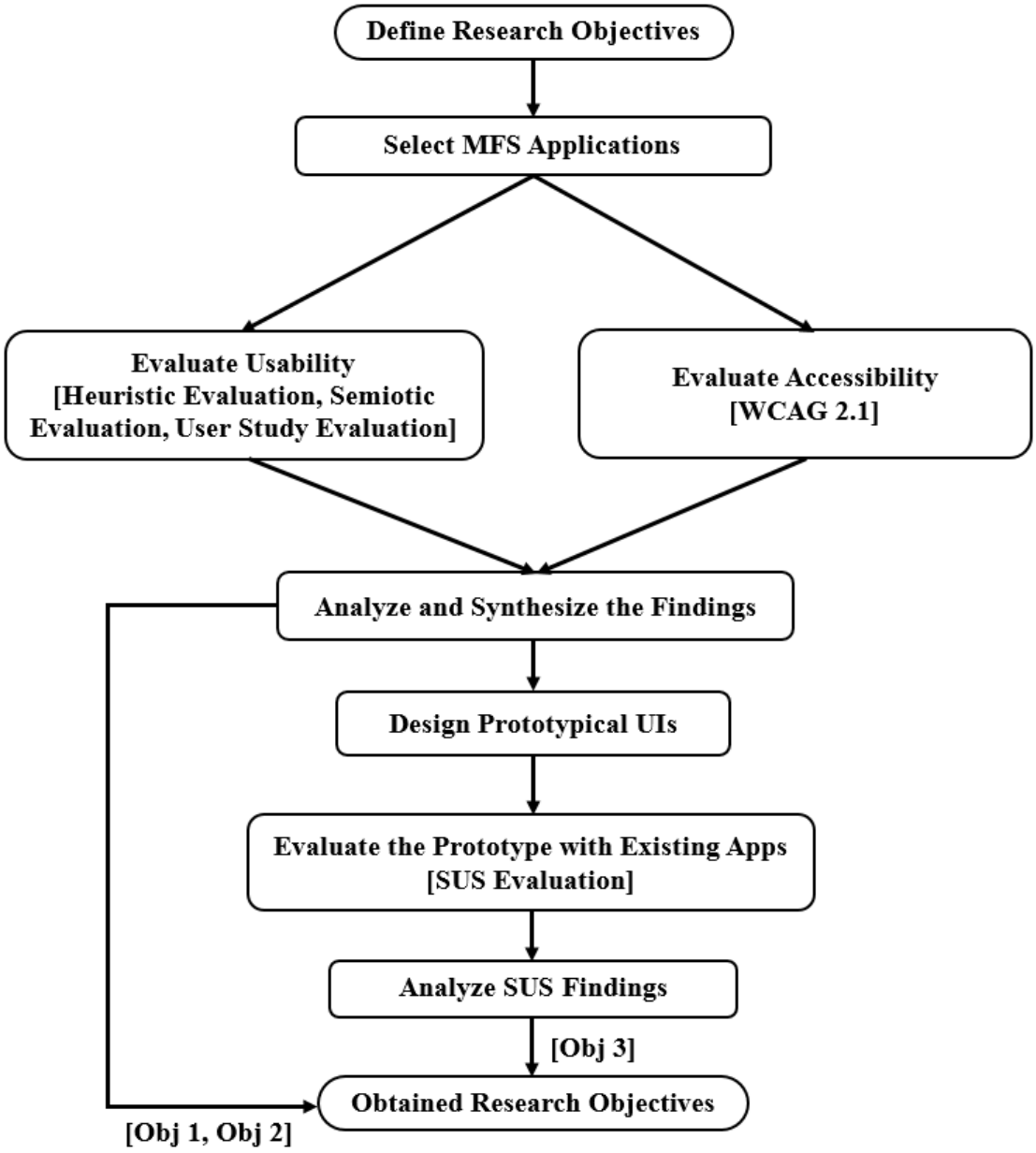



**Fig. 1.1:** Research methodology for assessment of usability and accessibility of major MFS applications used in Bangladesh.

This research is conducted in following four primary steps:

- *Selection of the MFS Applications*: In this research three major MFS applications namely bKash, Nagad, and Rocket were selected for conducting the usability and accessibility evaluation based on few criteria like installation count of the application from Google Play Store, user ratings (users' satisfaction level after using the application) from Google Play Store, number of active users of that MFS application at present, and current market share.

- *Conducting Usability Evaluation*: Usability evaluation was conducted on the selected applications through Heuristic Evaluation (HE), Semiotic Evaluation (SE), and User Study Evaluation (USE). The HE was carried out based on Bertini et al.'s Eight Heuristics (Bertini et al., 2009). The SE was conducted following the semiotic heuristics proposed by Islam and Bouwman (2016). User Study Evaluation was conducted by training a group of users to perform specific tasks and then endorsing their post-test feedback on *effectiveness* of use, *efficiency* of the system, and user *satisfaction*. In these evaluations, usability problems, evidence of the identified problems (violated heuristics), severity ratings, and (re)design recommendations were collected and analyzed to devise the overall usability issues of the selected MFS applications.
- *Conducting Accessibility Evaluation*: The accessibility of the selected applications were evaluated through the Web Content Accessibility Guidelines (WCAG) 2.1 (White, 2019) as recommended by W3C and the accessibility problems of the selected MFS applications are identified.
- *Validating the Outcomes of the Evaluation Studies*: Few prototypical UIs were designed considering the design considerations based on the revealed usability and accessibility problems. Then the selected applications and the prototypical UIs were evaluated through System Usability Scale (SUS) technique (Kaya et al., 2019) to justify the significance of considering the usability and accessibility guidelines in designing a more usable and accessible MFS application in the context of Bangladesh.

## 1.6 Thesis Scope

This research aimed at evaluating the usability and accessibility of the three major MFS applications in Bangladesh and finding the limitations and the shortcomings of these applications with a view to preparing a prototype of a near ideal MFS application keeping in consideration of the demographic, socio-economic and cultural aspects of the present and prospective users. The outcome of this research is expected to aid the MFS application authorities to understand the digital gap between the users and the application so that the designs of those applications can be appropriately modified for improved usability and accessibility by the users.

## 1.7 Organization of the Chapters

This paper is organized into following chapters:

*Chapter 2:* This chapter presents the 'Theoretical Background' and discusses the 'Related Works' in this field of research. Under the theoretical background, the HCI issues related to mobile applications, need for evaluation of mobile applications, evaluation techniques like usability evaluation and accessibility evaluation are discussed. Besides, the relevant studies conducted to evaluate mobile applications especially MFS applications are discussed with findings.

*Chapter 3:* This chapter focuses on the "Usability Evaluation". Here, heuristic evaluation, semiotic evaluation, and user study evaluation will be conducted. Details of these three study procedures, data extraction and accumulation, data analysis, and findings are presented in this chapter.

*Chapter 4:* This chapter focuses on the "Accessibility Evaluation" of the selected MFS applications. Here, WCAG 2.1 outlined by W3C are discussed. In consonance to the WCAG guidelines, conduct of the accessibility evaluation is elaborated discussed. Relevant data collection method, data analysis, and summary findings are presented in this chapter.

*Chapter 5:* This chapter presents the "Prototype Development and SUS Evaluation". In this chapter, the problems of usability and accessibility evaluation will be compiled at first from the findings of usability and accessibility evaluation. Then based on these problems identified, necessary design modifications/considerations will be suggested. Based on suggested design modifications, few prototypes of selected User Interfaces (UI) will be developed and a System Usability Scale (SUS) evaluation will be conducted between those UIs and the three selected MFS applications to show the improvement in User Experience (UX).

*Chapter 6:* This chapter presents the "Conclusion and Discussion". It concludes the paper analyzing the thesis outcomes and implications along with highlighting the limitations faced during the research and scopes for possible future research in this field.

# CHAPTER 2
# THEORETICAL BACKGROUND AND RELATED WORK

This chapter briefly discusses some of the key concepts related to Mobile Financial Services (MFS), MFS application in Bangladesh, Human-Computer Interaction (HCI) practices, and likely problems to be faced by different user groups in Bangladesh are presented. Then the need for usability evaluation and accessibility evaluation is discussed along with different facets of these evaluation techniques and data analysis methods. Research works related to the usability and accessibility evaluation of different applications and in particular related to MFS applications are discussed next. At last, a chapter summary is presented.

## 2.1 Mobile Financial Services (MFS)

The financial services offered to the people with the help of mobile telecommunication services are known as Mobile Financial Services, in brief MFS. MFS can be accessed through a feature phone or a smartphone. A feature phone executes the transactions through the use of a mobile network while a smartphone depends on internet connectivity for running the MFS application. The user applications installed in the mobile phone for the purpose of making financial transactions with the help of MFS are known as MFS applications.

Mobile Financial Services can be accessed by the users in following ways:

- Firstly, by dialing a specific code designated for a specific mobile financial service (e.g. for bKash *247#) from any phone. This option is especially designed for feature phones or button phones. An active SIM (Subscriber Identity Module) connection is required to use code based MFS since the MFS account is operated against the mobile number.
- Secondly, by mobile phone applications installed and configured on smart phones which are commonly known as Mobile Financial Service (MFS) applications. To use an MFS application, a mobile needs to have an internet connection alongside the SIM connectivity.

Smart phones are now easily affordable and accessible for most of the people of Bangladesh due to its availability in the local markets, competitive low prices, and presence of mobile internet almost all over the country. Smart phones offer many options and facilities which are not available in feature phones. A smart phone offers many features of a palmtop or a laptop,

for example, users can access social media, email, and many more applications by smart phones. Using the MFS applications through smart phones, the MFS users can buy any product online and make necessary payments within Bangladesh, or can pay various utility bills like electricity, water, gas, telephone, etc., or can send money to any recipient within Bangladesh, or can recharge mobile balance without going to the banks or to any market. Using MFS through smart phones provides number of advantages over the use of MFS by feature phones. Some of these advantages are:

- Provides a complete visibility to the users regarding the options or services available in the application.
- Shows the user where he/she stands at any stage or at any point in time while using the application
- Guides the user regarding what is to be done next to accomplish a specific task.
- Informs the user whether the task has been completed successfully or it is rejected/aborted without completion, etc.

Indeed, the use of feature phones have reduced drastically in the present days. Only old aged users who have discomfort in adopting new technologies or users who are resistant to new technologies are still using feature phones. Therefore, more than 90% of the MFS users depend on MFS applications for accessing this service.

According to AFI MFSWG Guideline Note (2013), Mobile Financial Service (MFS) is the use of mobile phones to access financial services and execute financial transactions. MFS includes both mobile banking and mobile payments. The concept is to open a bank account through the use of a mobile phone number and without physically going to any bank. Wherever the mobile network is available, the MFS will also be available there. The MFS applications are expected to be extremely user-friendly so that people with a diverse educational, social and financial background can easily get access to it and feel comfortable in using the services.

The current features of MFS applications are: MFS enables users to make deposits, withdraw cash and send money or receive funds from a mobile account. Besides, an MFS user is also able to make payments to various online and offline shops while buying goods with the help of this application. Through an MFS application, a user can also pay various utility bills like electricity bills, telephone bills, gas bills, school/college/university fees, etc. This application also provides the facility to buy mobile airtime for any mobile users. A user can refill his

account through money transfer from any bank account that is affiliated with that particular MFS application. Also, an account can be refilled by cash deposition to any authorized agent of that MFS. Apart from transactional services such as fund transfer and payments, MFS applications also allow non-transactional services such as viewing financial information on user's mobile phone.

## 2.2 MFS Applications in Bangladesh

According to Bangladesh Bank Website (2023), Bangladesh Bank introduced efficient off-branch MFS in Bangladesh in 2011 as the country had a nationwide mobile network coverage, a large number of mobile phone users, and a growing IT infrastructure. Dutch-Bangla Bank Ltd pioneered the country's first MFS operation in March 2011 by introducing DBBL Mobile, which was later rebranded as Rocket (Zaman, 2023). MFS provided financial inclusion to a large number of people who did not have access to formal financial services (Mizan, 2021). Thereby, MFS has become a popular service. In July 2022, there were about 181 million registered MFS users in Bangladesh, of which 50 percent of accounts are actively in use (Tahasan and Hoque 2022). In the last ten years, the number of users has increased exponentially making Bangladesh the largest MFS market in the world (Bangladesh Bank Website, 2023).

As per the data of Bangladesh Telecommunication Regulatory Commission (BTRC), there are around 131.44 Million internet users in Bangladesh of which 118.96 Million are mobile internet users (BTRC, 2023). A significant number of these mobile internet users use MFS Applications for various financial transactions. The MFS applications need to be highly usable and user-friendly so that people with diverse educational, social, and financial backgrounds can easily access the applications and are able to use the services with utmost comfort and satisfaction. Usability and accessibility are two key terms in user experience (UX) analysis. Therefore, assessing the usability and accessibility of the MFS applications in the context of Bangladesh is of great importance.

## 2.3 Human-Computer Interaction and MFS

Human-computer interaction (HCI) is a multidisciplinary field of study focusing on the design of computer technology and, in particular, the interaction between humans (the users) and

computers (Dix, 2023). While initially concerned with computers, HCI has since expanded to cover almost all forms of information technology design. Initially, HCI researchers focused on improving the usability of desktop computers (i.e., practitioners concentrated on how easy computers are to learn and use). However, with the rise of technologies such as the Internet and the smartphone, computer use would increasingly move away from the desktop to embrace the mobile world. HCI is a broad field which overlaps with areas such as User-Centered Design (UCD), user interface (UI) design and user experience (UX) design. There are some differences between HCI and UX design. Practitioners of HCI tend to be more academically focused. They are involved in scientific research and developing empirical understandings of users. Conversely, UX designers are almost invariably industry-focused and involved in building products or services, e.g., smartphone apps and websites (Dix, 2023).

HCI is a computer-mediated human communication process that involves three agents: designers, users and system. An effective HCI is achieved via a two-fold communication process:

- Communication between designer and system.
- Interaction between system and user.

With the help of HCI tools, the MFS applications will be assessed to identify their usability and accessibility problems and necessary design modification recommendations will be drawn so that UX of these application can remarkably improve. The user groups of MFS applications are of varied types based on different factors like age, gender, literacy, exposure to digital technology, education level, domicile, etc. For example:

- *Age*: young (18-39) users, mid aged (40-59) users, and old aged (60 and above) users.
- *Gender*: Male, female, transgender.
- *Literacy*: Illiterate and literate.
- *Digital Literacy*: Digitally illiterate and digitally literate.
- *Education*: Literate but education level up to primary education (class 1 - class 5), education level up to higher secondary education (class 6 - class12), education level undergraduate and above.
- *Income Level*: Low, lower-middle, upper-middle, and high income group.
- *Domicile*: users residing in the urban areas, users residing in the rural areas.
- *Human Ability*: Normal users, users with disability (physical and mental inabilities like vision impairment, deaf or hard of hearing, mental health conditions, etc) and users with

special needs (learning disabilities like autism spectrum disorders, cognitive issues, learning disorder, etc).

It is natural that user experience (UX) of different user groups differ from each other due to their background knowledge and other characteristics. If the font size of the mobile application is relatively small, an old aged user is likely to face difficulty to read the texts in the application. In Bangladesh, female population is comparatively less engaged in direct commercial job sector. Those who earn money, they usually pay different bills and sends money to other family members. Therefore, female population has relatively less exposure to handling money where MFS applications may be required. Users who are accustomed using Facebook, Twitter, WhatsApp, Viber, etc may be considered as digitally literate. They are well oriented with smart phones. They will have an upper hand while learning the use of MFS application. Education level of an individual not only upgrades his/her mental faculty, but also improves his/her standard in many ways. A highly educated person is likely to grab the features of the MFS application faster than a relatively less educated person. People living in the urban areas have experience of using fast internet services through broadband internet connections and by 4G/5G mobile networks. In the rural areas, broadband internet connection is not commonly available. MFS users dependent on 2G/3G internet connections provided by the Mobile Network Operators (MNO). It may also be believed that people living in the rural areas are behind the people in the urban areas in terms of digital awareness. Similarly, users with physical or mental disabilities or special needs will have different user experience pertaining to their spectrum of disabilities, disorders, or limitations.

## 2.4 Usability Evaluation Methods

According to ISO 9241-11:2018, usability is “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use”. Usability evaluation focuses on how well users can learn and use a product to achieve their goals. Usability evaluation evaluates both design and functionality. In this research, heuristic evaluation, semiotic evaluation, and user study evaluation techniques are used as methods for assessing usability of MFS applications. Usability of an application refers to the extent to which it can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use (Ferreira et al., 2020). Poor usability affects the utility of a system and discourages the users to use the system. There

are four usability evaluation approaches: analytical approach, empirical approach, formative approach, and summative approach. In this research, two evaluation methods i.e. analytical approach and empirical approach have been utilized for usability evaluation. Heuristic evaluation and semiotic evaluation falls under analytical approach and user study evaluation follows the empirical approach.

### 2.4.1 Heuristic Evaluation

A heuristic evaluation is a usability inspection method for computer software and mobile applications that helps to identify usability problems in the user interface design. It specifically involves evaluators examining the interface and judging its compliance with recognized usability principles (Kumar et al., 2020). Unlike user-testing, where the website/mobile application/prototype is evaluated by regular users, in a heuristic evaluation the site or application is evaluated by usability experts. This is why, it is referred to as an "expert review".

Heuristics are general principles for evaluating interaction designs. Evaluators judge the design against a set of guidelines (known as 'Heuristics') that make systems easy to use. There are different sets of heuristics that can be applied for HE, e.g., Nielsen's Ten Principles (Nielsen, 1995), Shneiderman's Eight Golden Rules (Aottiwerch and Kokaew, 2017), Tognazzini's Sixteen Principles (Tognazzini, 2002), and Bertini's Eight Heuristics (Bertini et al., 2009). Among these heuristics, Bertini's Eight Heuristics are specially formulated for evaluating mobile based applications. Rest of the heuristic guidelines are more suitable for analyzing computer based web applications. For this reason, in this research the HE will be carried out based on Bertini et al.'s Eight Heuristics. These heuristics are as follows:

Heuristic-1: Visibility of system status and losability/ findability of the mobile device.
Heuristic-2: Match between system and the real world.
Heuristic-3: Consistency and mapping.
Heuristic-4: Good ergonomics and minimalist design.
Heuristic-5: Ease of input, screen readability, and glancability.
Heuristic-6: Flexibility, efficiency of use and personalization.
Heuristic-7: Aesthetic, privacy and social conventions.
Heuristic-8: Realistic error management.

According to Paz et al. (2017), a HE is proposed to be conducted in five steps: planning, training, evaluation, discussion, and reporting. In this research, these five steps have been combined into following three steps:

- *Prepare for a heuristic evaluation*: Planning the conduct of the HE, choosing and training the team members. Ideally, three to five people is suggested to independently evaluate the same interface.
- *Evaluate independently*: Each team member should evaluate the interfaces on their own.
- *Consolidate identified issues*: Once all the team members have performed their independent evaluations and recorded necessary data, then all the issues are synthesized and the final output is derived.

### 2.4.2 Study Procedure of Heuristic Evaluation

A heuristic evaluation is a way to test whether a website/mobile application is user friendly on not. Detail procedures of conducting a heuristic evaluation is outlined below (Wong, 2022):

- An appropriate set of heuristics is selected for conducting the evaluation, such as Ben Shneiderman's eight golden rules.
- The evaluators are selected so that they have expertise in usability studies. Usually 3-5 evaluators are needed for accomplishing a full evaluation process since single evaluator is likely to miss some problems.
- Evaluators are briefed in the first instance to ensure that they exactly know what they are meant to do and cover during the evaluation. They must be free of biasness.
- Each evaluator independently checks for compliance with usability principles i.e. heuristics and record identified usability problems. Different evaluators will find different problems. Evaluators only communicate each other after completion of individual inspection. Usually a debriefing session is conducted at the end of the evaluation phase while collaboration between the evaluators take place for collecting their findings. The evaluators are also encouraged to suggest potential solutions to the identified usability problems based on the heuristics.
- At last, all the findings are aggregated, categorized, and prioritized findings are effectively reported.

### 2.4.3 Semiotic Evaluation

Semiotics is refers to the study of signs and symbols and their interpretation (Sebeok, 2001). Semiotic engineering focuses on facilitating communication between designers and users during interaction. Designers need to be integrated into interfaces to guide users on interpreting the signs within a system or program. Semiotics encompasses various forms of communication such as signs, logos, gestures, and linguistic and non-linguistic methods. This study utilizes the Semiotic Interface Sign Design and Evaluation (SIDE) Framework for evaluating semiotics in interfaces. (Islam and Bouwman, 2016).

Semiotic engineering analyzes the connection between system symbols (e.g., words, icons, graphical layout, buttons, links, etc.), semantics, and functions in order to understand the designer-to-user communication. In principle, the ability of semiotic engineering is to produce successful design in order to ensure that the user receives the accurate messages sent by the designers.

### 2.4.4 Study Procedure of Semiotic Evaluation

The Semiotic Interface sign Design and Evaluation (SIDE) framework is proposed for the design and evaluation of web interface signs to make them intuitive for end users and to improve the system's overall usability. This framework has been employed for conducting semiotic evaluation of the MFS applications. SIDE framework includes a set of determinants (themes) and attributes (sub-themes) of interface signs and a set of semiotic heuristics for interface sign design and evaluation.

The semiotic heuristics of SIDE Framework are divided into five levels:

- **Syntactic** is the features of interface sign presentation.
- **Pragmatic** is the relation of interface sign with their interpretation or uses.
- **Social** is the relation of interface sign with its meaning in respect to its social consequences.
- **Environment** is the users' presupposed knowledge or ontology owned to interpret the meaning of the interface sign.
- **Semantic** is the referential meaning of interface sign.

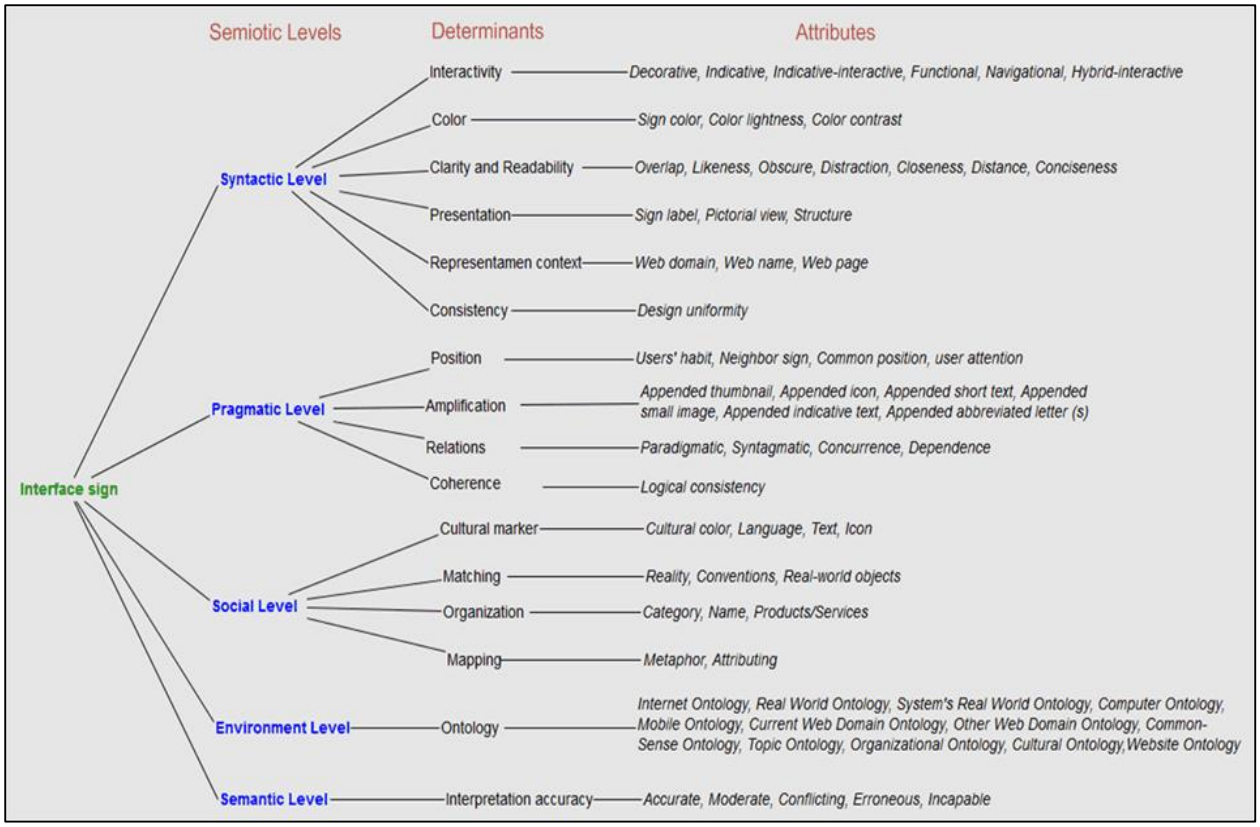



**Fig. 2.1:** SIDE Framework: layers, determinants, and attributes.

The signs or symbols are tested against seventeen semiotic heuristics that constitute the SIDE Framework. These seventeen heuristics are grouped into five levels as shown in Table 2.1.

**Table 2.1:** List of semiotic heuristics in the SIDE Framework

| Level | Semiotic Heuristics |
|---|---|
| Syntactic | SH1. Clearly present the purpose of interactivity<br>SH2. Make effective use of color to design an interface sign<br>SH3. Make the representamen readable and clearly noticeable<br>SH4. Make a sign presentation clear and concise<br>SH5. Create the representamen context appropriately<br>SH6. Follow a consistent interface sign design strategy |
| Pragmatic | SH7. Place the interface sign in the proper position in a UI<br>SH8. Make effective use of amplification features<br>SH9. Create good relations among the interface signs of a UI<br>SH10. Retain the logical coherence in interface sign design |

| | |
|---|---|
| Social | SH11. Design interface signs to be culturally sensitive or reactive<br>SH12. Matches the reality, conventions, or real-world objects<br>SH13. Make effective use of organizational features<br>SH14. Map with metaphorical and attributing properties |
| Environment | SH15. Model the profiles of the focused end-users<br>SH16. Make effective use of ontological guidelines |
| Semantic | SH17. Realize a match between a designer's encoded and a user's decoded meaning |

### 2.4.5 User Study Evaluation

User study is the means for systematic examination of the characteristics and behavior of the users of the systems and services. The 'user study' is directly linked with the effectiveness (performance) of certain applications as they aim at satisfaction of user needs. User study evaluation refers to the tests conducted by a selected group of users and then evaluating their performance based on set criteria. This evaluation gives a clear idea about the loopholes or weaknesses in a system that is used by many users.

### 2.4.6 Study Procedure of User Study Evaluation

In order to conduct a user study evaluation, a group of participants are selected randomly in way so that they represent almost all kinds of user groups in the present context. Then the participants are briefed on their roles and study objectives and trained to perform the planned tasks. Then the users are tested to perform those specific tasks, and at last, the users fill up a set of post-test questionnaires which also works as a tool for the test. A group of qualified/experienced evaluators are needed to conduct a user study evaluation. The evaluators judge the tasks performed by the participants while carrying out the tasks as well as study the answers of the post-test questionnaires. By evaluating their performances and post-test answers, *effectiveness*, *efficiency*, and *satisfaction* are measured for the applications to be evaluated.

## 2.5 Accessibility Evaluation Method

Accessibility can be viewed as the ability to access and benefit from some systems. It is the practice of making a website or a mobile application usable by as many people as possible.

Although accessibility is thought of as being people with disabilities, it also benefits other groups such as those using mobile devices, or those with slow internet connections (Domingo, 2012). Accessibility is also defined as the practice of enabling individuals with cognitive or physical impairments to seamlessly interact with products, applications, or services. Some of these impairments include vision or hearing loss, mobility constraints, and memory changes (Moon et al., 2019). Accessibility evaluation seeks to understand how well digital content complies with established usability standards for people who have disabilities. Accessibility evaluation is an important component of usability evaluation.

The Web Content Accessibility Guidelines (WCAG) is the most-referenced set of standards for evaluating the accessibility of websites or mobile applications and is widely considered the best way to achieve accessibility. In this research, WCAG 2.1 has been employed to evaluate the accessibility of MFS applications used in Bangladesh. WCAG are organized in four main principles: Perceivable, Operable, Understandable, and Robust (Caldwell et. al., 2008); briefly known as POUR. Under these four principles there are total thirteen guidelines. Observance of these guidelines makes the web contents/applications more accessible to the users.

### 2.5.1 Perceivable

Information and user interface components must be presented to users in ways they can perceive. This means that users must be able to comprehend the information being depicted. It cannot be invisible to all their senses.

Perceivable Guidelines

- *Text Alternatives:* Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language.
- *Time-based Media:* Provide alternatives for time-based media.
- *Adaptable:* Create content that can be presented in different ways (for example simpler layout) without losing information or structure.
- *Distinguishable:* Make it easier for users to see and hear content including separating foreground from background.

### 2.5.2 Operable

User interface components and navigation must be operable. The interface cannot require interaction that a user cannot perform.

Operable Guidelines

- *Keyboard Accessible:* Make all functionality available from a keyboard.
- *Enough Time:* Provide users enough time to read and use content.
- *Seizures and Physical Reactions:* Do not design content in a way that is known to cause seizures or physical reactions.
- *Navigable:* Provide ways to help users navigate, find content, and determine where they are.
- *Input Modalities:* Make it easier for users to operate functionality through various inputs beyond the keyboard.

### 2.5.3 Understandable

Information and the operation of a user interface must be understandable. Users must be able to understand the information as well as the operation of the user interface.

Understandable Guidelines

- Readable: Make text content readable and understandable.
- Predictable: Make Web pages appear and operate in predictable ways.
- Input Assistance: Help users avoid and correct mistakes.

### 2.5.4 Robust

Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies. As technologies and user agents evolve, the content should remain accessible.

Robust Guideline

- Compatible: Maximize compatibility with current and future user agents, including assistive technologies.

## 2.6 SUS Evaluation Method

SUS evaluation is a kind of quantitative usability testing method. It was originally proposed in 1986 by John Brooke to measure the usability of new computing systems (Lewis, 2018). The SUS score is the metric that has become the industry standard for measuring the usability of websites, computer and mobile applications. This score helps the developers and HCI experts to make data-informed decisions about UX directions. SUS score is a powerful tool to tie usability into business success. To obtain the SUS score, participants respond to ten following statements to gauge their perception of the usability of the system in question. By responding to each question with a 1-5 rating of how strongly they 'agree' or 'disagree' with the statements, an overall score can be calculated.

**Table 2.2:** System Usability Scale (SUS) Questionnaires with possible user responses

| **Ser** | **Questions** | **User Responses** | | | | |
|---|---|---|---|---|---|---|
| | | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
| Q1 | I think that I would like to use this system frequently. | 1 | 2 | 3 | 4 | 5 |
| Q2 | I found the system unnecessarily complex | 5 | 4 | 3 | 2 | 1 |
| Q3 | I thought the system was easy to use | 1 | 2 | 3 | 4 | 5 |
| Q4 | I think that I would need the support of a technical person to be able to use this system | 5 | 4 | 3 | 2 | 1 |
| Q5 | I found the various functions in this system were well integrated | 1 | 2 | 3 | 4 | 5 |
| Q6 | I thought there was too much inconsistency in this system | 5 | 4 | 3 | 2 | 1 |
| Q7 | I would imagine that most people would learn to use this system very quickly | 1 | 2 | 3 | 4 | 5 |
| Q8 | I found the system very cumbersome to use | 5 | 4 | 3 | 2 | 1 |
| Q9 | I felt very confident using the system | 1 | 2 | 3 | 4 | 5 |
| Q10 | I needed to learn a lot of things before I could get going with this system | 5 | 4 | 3 | 2 | 1 |

## 2.7 Data Analysis and Visualization

- *Analyzing and Synthesizing the Data*

  The data and findings of various usability and accessibility assessments to be analyzed and synthesized to get a compiled version of the design problems identified in the understudy MFS applications. This will pave the way for designing prototypical interfaces for performing the same tasks that were tested during the User Study Evaluation.

- *Develop Prototypical User Interfaces*

  There are number of online application tools like Figma, ProtoPie, InVision, Adobe XD, Balsamiq, Origami, etc that allow the development of prototypical user interfaces for mobile devices. Of them, Figma is more commonly used by most UI developers. In this research, *Figma* application has been utilized to develop UIs for performing few specific tasks.

- *Evaluate the UIs of Selected MFS Applications and Prototypical UIs through System Usability Scale (SUS)*

  In this step, SUS evaluation will be carried out to visualize the data derived from previous evaluations and to identify whether the performance of the prototypical UIs perform better than the existing relevant UIs of selected MFS applications.

- *Analyze the SUS findings*

  Data derived from conducting the SUS evaluation will be analyzed to confirm/justify/evaluate the significance of considering the usability and accessibility guidelines in designing a more usable MFS application in the context of Bangladeshi users.

## 2.8 Related Studies

This section briefly discussed some research works related to the usability evaluation and accessibility evaluation of MFS applications. To identify the related publications or articles, multiple data sources including Google Scholar, Science Direct, IEEE, Association for Computing Machinery (ACM), and Scopus were consulted.

Usability analysis of various similar kinds of applications is not new in the field of Human-Computer Interaction. But usability evaluation of MFS applications is relatively new since very limited resources could be found in this regard through web search or library study. Sultana (2014) explored the MFS business and regulations and its evolution in South Asian markets purely from a business point of view.

Hussain, Abubakar and Hashim (2014) conducted a systematic literature review to propose a set of dimensions and sub-dimensions for evaluating mobile banking applications. Islam, Bouwman and Islam (2020) evaluated web and mobile user interfaces with semiotics with the goal of increasing the understanding of the intuitive nature of interface signs of web and mobile interfaces, and of the practical use of intuitive signs. Mokhlesur et. al. (2020) carried out an empirical study on assessing the usability of ride-sharing mobile application in Bangladesh and portrayed the user behavior regarding the use of these applications by the people of variant age and gender group. Muaz, Islam and Islam (2021) explored the usability of truck hiring mobile applications in Bangladesh using heuristic and semiotic evaluation where usability problems and design errors were identified and possible solutions were suggested. Shusmoy, Kabir, and Islam (2020) evaluated usability of pregnancy tracker applications in Bangladesh to find out the usability problems and design errors through heuristic and semiotic evaluation.

Malik et al. (2021) used two methods 'User Testing' and 'Heuristic Evaluation' for usability evaluation of two major mobile banking applications of Pakistan and suggested to use easy terminologies in the user interface, maintain enhanced visibility of the transaction status, keep feedback method to guide new users, keep the user abreast about where he is and what to do next by improved navigation and to keep the interface simple by providing only necessary information.

Khan et al. (2022) investigated the relationship between service quality and customer satisfaction of BKash MFS application used in Bangladesh. The author has given few insights out of the study for researchers, financial policymakers, and senior management from banking industry for rendering and upgrading services to end-users and customers of mobile banking. While Akter et al. (2019) has conducted a comparative study on mobile banking services between Bangladesh and South Korea and shown that belief on lack of effort on educating the consumers toward online banking further affected the usability of online banking in both the countries.

Nugraha et al. (2018) evaluated the usability of the three major mobile banking applications of Indonesia based on the main functions performed by the applications. In this study, the author has shown that poor interface design is lowering the usability of most of the applications. The author identified that the three mobile banking applications have quite good usability although there are still several aspects that need to be improved.

Islam et al. (2017) carried out a research on the usability of the e-government websites of Bangladesh. The study results indicate that e-government websites of Bangladesh are significantly suffering from usability problems. The author also conducted separate researches on the usability evaluation of mobile health applications used in Bangladesh (Islam et al., 2020) and on a mobile application for mental health care during COVID-19 pandemic (Islam et al., 2021).

Abubakar et al. (2016) proposed a model which was evaluated by six domain experts' using heuristic evaluation approach and identified that there are needs to apply the model with real mobile banking application users in order to strengthen its accuracy and usefulness for the intended applications. In another study, Sanger et al. (2015) proposed a model for increasing the usability of mobile banking applications on smart phones where he suggested that learnability, satisfaction and efficiency are the first grade factors that greatly determines the usability of an application.

Using a Systematic Literature Review (SLR) Hussain et al. (2014) has presented a set of usability dimensions and measurement that can be used to evaluate the usability of mobile banking application. While Cooharojananone et al. (2012) evaluated the usability factors on mobile payment application of two different service providers in Thailand and showed that usefulness, ease of use, trust, and design affects the intention of the users on mobile payment applications.

The above discussion portray that a significant number of researches have been conducted on the usability evaluation of mobile banking applications in different countries of the world, but a little has been focused in the context of Bangladesh. Again, a few researches have been conducted on MFS applications of Bangladesh like bKash or Rocket where the focus is mostly on their quality of service, comparison and differences. However, these studies have not focused on the UX or usability of the UI design which is one of the key factors for adopting these MFS applications by the mass population in the socio-economic and cultural context of Bangladesh. Under these pretext, it is important to assess the usability of the MFS applications

used in Bangladesh highlighting few design considerations for improvement with a view to making those applications more versatile for wider acceptance by the common people.

## 2.9 Chapter Summary

This chapter discusses the theoretical background of the inception and prevalence of Mobile Financial Service Applications in the perspective of Bangladesh, importance of HCI for better usability and accessibility of mobile applications in the context of Bangladeshi users, various aspects of usability evaluation and accessibility evaluation including their concepts and means by which the evaluations can be carried out, and finally, related studies conducted in this field were presented. It is clearly understood that there had been number of studies on usability and accessibility of various web based applications, and few mobile applications. But there were no complete study conducted on the usability and accessibility evaluation of the MFS applications in Bangladesh prior to this study.

# CHAPTER 3
# USABILITY EVALUATION

This chapter examines three usability evaluation techniques, along with data analysis and findings. Initially, three prominent MFS applications are chosen for evaluation from a total of thirteen active MFS applications in Bangladesh, following specific criteria. Subsequently, the selected MFS applications undergo sequential assessment using three evaluation methods: heuristic evaluation, semiotic evaluation, and user study evaluation, aimed at identifying their usability issues.

## 3.1 Selection of MFS Applications

All thirteen MFS operators active in Bangladesh have hosted their respective mobile applications in Google Play Store (for Android users) and Apple App Store (for iOS users) for common access. According to Kameke (2023), monthly market share of mobile operating systems in Bangladesh 2021-2023 shows that in August 2023, Android held a share of 95.77 percent of the mobile operating system market in Bangladesh. Comparatively, iOS accounted for 3.95 percent of the mobile operating system market in Bangladesh in August 2023. Therefore, data derived from Google Play Store have been considered for this research. Besides, data from Bangladesh Bank website and national dailies have been considered. To select the most widely used three MFS applications, the following key considerations have been applied on all MFS applications:

- Average user ratings of the application in Google Play Store.
- Number of user reviews about the application in Google Play Store.
- Number of downloads from Google Play Store.
- Total number of active users of a particular application.
- Present market share of the applications.

A comparative statement of these MFS applications in respect of above considerations is presented at Table 3.1 (Bangladesh Bank Website, 2023 and data retrieved from Google Play Store). From this comparative study, it is clearly evident that bKash, Nagad, and Rocket are the three most widely used MFS applications in Bangladesh. These three applications together hold almost 99% of the total MFS market share in Bangladesh.

**Table 3.1:** Selection of major MFS applications used in Bangladesh

| Ser | Name of the MFS Application | Owner Company | Average User Ratings | No of User Reviews | No of Downloads | No of Active Users | Present Market Share |
|---|---|---|---|---|---|---|---|
| 1. | bKash | BRAC Bank Limited | 4.2 | 1,31,00,000 | 50,000,000+ | 5,39,68,418 | 66.46% |
| 2. | Nagad | Bangladesh Post Office | 3.8 | 3,41,000 | 10,000,000+ | 3,41,96,247 | 13.35% |
| 3. | Rocket | Dutch-Bangla Bank Limited (DBBL) | 4.1 | 7,75,000 | 10,000,000+ | 2,44,92,299 | 19.27% |
| 4. | SureCash | Rupali Bank Limited | 4.2 | 1,390 | 1,00,000+ | 2,14,79,002 | 0.92% |
| 5. | Upay | United Commercial Bank Limited | 4.6 | 41,100 | 50,00,000+ | | |
| 6. | Trust Axiata Pay (tap) | Trust Bank Limited | 3.7 | 4,58,00 | 500,000+ | | |
| 7. | mCash | Islami Bank Bangladesh Limited | 3.4 | 2030 | 100,000+ | | |
| 8. | OK Wallet | One Bank Limited | 3.8 | 1210 | 1,00,000+ | | |
| 9. | Islamic Wallet | Al-Arafah Islami Bank Limited | 3.9 | 664 | 10,000+ | | |
| 10. | MYCash | Mercantile Bank Limited | 3.7 | 797 | 50,000+ | | |
| 11. | MeghnaPay | Meghna Bank Limited | 3.7 | 62 | 1,000+ | | |
| 12. | FSIBL FirstCash | First Security Islamic Bank Limited | 4.5 | 112 | 10,000+ | | |
| 13. | TeleCash | South-East Bank Limited | 3.9 | 29 | 1,000+ | | |

Among the three major applications, bKash leads the comparison table which is an initiative of BRAC Bank Limited (a private commercial bank), started its journey in 2010, having an average user rating of 4.2 in Google Play Store, total number of user reviews is more than 1,31,00,000; total number of downloads from Google Play Store is more than 5,00,00,000; and 40.07% of the total MFS users use bKash. It has 66.46% of the market share in terms of average daily transactions (Hasan, 2022).

Nagad is in the second position, which is an initiative of Bangladesh Postal Services, a government organization. Nagad started its journey on 26 March 2019, just before one year of the beginning of COVID-19 pandemic that spread all over the world. Nagad shows an average user rating of 3.8, total number of user reviews 3,41,000; total number of downloads is more than 1,00,00,000 from Google Play Store, and 25.39% of the total MFS users depend on Nagad. It holds 13.35% of the market share in terms of the average daily transactions (Hasan, 2022).

The third most popular MFS application in Bangladesh is Rocket which started its journey on 31 March 2011. It is an initiative of Dutch-Bangla Bank Limited (DBBL), a private commercial bank. Rocket is having an average user rating of 4.1, the number of user reviews 7,75,000; the number of downloads is more than 1,00,00,000; and currently 18.18% of the total MFS users rely on Rocket. It is enjoying a 19.27% market share in terms of average daily transactions (Hasan, 2022).

In light of above discussion, bKash, Nagad, and Rocket are the three MFS applications that will be evaluated for usability and accessibility assessment in this research.

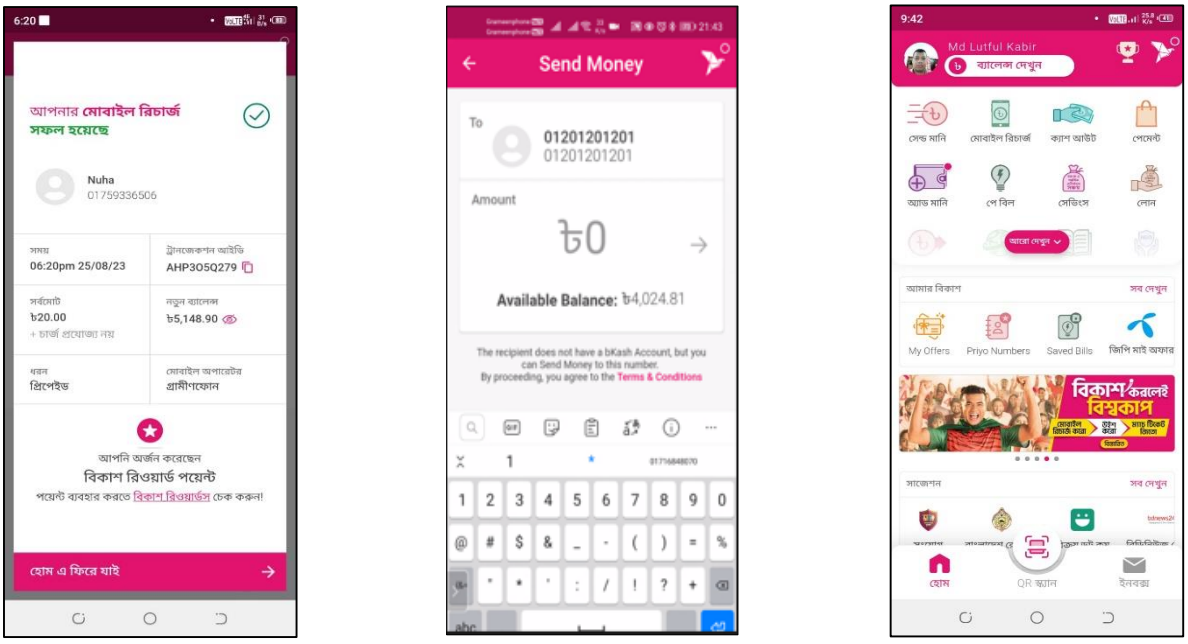
## 3.2 Conduct of Heuristic Evaluation

This evaluation study is designed considering the socioeconomic and demographic background of digitally illiterate and semi-illiterate people in Bangladesh such as knowledge about the subject matter, educational background, and experience with mobile application interfaces in Bangladesh.

For this evaluation, the researcher formed a team with four other Master's students of Computer Science and Engineering who all completed the course on Human-Computer Interaction (HCI) in their master's curriculum and have practical experience in usability and UX evaluation. As mentioned in Chapter 2, Bertini et al.'s eight heuristics are chosen as the yardstick for evaluating the usability of the three MFS applications in this research.

### 3.2.1 Severity Ratings

During the evaluation, a considerable number of heuristic violations were identified for all three MFS applications, of which, some of the violations were common for all the applications. Those violations or problems were categorized according to the Severity Ratings suggested by Jakob Nielsen (Paz et al., 2018), where '0' indicates *'not a usability problem'*, i.e., I do not agree that this is a usability problem at all; '1' denotes *'a cosmetic problem only'*, i.e., need not be fixed unless extra time is available; '2' indicates *'a minor usability problem'*, i.e. fixing this should be given low priority; '3' points to *'a major usability problem'*, i.e., important to fix, so should be given high priority; and '4' represents *'a catastrophic usability problem'*, i.e., imperative to fix this before product can be released. The severity of a usability problem is determined by the combination of three factors: *frequency*, *impact*, and *persistence*. The HCI experts/practitioners including the researcher jointly conducted this heuristic evaluation. The aggregated list of usability problems identified through heuristic evaluation by Bertini et al.'s eight heuristics have been attached as Appendix A (bKash), B (Nagad), and C (Rocket) to this research paper. A few example problems derived from the appendices are shown below in Table 3.2, 3.3, and 3.4.



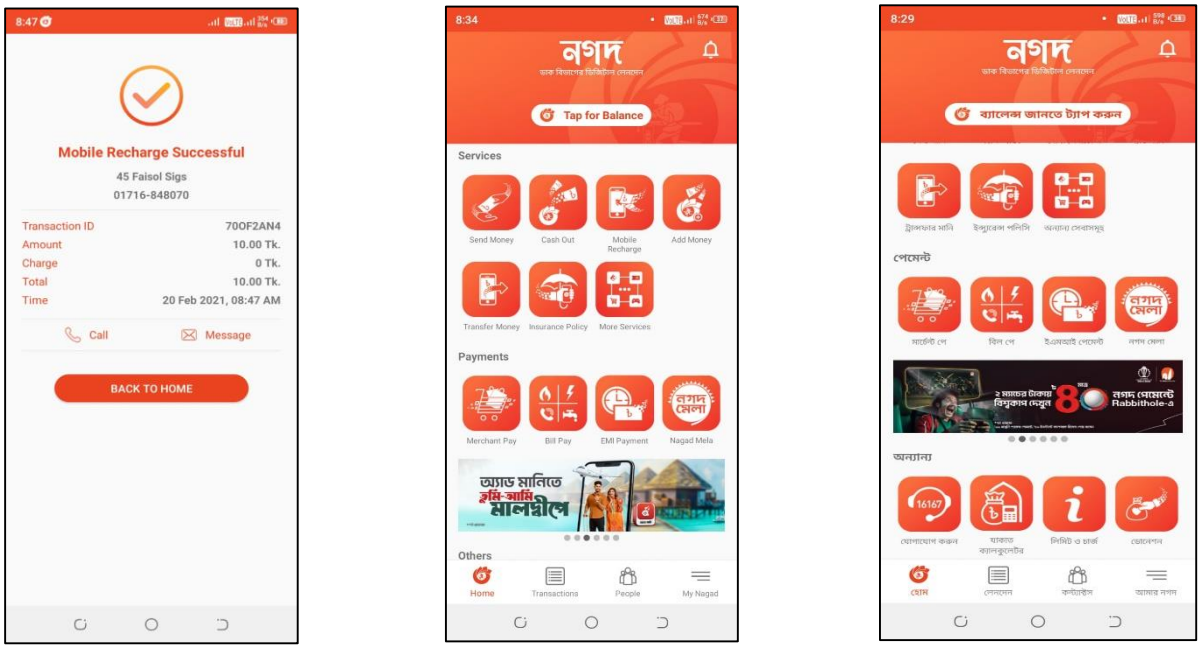

**(a)** **(b)** **(c)**

**Fig. 3.1:** bKash UIs showing usability problems.

**Table 3.2:** Few usability problems identified through heuristic evaluation of bKash

| bKash | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solutions |
|---|---|---|---|---|
| Problem no. 1 (Appendix A) | After completion of a successful mobile recharge, there is no option to continue with another mobile recharge. For this reason, if the user needs to do another mobile recharge, he/she is compelled to go back to Home page and start the process from the beginning (see Fig 3.1 (a)). | H6 (Flexibility, Efficiency of Use, and Personalization) | 1.8 | After completion of a successful mobile recharge, the application should ask the user whether he/she wants to continue with another mobile recharge. If 'Yes', there should be a navigation button to directly go back to Mobile Recharge page. If 'No', then the user will be automatically navigated to the Home page. |
| Problem no. 6 (Appendix A) | While sending money, if user provides invalid mobile number, the application is unable to prevent from proceeding to next page. (see Fig 3.1 (b)). | H8 (Realistic Error Management) | 2.4 | Instead of identifying that the mobile number is invalid after completing the whole process, the application should be able to identify that the mobile number given as input is a wrong number. There should be a mobile number and mobile operator validation checker to prevent possible errors which will save users' time and bring efficacy to the system. |
| Problem no. 7 (Appendix A) | The home page of the application that appears after Log In looks a bit clumsy and cluttered because of so many icons and irrelevant information/logo | H4 (Good Ergonomics and Minimalist Design) | 1.6 | In the home page, displaying of excessive information and design elements should be avoided. For example, advertisement of bKash, Suggestions and Offers are irrelevant or redundant for the home |

| bKash | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solutions |
|---|---|---|---|---|
| | as well as advertisement that make the page quite untidy. The page also lacks in aesthetic view that is required to attract a user. (see Fig 3.1 (c)). | | | page of this application. These should have been avoided and all important icons/options should have been placed. The aesthetic view of this application also demands improvement. |



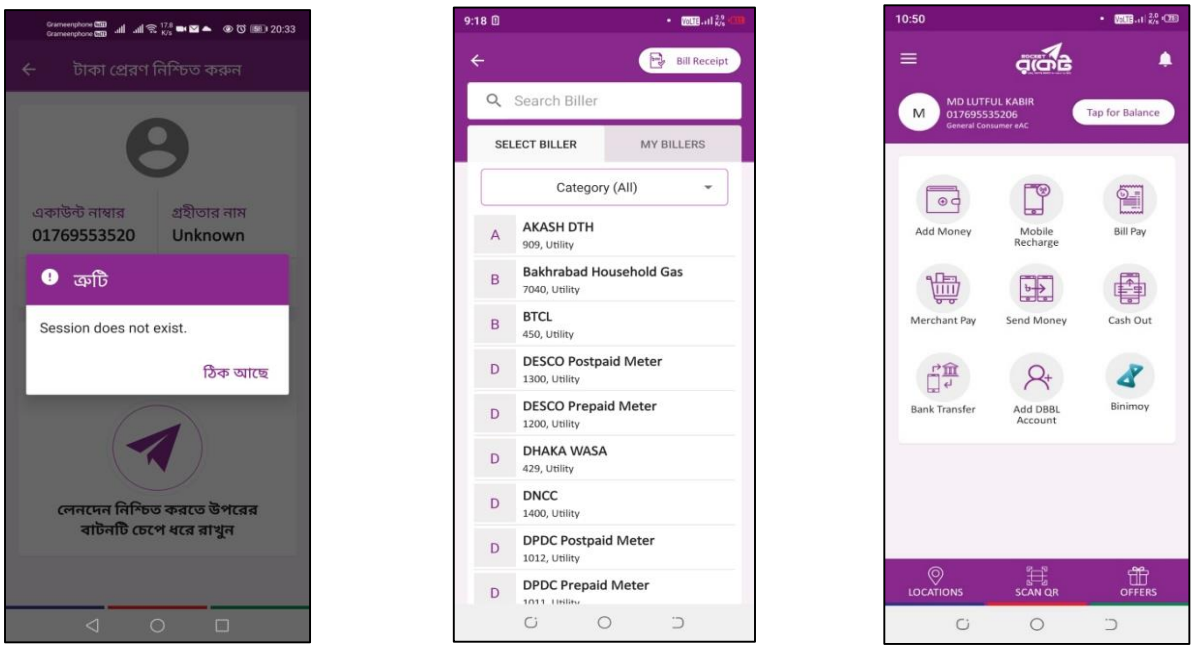

**(a)** **(b)** **(c)**

**Fig. 3.2:** Nagad UIs showing usability problems.

**Table 3.3:** Few usability problems identified through heuristic evaluation of Nagad

| Nagad | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solutions |
|---|---|---|---|---|
| Problem no. 4 (Appendix B) | Although there are 06 state-owned commercial banks, 03 specialized banks and 43 Private Commercial Banks (PCB) in Bangladesh, Nagad is connected to only | H6 (Flexibility, Efficiency of Use, and Personalization) | 3 | Nagad should be connected with more number of banks to allow its users to have flexibility of bringing money |

| Nagad | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solutions |
|---|---|---|---|---|
| | seven (7) PCBs of Bangladesh for internet banking. Therefore, the users are facing difficulty to bring money (Add Money) to their mobile financial account from the bank account. (see Fig. 3.2 (a)) | | | (Add Money) to their mobile account. |
| Problem no. 6 (Appendix B) | Zooming is not available in this mobile application. (see Fig. 3.2 (b)) | H5 (Ease of input, screen readability and glanceability) | 4 | Zoom In and Zoom Out option should be incorporated |
| Problem no. 7 (Appendix B) | Guideline not provided about the usage of each option and an entire task thoroughly. (see Fig. 3.2 (b)) | H1 (Visibility of system status and findability of the mobile device) and H6 (Flexibility, Efficiency of Use, and Personalization) | 4 | Necessary guidelines about the usage of each option and an entire task should be added so that users can easily use the application. |




**(a)** **(b)** **(c)**

**Fig. 3.3:** Rocket UIs showing usability problems.

**Table 3.4:** Few usability problems identified through heuristic evaluation of Rocket

| Rocket | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solutions |
|---|---|---|---|---|
| Problem no. 8 (Appendix C) | Though the session has expired, the application allows the user to interact with all the functionalities i.e. 'Send Money' until the final stage. After completing all the stages even after providing the PIN number, the transaction is denied as session has expired, which is a complete wastage of time and effort. (see Fig. 3.3 (a)) | H6 (Flexibility, Efficiency of Use, and Personalization) | 3 | The application may be redesigned in such a way that, it will not allow any interaction of the user when the session has expired. User need to log in again to carry out any further interaction. |
| Problem no. 9 (Appendix C) | MFS applications are highly secured and always password protected. To increase its security, every session has a limited life if the device is left idle. However, in this application it is identified that there is a bug in the software. The application responses as per the command given to it even after the session time is over. Finally, before any transaction, it says that the session has already expired. (see Fig. 3.3 (b)) | H8 (Realistic Error Management) | 3 | Like other secure apps, after the session time is over, the app should not work. It should ask for authentication password and it should work only after successful authentication. |
| Problem no. 13 (Appendix C) | Icons are quite large considering the text size of the labels/icons which are difficult to read. (see Fig. 3.3 (c)) | H4 (Good Ergonomics and Minimalist Design) | 3 | Font size of the labels of the icons should be made bigger. |

### 3.2.2 Analysis and Findings

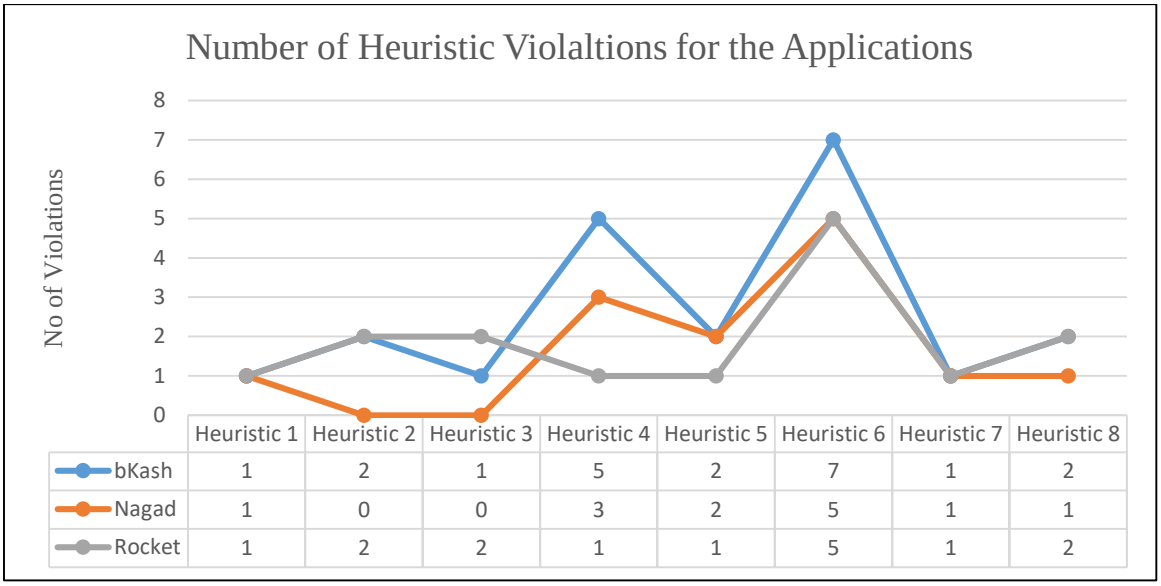
Having compiled the results regarding the number of violations in respect to different heuristics and their corresponding severity ratings, the data is shown in Table 3.5 as follows:

**Table 3.5:** Statistics of heuristic violations and average severity ratings for the applications

| **Heuristics** | **bKash** | | **Nagad** | | **Rocket** | |
|---|---|---|---|---|---|---|
| | No of Violations | Sum of Severity Ratings | No of Violations | Sum of Severity Ratings | No of Violations | Sum of Severity Ratings |
| Heuristic 1 | 1 | 3.8 | 1 | 3.8 | 1 | 3.8 |
| Heuristic 2 | 2 | 4.8 | 0 | 0 | 2 | 4.8 |
| Heuristic 3 | 1 | 1.4 | 0 | 0 | 2 | 3.4 |
| Heuristic 4 | 5 | 10.8 | 3 | 6.8 | 1 | 2.8 |
| Heuristic 5 | 2 | 5.6 | 2 | 5.2 | 1 | 3.8 |
| Heuristic 6 | **7** | **16.4** | **5** | **13.2** | **5** | **14.2** |
| Heuristic 7 | 1 | 1.6 | 1 | 2 | 1 | 2 |
| Heuristic 8 | 2 | 5.4 | 1 | 2 | 2 | 5.6 |
| **Total** | **21** | **49.6** | **12** | **31** | **15** | **40.4** |
| **Average Severity Rating** | **2.36** | | **2.58** | | **2.69** | |

The summary of the revealed usability problems is presented in Table 3.5. In bKash app total 21 usability problems are identified with total severity rating 49.6. Average severity rating of bKash is 2.36. Similarly, total 12 usability problems are found in Nagad adding the severity rating to total 31. Average severity rating of Nagad is 2.58. For Rocket app, total 15 usability problems are identified whose total severity rating is 40.4. Average severity rating of Rocket is 2.69. Therefore, it can be said that although relatively less number of usability problems have been identified in Nagad, but the average severity rating of Nagad is higher than bKash. The average severity rating of Rocket is higher than bKash and Nagad, meaning that, usability problems in Rocket are relatively severe than the usability problems of bKash and Nagad. The average severity ratings of the applications provide a clear picture about the usability standard of the applications under study.

From Table 3.5, it is clearly evident that the most violated heuristic is H6 (Flexibility, Efficiency of Use, and Personalization) and the least violated heuristics are H1 (Visibility of system status and findability of the mobile device), H3 (Consistency and Mapping), and H7 (Aesthetic, Privacy and Social Conventions). No of heuristic violations and average severity ratings of the heuristic violations are shown in Figure 3.4 and 3.5 respectively.




| | Heuristic 1 | Heuristic 2 | Heuristic 3 | Heuristic 4 | Heuristic 5 | Heuristic 6 | Heuristic 7 | Heuristic 8 |
|---|---|---|---|---|---|---|---|---|
| bKash | 1 | 2 | 1 | 5 | 2 | 7 | 1 | 2 |
| Nagad | 1 | 0 | 0 | 3 | 2 | 5 | 1 | 1 |
| Rocket | 1 | 2 | 2 | 1 | 1 | 5 | 1 | 2 |

**Fig. 3.4:** Number of heuristic violations for the applications.

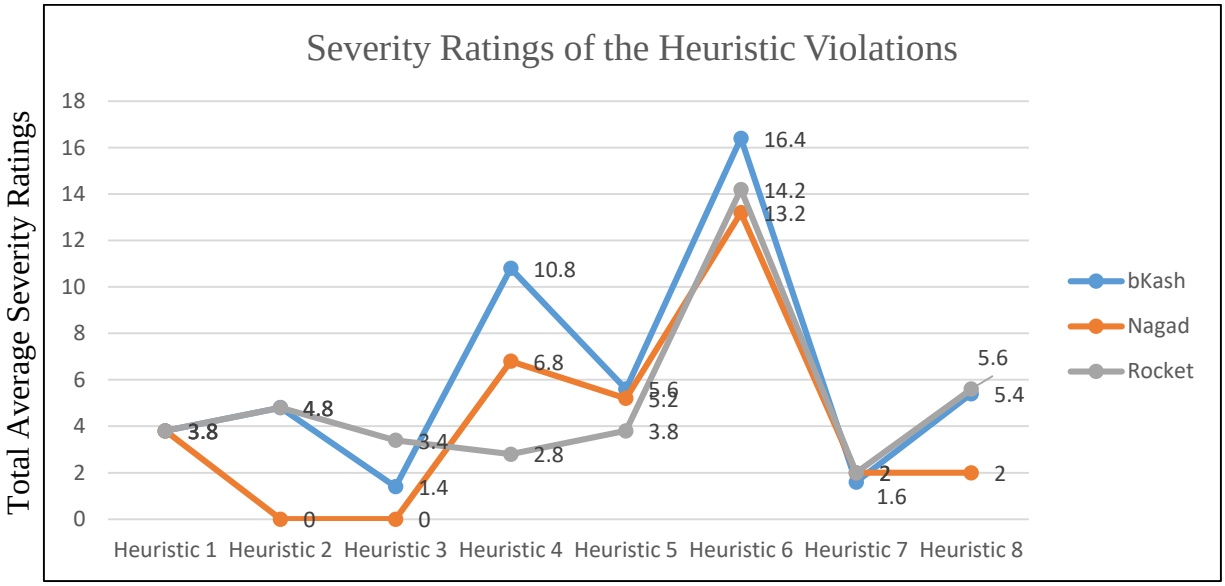



**Fig. 3.5:** Severity ratings of heuristic violations in the applications.

The following usability problems are found common to all the MFS applications (as discussed in Appendix A, B, and C) and need to be resolved with high priority:

- "Zoom In" option is not available in all three MFS applications. It would help the aged users to read the write ups or see the icons more clearly. The "Zoom In" problem falls under Heuristic 5 (Ease of input, screen readability and glanceability) and the usability problem has been graded as a catastrophic usability problem. So, this problem needs to be addressed urgently to achieve better usability.
- Guidelines are not provided about "the usage of different options" or "tasks that can be completed by a sequence of steps" in the MFS applications. Issues related to not providing guidelines of how to use various options of an application or how to perform specific tasks by a particular application violates Heuristic 1 (Visibility of system status and findability of the mobile device) and it is also graded as a usability catastrophe. So, this issue should also be resolved as soon as possible.
- Icons are comparatively larger than the labels/texts and the labels/texts are difficult to read. When an icon is not intuitive enough to give a clear meaning to the users, the users rely on the label/text below the icon to get the actual meaning of the icon, i.e., what this icon is all about or what option does it offer. Small font size in the labels of the Icons is a problem for the common users specially the aged users. This violates Heuristic 4 (Good Ergonomics and Minimalist Design) and regarded as a major usability problem which needs to be addressed with high priority.
- There are many advertisements in the UIs especially in the first page (splash screen/home page/landing page) of the application which makes the page cluttered and clumsy for users. This common usability problem speaks about the presence of so many advertisements on the UIs cluttering the UIs and causing discomfort to the common users. This problem violates both Heuristic 4 (Good Ergonomics and Minimalist Design) and Heuristic 7 (Aesthetic, Privacy and Social Conventions) and graded as a minor usability problem which should be fixed as per priority.

Aggregated findings of heuristic evaluation are presented as under:

- Although bKash is having the highest number of heuristic violations, its average severity ratings is the lowest, i.e., bKash is more usable than other applications.

- Common and most violated heuristics for all the applications is H6 (Flexibility, Efficiency of Use, and Personalization) followed by H4 (Good ergonomics and minimalist design), i.e., the UI designers need to consider these two issues more seriously while designing an application.
- Catastrophic usability problems (e.g. usability problem no 11 & 13 of bKash, usability problem no 6 & 7 of Nagad, and usability problem no 12 & 14 of Rocket) need to be resolved without delay and major usability problems (e.g. usability problem no 8, 12 & 14 of bKash, usability problem no 4 & 8 of Nagad, and usability problem no 2, 8 & 9 of Rocket) should be resolved with high priority.

## 3.3 Conduct of Semiotic Evaluation

The semiotic evaluation investigates the intuitiveness of the UI elements of the selected applications that includes signs, symbols, navigation links, buttons, thumbnails, and other visual directives (Islam, Bouwman and Islam, 2020). Total 27 interface signs were selected for the semiotic evaluation including nine interface signs from each of the MFS applications (bKash, Nagad, and Rocket). These nine interface signs are common in all three applications according to their tasks specifications. The intuitiveness of the selected interface signs are assessed within a range of 1-9, where *1-3* signifies *low intuitiveness*; *4-6* implies *medium intuitiveness*; and *7-9* denotes *high intuitiveness*. During the assessment, the problems associated with the interface signs are discussed and probable solutions are suggested.

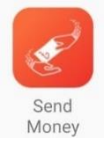
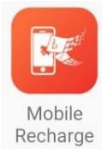
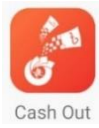
### 3.3.1 Procedural Guidelines for Evaluating Interface Signs

- Understanding the applications under study and modeling the profiles of end-users
  - Understanding the application: the domain, name, purpose and functionality of the application (i.e., what do they want to communicate or provide?)
  - Modeling the profiles of the focused end-users based on their familiarity with ontologies
- Evaluating or investigating the selected interface signs
  - *Step 1*: Understanding the referential meaning of the selected interface sign.

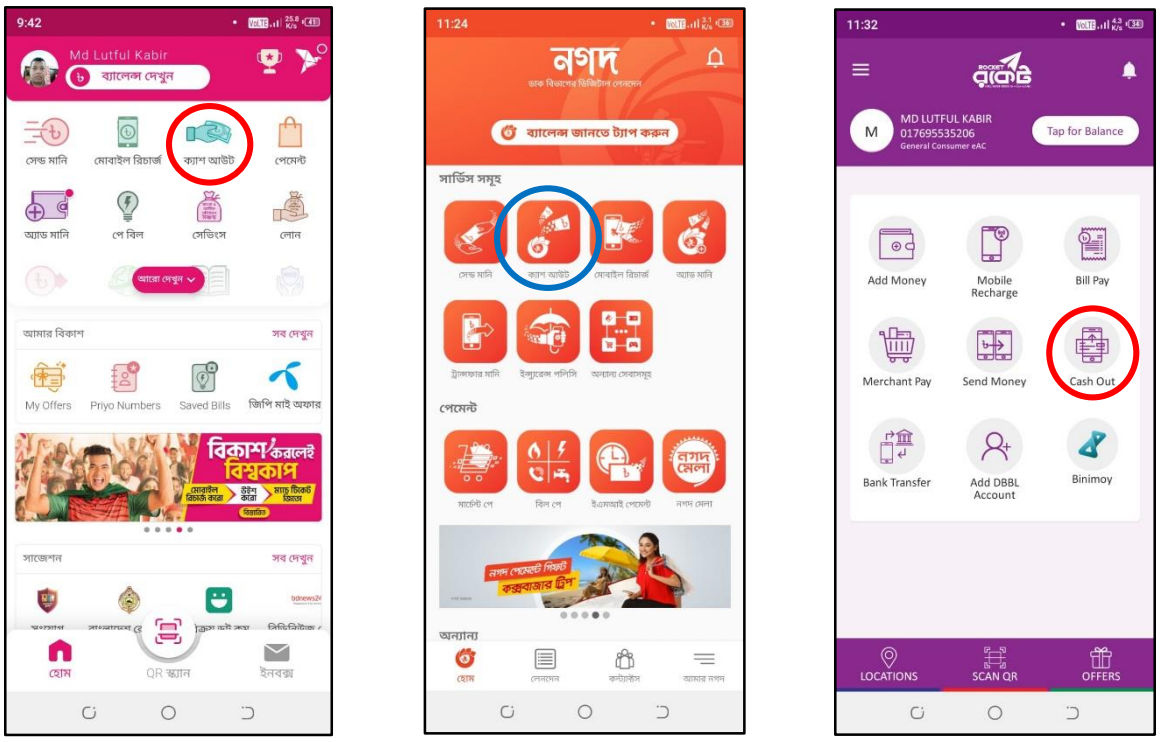
- *Step 2*: Analyzing or evaluating the selected interface sign. (What properties of the signs are used? What properties are missing?)
- *Step 3*: Assessing the intuitiveness level (high/moderated/low). (How accurately can the user interpret the sign? How complicated or difficult is it for the users to interpret this sign? How certain or confident are the users in their interpretation? How transparent is the sign in terms of its actual content/meaning?)
- *Step 4*: Recommending possible design solutions, where necessary, to improve the intuitiveness of the sign. (How can the sign be made more intuitive to end-user? hat properties of the signs can be used to improve the intuitiveness of the sign?)

Here, it is important to mention that Step 1 needs to be carried out once for each application, while step 2 needs to be carried out repeatedly for each sign selected for evaluation.

**Table 3.6:** Interface signs selected for semiotic evaluation

| **Purpose of the Interface Sign** | **bKash** | **Nagad** | **Rocket** |
|---|---|---|---|
| Logo |  |   |   |
| Send Money |   |   |   |
| Mobile Recharge |   |   |   |
| Cash Out |   |   |   |
| Pay Bill/ Bill Pay |   |   |   |

| Purpose of the Interface Sign | bKash | Nagad | Rocket |
|---|---|---|---|
| Make Payment/ Merchant Pay | Make Payment | Merchant Pay | Merchant Pay |
| Add Money/ Bank Transfer | Add Money | Add Money | Bank Transfer |
| Tap for Balance | ap for Balance | Tap for Balance | Tap for Balance |
| Log out/ Sign out | Log out | Sign out | Logout |




(a) (b) (c)

**Fig. 3.6:** The 'Cash Out' signs are marked from (a) bKash, (b) Nagad, and (c) Rocket.

### 3.3.2 Investigating the Selected Interface Sign - 'Cash Out'

*Step1: Understanding the referential meaning of the selected interface signs.*

The 'Cash Out' sign represents the option to withdraw money in cash from an account. For drawing money from an MFS (bKash/Nagad/Rocket) account, the user has to go to an authorized agent of that MFS, get the agent's name or agent number, and put that name/number in the MFS application to receive the cash money from that agent. The agent will receive instruction from the MFS Company to his (agent's) mobile application for providing the cash money to the MFS user. For a new user, this 'Cash Out' option seems to be difficult to understand. The sign does not give a clear idea of what to do and how to do.

*Step 2: Analyzing or evaluating the selected interface signs by the semiotic heuristics at five levels (Table 3.7):*

**Table 3.7:** Evaluation of the selected interface signs by the semiotic heuristics

a. Syntactic Level:

| **Cash Out** | **bKash** | **Nagad** | **Rocket** |
|---|---|---|---|
| |  |  |  |
| SH1 | The sign or the icon does not present the purpose of interactivity. Cash money is shown in the hand but who is receiving or giving the money is not understood from the icon. | The sign shows that money is going out of the Nagad logo. However, the purpose of interactivity is not much clear from this icon. | The sign presents that money is going out from the mobile. But is this money going to another Rocket account or a bank account or the MFS user (Rocket account holder) himself withdrawing the money in cash, this is not clear from the icon. |
| SH2 | To design this interface sign color could not be used effectively to make this sign more intuitive. | The sign has been placed within a background color and this background color resembles the theme color of Nagad with is red orange color. Color could be more efficiently | Poor use of color combination has been used for this sign. The icon is represented by purple color which is the theme color. |

| Cash Out | bKash | Nagad | Rocket |
|---|---|---|---|
| |  |  |  |
| | | used to make the icon more intuitive. | |
| SH3 | The sign or representamen is readable and clearly noticeable. But the textual part of the icon is relatively smaller. | The sign is readable and clearly noticeable. Its textual part is also relatively smaller. | This sign is readable and noticeable. Here textual part is more clearly visible. |
| SH4 | The sign presentation is clear and concise. | This sign presentation is relatively clumsy especially due to the color combination. | This sign presentation is somehow clumsy due to the design itself. |
| SH5 | The context of this sign is not fully appropriate. | The context of this sign is also partially appropriate. | Creation of the context of this sign is somehow appropriate. |
| SH6 | This interface sign design is not much consistent with other signs of this application. | This sign is quite consistent with its interface sign design strategy. | This sign is quite consistent with its interface sign design strategy. |

b. Pragmatic Level:

| Cash Out | bKash | Nagad | Rocket |
|---|---|---|---|
| |  |  |  |
| SH7 | As ‘Cash Out’ is one of the major activity in MFS, therefore this particular interface sign is rightly placed in the home page of this application. | This particular interface sign is placed in the proper position in the home page UI. | This particular interface sign is also placed in the proper position in the home page UI. |
| SH8 | Effective use of amplification features have not been utilized properly for the signs | Effective use of amplification features have not been utilized | Effective use of amplification features have not been utilized |

| Cash Out | bKash | Nagad | Rocket |
|---|---|---|---|
| |  |  |  |
| | or icons. For example, no help file or user assistance guidelines are visible in the home page of the application. The very name of the icon/sign 'Cash Out' is confusing especially for a new user. Therefore, a 'guidance UI' could be introduced in this application which would appear after touching the 'Cash Out' icon. This 'guidance UI' would tell the purpose of this option and methods by which this activity can be completed. The 'guidance UI' would direct the user to the subsequent activity page. | properly for the signs or icons. | properly for the signs or icons. |
| SH9 | The relations among the interface signs of bKash is moderate. | Relations among the interface signs of Nagad UIs is good. | Relations among the interface signs of Rocket UIs is also good. |
| SH10 | The logical coherence in interface sign design could not be retained properly. | The logical coherence in interface sign design is maintained in a better way. | The logical coherence in interface sign design could be retained in a better way than bKash. |

c. Social Level:

| Cash Out | bKash | Nagad | Rocket |
|---|---|---|---|
| |   |   |   |
| SH11 | This sign is not a culturally sensitive one. Here cash out can be explained in simple terms as money taken out of an MFS (bank) account. Bank has a culturally sensitive sign in Bangladesh. Therefore, instead of the Nagad logo, a small mud made bank sign could be used. | Design of 'Cash Out' interface sign is not culturally sensitive or reactive. A culturally sensitive interface sign would have described the purpose of the sign more conveniently to the users. | This is also not a culturally sensitive or reactive sign. |
| SH12 | This interface sign matches with the reality, conventions, or real world objects to some extent. | This interface sign hardly matches with the reality, conventions, or real world objects that much. | This interface sign matches very little with the reality, conventions, or real world objects. |
| SH13 | Effective use of organizational features have been made in the UIs of bKash. | Effective use of organizational features have been made in the UIs of Nagad. | Effective use of organizational features have been made in the UIs of Rocket. |
| SH14 | Application of this semiotic heuristic is not followed properly. | Metaphors and attributing properties have not been used properly in this sign. | Metaphors and attributing properties have not been used properly in this sign. |

d. Environment Level:

| Cash Out | bKash | Nagad | Rocket |
|---|---|---|---|
| |   |   |   |
| SH15 | By modelling the profiles of the focused end-users, the kind of | The end-users of this MFS application entails users of diverse category | The user profiling shows that all kinds of people of our society use this |

| | | | |
|---|---|---|---|
| | users for whom the application is being designed can be well understood. bKash is used by the people of all walks of lives. However, most of the users belong to the middle-class and lower middle-class segment of our society. | that includes digitally educated, semi-educated, and uneducated users, financially solvent, mediocre, and poor users, etc. So, if the profiles of focused end-users are modelled, it will include all kinds of users. | MFS application. However, it is at times purpose oriented. |
| SH16 | Effective use of ontological guidelines has not been made. | Ontological guidelines have not been used effectively. | Ontological guidelines have not been followed effectively. |

e. Semantic Level:

| **Cash Out** | **bKash** | **Nagad** | **Rocket** |
|---|---|---|---|
| |   |   |   |
| SH17 | The designer want to mean that someone is handing over cash money to the user while the user may think that he is giving cash money to someone else or he is receiving cash money from someone else. So, the designer's encoded meaning and the user's decoded meaning does not match properly. | The designer intends to mean that money is going out of Nagad account while the user might think that money if flying out of Nagad account i.e., money is sent to some other account. Hard cash money withdrawal is not clearly understood from the sign or icon. So, there is a distinct difference between the designer's thinking and the uers's understanding. | The designer intends to mean that money is going out of the mobile account while the user is likely to think that money is being transferred to some other account or money is taken out. The actual meaning of 'Cash Out' is properly reflected by this sign. So, both the designer and the user are not fully in the same line of interpretation. |

Step 2 is repeated for all the signs/icons for analyzing/evaluating the selected interface signs through the semiotic heuristics.

*Step 3: Assessing the intuitiveness level of the signs (high/moderate/low).*

Based on the analysis in Step 2, the intuitiveness scores of all 27 signs or icons of the three MFS applications have been assessed. The intuitiveness scores are shown in following table:

**Table 3.8:** Intuitiveness scores of the selected interface signs through semiotic evaluation

| Ser | Interface Signs | bKash | Nagad | Rocket |
|---|---|---|---|---|
| 1. | Logo | 4 | 5 | 3 |
| 2. | Send Money | 4 | 7 | 8 |
| 3. | Mobile Recharge | 4 | 4 | 7 |
| 4. | Cash Out | 5 | 5 | 6 |
| 5. | Pay Bill/ Bill Pay | 6 | 8 | 7 |
| 6. | Make Payment/ Merchant Pay | 5 | 7 | 8 |
| 7. | Add Money/ Bank Transfer | 3 | 5 | 8 |
| 8. | Tap for Balance | 8 | 8 | 8 |
| 9. | Log out/ Sign out | 8 | 7 | 7 |
| **Average Intuitiveness Score** | | **5.22** | **6.22** | **6.88** |

The summary of intuitiveness score is shown in Table 3.8. The intuitiveness scores of the 'Cash Out' icon of bKash, Nagad and Rocket are 5, 5 and 6 respectively. The 'Cash Out' icon of bKash violates two syntactic heuristics (SH2, SH5, and SH6) as it has not made the effective use of color and it does not clearly refer to its purpose. The 'Cash Out' icon of Nagad violates few heuristics like syntactic heuristic (SH4) as it is not very clear and concise in its presentation. The 'Cash Out' icon of Rocket violates a number of heuristics including syntactic heuristic (SH5) as it does not represent the context of its function very clearly.

*Step 4: Recommending possible design solutions, where necessary, to improve the intuitiveness of the sign.*

- The aggregated findings of semiotic evaluation shows that Rocket is having the highest average intuitiveness score, Nagad is having the 2nd highest average intuitiveness score, and bKash is having the lowest average intuitiveness score.
- Following guidelines have been followed to redesign the interface signs/icons:
  - Interface signs that shows low intuitiveness score (1-3) must be redesigned and replaced, e.g., Add Money/Bank Transfer sign of bKash and the logo of Rocket.
  - Interface signs that shows medium intuitiveness score (4-6) should be redesigned and replaced, e.g., Send Money of bKash and Mobile Recharge sign of bKash and Nagad.

### 3.3.3 Analysis and Findings

The results of semiotic evaluation are shown in Table 3.8. bKash shows medium intuitiveness (4-6) in six interface signs out of nine selected signs, high intuitiveness (7-9) in two interface signs and low intuitiveness (1-3) for the remaining one interface sign. Nagad shows high intuitiveness (7-9) in five interface signs out of nine selected signs and medium intuitiveness (4-6) for the remaining four interface signs. Rocket shows high intuitiveness (7-9) in seven interface signs out of nine selected signs, medium intuitiveness (4-6) in one interface signs and low intuitiveness (1-3) for the remaining one interface sign. The average intuitiveness for the selected interface signs for bKash, Nagad and Rocket are 5.22, 6.22 and 6.88 respectively. As Rocket is having the highest average intuitiveness score (6.88), therefore from the semiotic perspective Rocket is the most intuitive MFS application among these three applications and the interface signs of this application are easily understandable. Nagad is having the 2nd highest average intuitiveness score (6.22), which refer that interface signs of this application are moderately intuitive and reasonable. bKash is having the lowest average intuitiveness score (5.22), therefore bKash need to redesign their interface signs to make them more intuitive and increase contextual representation.

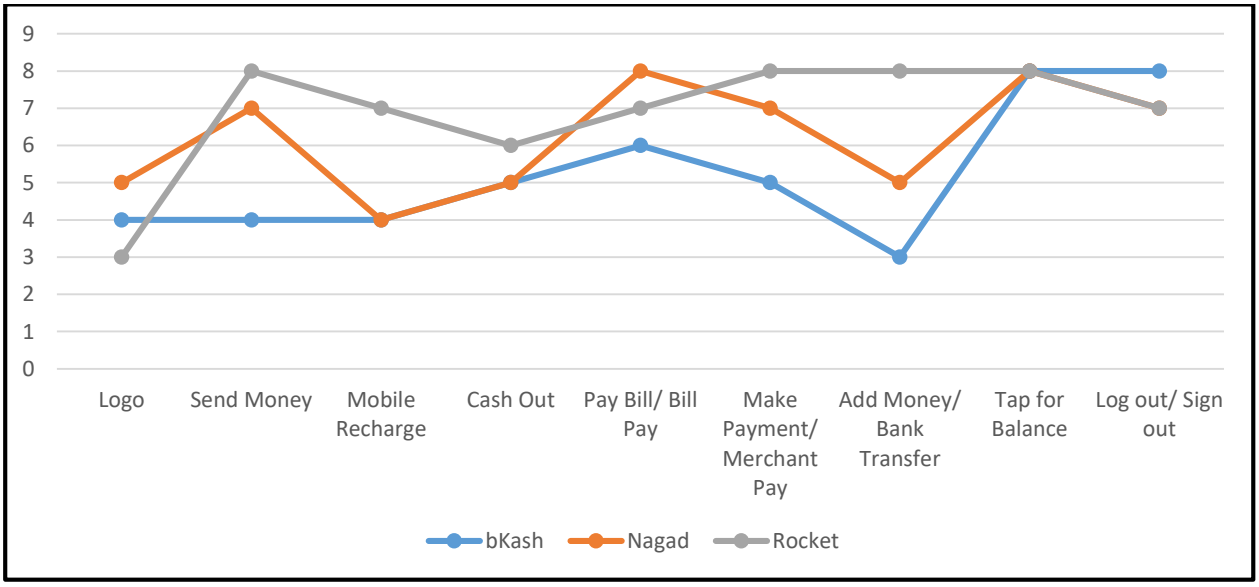



**Fig. 3.7:** Comparative intuitiveness scores of the selected interface signs.

Due to the lack of intuitiveness following interface signs of the three MFS applications should be redesigned considering the violations of the semiotic heuristics:

- Add Money/Bank Transfer, Send Money, and Mobile Recharge signs of bKash
- Mobile Recharge Nagad
- Logo of Rocket

Besides, all the signs/icons should be newly designed in the prototypical UIs considering the semiotic heuristics.

## 3.4 Conduct of User Study Evaluation

In this research, a user study evaluation is conducted to evaluate the performance of the selected MFS applications from the HCI perspective. Detailed procedure and results of this evaluation is discussed in the following sub-sections.

### 3.4.1 Participants' Profile

Total thirty respondents took part in the user study evaluation of which fifteen were men and fifteen were women. They were selected randomly from Dhaka city. Their age is between thirty to sixty years. They are from varying occupations including housewives, gatekeepers, and drivers. All of them are capable reading and writing in Bengali. Nineteen participants are capable of reading and writing in English, rest eleven barely understand basic level English. All had experience of using Android based smartphones (WhatsApp, Viber, Facebook Messenger, Imo, etc). Fourteen of the participants had experience of using MFS applications by themselves, rest sixteen knew about bKash, Nagad, and Rocket but did not use personally.

### 3.4.2 Study Procedure

All participants were taken through an experiment session following the steps below:

- Participants were briefed separately about the purpose of the study. It was made clear to them that the experiment/survey was not aimed to assess them. The purpose was to evaluate the existing MFS applications. It was ensured that participants provide an unbiased opinion about the overall application functionalities and performance during the experiment.
- Then participants were provided with a short training of 5–10 minutes individually so that they are able to demonstrate how to use different MFS applications.

- After completion of the training, the participants were asked to perform two main tasks by each of the selected MFS applications:
  - Task 1: Navigate to ‘Send Money’ option.
  - Task 2: Complete ‘Send Money’ operation.

At last, all participants were asked to complete a set of post-test questionnaires.

### 3.4.3 Study Evaluation

Every user took different time to complete the assigned tasks. Their tapping behavior was also different from each other based on various factors like their previous exposure to MFS applications and digital media, education background, age, etc. All relevant data were recorded by the evaluators and filled up in the data sheet. The summarized output of the evaluation is shown in Table 3.9.

**Table 3.9:** Summarization of the user evaluation study for all m-banking applications

| Evaluation Metrics | Data Type | Tasks | Average Value | | |
|---|---|---|---|---|---|
| | | | bKash | Nagad | Rocket |
| Effectiveness | Tapping Behavior (no of taps required to perform a task) | Task 1 | 13.33 | 10 | 13.33 |
| | | Task 2 | 27.67 | 26.33 | 29.33 |
| | No of Attempts | Task 1 | 1.33 | 2 | 1 |
| | | Task 2 | 2 | 2 | 1.67 |
| Efficiency | Completion Time (Sec) | Task 1 | 18.67 | 17.67 | 54 |
| | | Task 2 | 47.33 | 35 | 63.67 |
| | Asked for Help (no of times) | Task 1 | 2 | 1 | 2.33 |
| | | Task 2 | 2 | 2 | 2 |
| Satisfaction | Overall Satisfaction | - | 2.33 | 2 | 2 |
| | Easy to Use | - | 2 | 2.33 | 2.33 |
| | Easy to Learn | - | 2.33 | 2.67 | 3 |
| | Future Use | - | 3.33 | 1.67 | 3.33 |
| | Recommendation | - | 3.33 | 2.33 | 3.33 |

### 3.4.4 Analysis and Findings

The data derived from the above study were analyzed to identify the usability parameters according to ISO-1998 that includes effectiveness, efficiency, and satisfaction for the selected applications.

*Effectiveness*: Effectiveness is the accuracy and completeness to achieve goals. In this study, two variables were considered to measure effectiveness: (a) tapping behavior (number of taps used to perform a specific task), (b) number of attempts (how many times users tried to complete the task successfully). The result shows that for task 2, the average tapping activity among the users was quite consistent, however, this is not totally true for task 1. Although only bKash and Rocket have larger tapping behavior in task 1, for task 2 has the same highest tapping behavior in both bKash and Rocket. As a result, it can be deduced that users had greater difficulty navigating the option than completing the transaction. Additionally, Table 3 shows that the number of attempts is higher for bKash and Rocket than it is for the other 3 applications. Therefore, findings from effectiveness perspective are:

- The design should be created in such a way that the navigation may be completed swiftly and with minimal effort.
- Self-explanatory options should be provided as well as suitable help documents on each page so that users may receive sufficient guidance during the execution of each activity, making it easier for them to complete the tasks without serious problems.

*Efficiency*: Efficiency is the resources expended to complete a task successfully. In this study, two variables have been used to measure efficiency: task completion time (time taken to complete a task) and number of times help was sought for (number of times help asked from the researcher). The result shows that the task completion time for tasks 1 and 2 is relatively long, implying that users were confused and had difficulties completing the tasks correctly. Therefore, findings from efficiency perspective are:

- Some users were confused and had difficulties completing the tasks correctly. For all the applications, few users asked for assistance in doing the tasks.
- Effective voice assistance on each UI of the program in native language can be incorporated, allowing users to understand how to do each task successfully without having to look for assistance.

*Satisfaction*: Satisfaction is the participants' positive attitudes towards using the application. In this study, to measure satisfaction, five questions were asked encompassing: overall satisfaction level, ease of use, ease of learning, willingness to use the application in the future, and willingness to recommend it to others. These questions were measured using the 5-point Likert Scale, a type of response scale where the respondents can specify their level of agreement with a statement with answer scales typically ranging from 1 to 5 where '1'

represents ‘Strongly Disagree’, ‘2’ represents ‘Disagree’, ‘3’ represents ‘Neither Agree nor Disagree’, ‘4’ represents ‘Agree’, and ‘5’ represents ‘Strongly Agree’. User satisfaction has been measured by giving numbers to the questions from 1 to 5.

Analyzing the results of user study evaluation, following aspects are identified in regards to usability:

- From effectiveness perspective, in terms of tapping behavior Nagad leads the table, i.e., bKash and Rocket have scopes to improve; and in terms of number of attempts to accomplish certain tasks, Rocket leads other to applications by margin.
- With regards to efficiency, Nagad showed better performance among the three applications in terms of task completion time and number of times help was sought for.
- In respect of user satisfaction, all the MFS application showed almost equal results in different categories. However, bKash was preferred by the users for overall satisfaction.

Due to higher degree of integration with different utility services, merchant pay, and financial institutions, making multifarious payments through bKash is always easier than that of Nagad and Rocket. The findings of user study evaluation shows that from the perspective of user satisfaction, the values for all MFS applications are in the range of 2-3 which is not very satisfying. Since the users’ satisfaction is at the semi-moderate or moderate level, it is very important to improve the usability standard of the MFS applications for better assimilation by the digitally illiterate or common people, which will ultimately boost the application’s overall usage in Bangladesh.

## 3.5 Summary Findings

Summary finding of usability evaluation techniques i.e. heuristic evaluation, semiotic evaluation, and user study evaluation can be recorded as follows:

- From heuristic evaluation perspective, all the applications (bKash, Nagad, and Rocket) have been identified with a good number of usability problems. Considering the severity ratings of those problems, necessary design modification is to be done while implementing the prototypes of various UIs.
- From semiotic evaluation perspective, some of the signs (digital buttons) have been identified with low/medium intuitiveness scores. Those signs are to be redesigned to improve the overall intuitiveness score of the applications.

- From user study evaluation, it is identified that the effectiveness, efficiency, and user satisfaction score of the applications need to be improved further to increase the usability and improve the UX of these applications.

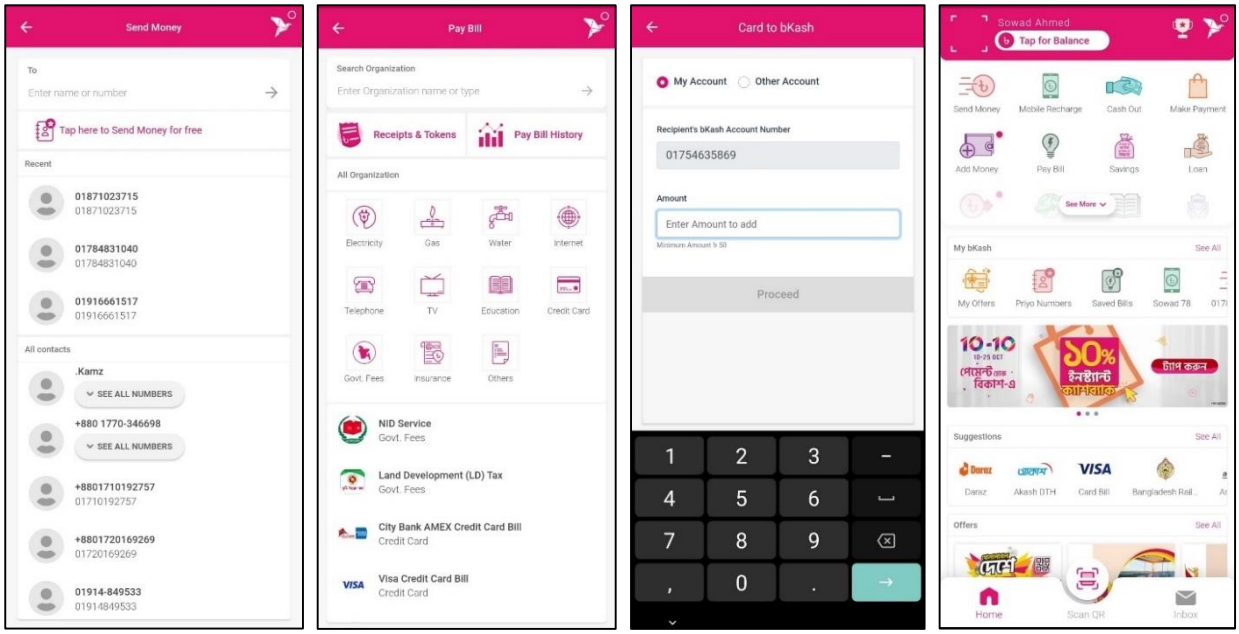
# CHAPTER 4
# ACCESSIBILITY EVALUATION

This chapter presents the Accessibility Evaluation (AE) of the MFS applications. Accessibility testing is the practice of making a web and mobile application usable to as many people as possible. Accessibility evaluation of selected MFS Applications (bKash, Nagad, and Rocket) are conducted based on Web Content Accessibility Guidelines (WCAG) 2.1 guidelines which are organized on four main principles i.e. perceivable, operable, understandable, and robust.

## 4.1 Study Procedure

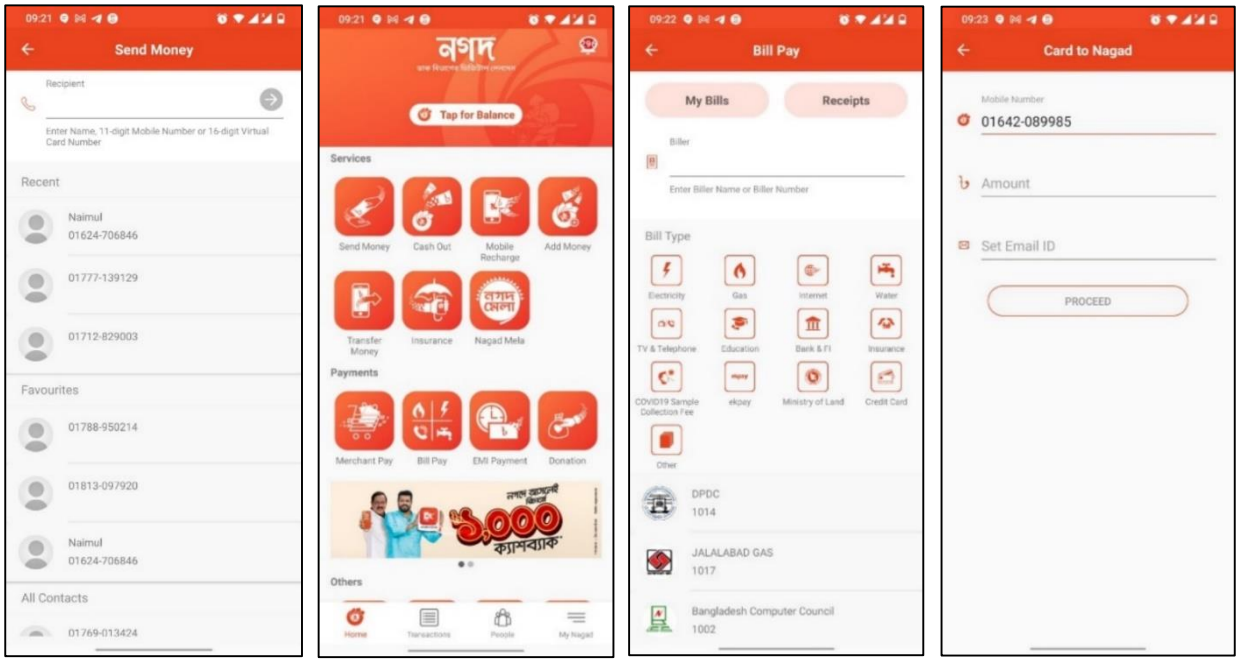
A web application/ mobile application need to be designed in a way so that optimized accessibility can be achieved. Wille et al. (2016) proposed few test procedures for checking the WCAG 2.0 guidelines in order to ensure enhanced accessibility. Both online and offline tools are available to measure the level of accessibility of various applications that work on the principles of WCAG. However, manual test procedures are considered to be more reliable method for conducting accessibility evaluation since human instincts can be applied in this evaluation process. A group of HCI experts conduct the accessibility tests of certain web or mobile applications based on the principles and guidelines outlined in WCAG 2.1. In this research, accessibility evaluation is conducted following manual test method.

Initially, four UIs with similar functions (Send Money, Pay Bill, Add Money, and Homepage) from all three MFS applications (shown in Fig. 4.1, 4.2, and 4.3) have been selected for conducting the accessibility evaluation. Then the accessibility evaluation team consisting of four HCI evaluators (lead by the researcher) conducted the evaluation independently. Sample output of such an accessibility evaluation of bKash, Nagad, and Rocket MFS application by an individual evaluator is attached as *'Appendix D'* to this research paper. On completion of individual evaluation by the evaluators, all derived data are compiled to present an aggregated result in regards to the accessibility status of the UIs evaluated. This evaluation gives the right picture about the accessibility condition of all the MFS applications under study. The combined report of accessibility evaluation is manifested in Table 4.1.



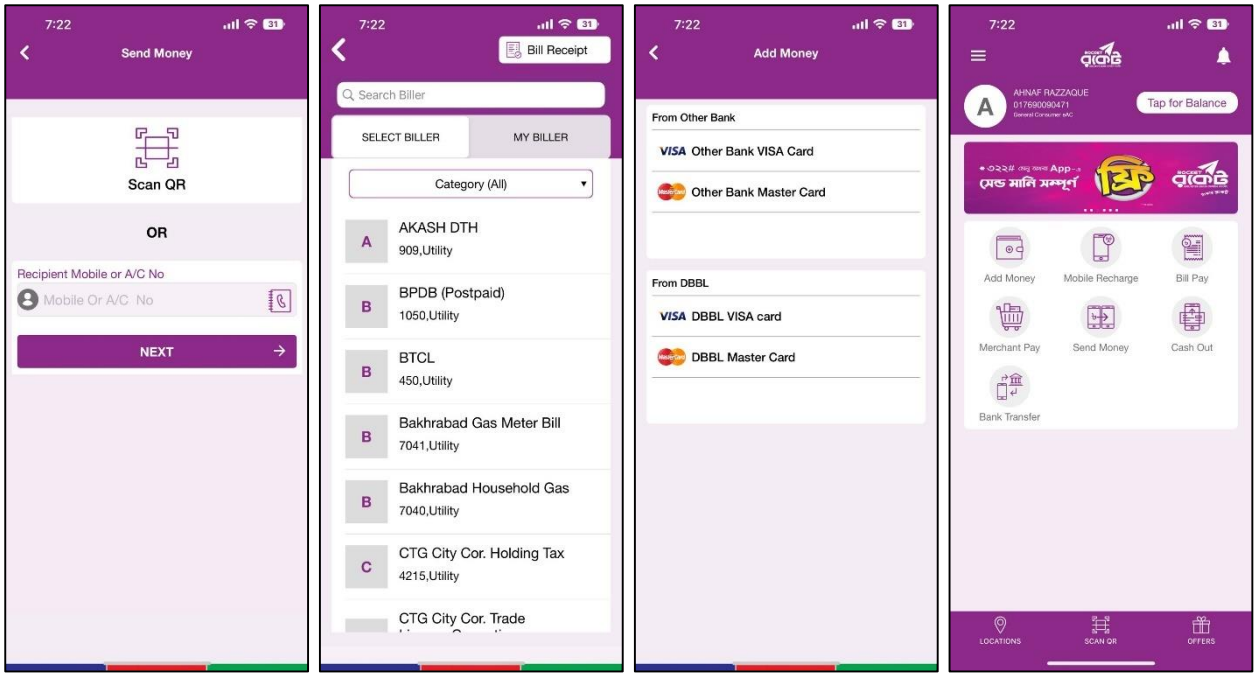

A1= Send Money A2 = Pay Bills A3 = Add Money A4 = Homepage

**Fig. 4.1:** bKash UIs selected for accessibility evaluation.




B1 = Send Money B2 = Bill Pay B3 = Card to Nagad B4 = Homepage

**Fig. 4.2:** Nagad UIs selected for accessibility evaluation.




C1 = Send Money C2 = Pay Bills C3 = Add Money C4 = Homepage

**Fig. 4.3:** Rocket UIs selected for accessibility evaluation.

The evaluators had few differences in their opinions about the conformance of some of the guidelines outlined in WCAG. However, the evaluators came to a common consensus on their differences after discussing the issues which are mentioned as 'Group Analysis' in Table 4.1.

**Table 4.1:** Summary result of the evaluation of MFS applications by all the evaluators

| Accessibility Principles | Evaluators | bKash | | | | Nagad | | | | Rocket | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A1 | A2 | A3 | A4 | B1 | B2 | B3 | B4 | C1 | C2 | C3 | C4 |
| *Perceivable information and user interface* | | | | | | | | | | | | | |
| 1. Text alternatives for non-text content | E1 | no | yes | yes | yes | no | yes | yes | no | yes | no | yes | no |
| | E2 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| | E3 | yes | yes | yes | yes | yes | yes | yes | yes | yes | no | yes | yes |
| | E4 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| 2. Caption and another | E1 | no | yes | no | yes | no | yes | yes | no | no | no | no | yes |
| | E2 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |

| Accessibility Principles | Evaluators | bKash | | | | Nagad | | | | Rocket | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A1 | A2 | A3 | A4 | B1 | B2 | B3 | B4 | C1 | C2 | C3 | C4 |
| alternative for multimedia | E3 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| | E4 | yes | yes | yes | yes | yes | yes | yes | no | yes | yes | yes | yes |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| 3. Content can be presented in different ways | E1 | no | no | no | yes | no | no | no | no | no | no | no | no |
| | E2 | no | no | no | yes | no | no | no | no | no | no | no | no |
| | E3 | no | no | no | no | no | no | no | no | no | no | no | no |
| | E4 | no | no | no | yes | no | no | no | no | no | no | no | yes |
| Group Analysis | All | no | no | no | yes | no | no | no | no | no | no | no | no |
| 4. Content is easier to see and hear | E1 | yes | yes | no | yes | no | yes | yes | no | yes | yes | yes | yes |
| | E2 | yes | no | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| | E3 | yes | yes | yes | yes | yes | yes | yes | yes | yes | no | yes | yes |
| | E4 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| *Operable user interface and navigation* | | | | | | | | | | | | | |
| 5. Functionality is available from a keyboard | E1 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E2 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E3 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E4 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| 6. Users have enough time to read and use the content | E1 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| | E2 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| | E3 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E4 | yes | yes | yes | yes | yes | yes | yes | no | yes | yes | yes | yes |

| Accessibility Principles | Evaluators | bKash | | | | Nagad | | | | Rocket | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A1 | A2 | A3 | A4 | B1 | B2 | B3 | B4 | C1 | C2 | C3 | C4 |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | no | yes | yes | yes | yes |
| 7. Content does not cause seizures and physical reactions | E1 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | no |
| | E2 | yes | yes | yes | yes | yes | yes | yes | yes | yes | no | yes | yes |
| | E3 | yes | yes | yes | yes | yes | yes | no | yes | yes | yes | yes | yes |
| | E4 | yes | yes | no | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| 8. Users can easily navigate, find content, and determine where they are | E1 | yes | yes | yes | yes | no | yes | yes | no | no | yes | no | no |
| | E2 | yes | yes | yes | yes | yes | yes | yes | no | no | yes | yes | no |
| | E3 | yes | yes | yes | yes | yes | yes | yes | no | no | yes | yes | no |
| | E4 | yes | yes | yes | yes | yes | yes | yes | no | no | yes | yes | no |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | no | no | yes | yes | no |
| 9. Users can use different input modalities beyond the keyboard | E1 | no | no | no | no | no | no | no | no | no | no | no | no |
| | E2 | no | no | no | no | no | no | no | no | no | no | no | no |
| | E3 | no | no | no | no | no | no | no | no | no | no | no | no |
| | E4 | no | no | no | no | no | no | no | no | no | no | no | no |
| Group Analysis | All | no | no | no | no | no | no | no | no | no | no | no | no |
| *Understandable information and user interface* | | | | | | | | | | | | | |
| 10. Text is reliable and understandable | E1 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| | E2 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | no | no |
| | E3 | yes | yes | yes | yes | yes | yes | yes | yes | yes | no | yes | no |
| | E4 | yes | yes | yes | no | yes | yes | yes | yes | yes | no | no | no |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | no |

| Accessibility Principles | Evaluators | bKash | | | | Nagad | | | | Rocket | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **A1** | **A2** | **A3** | **A4** | **B1** | **B2** | **B3** | **B4** | **C1** | **C2** | **C3** | **C4** |
| 11. Content appears and operates in predictable ways | E1 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E2 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E3 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E4 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| 12. Users are helped to avoid and correct mistakes | E1 | yes | yes | yes | no | yes | no | no | yes | no | yes | yes | no |
| | E2 | yes | yes | yes | yes | no | no | no | no | no | yes | yes | no |
| | E3 | no | no | no | no | no | no | no | no | no | no | no | no |
| | E4 | no | yes | yes | yes | no | yes | yes | no | no | yes | yes | no |
| Group Analysis | All | no | yes | yes | no | no | no | no | no | no | yes | yes | no |
| *Robust content and reliable interpretation* | | | | | | | | | | | | | |
| 13. Content is compatible with current and future user tools | E1 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E2 | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| | E3 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| | E4 | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Group Analysis | All | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |

After compiling the derived data from the individual accessibility evaluations, the output is then numerically calculated in Table 4.2 to find out the accessibility scores of the MFS applications. The total accessibility score is calculated out of 50 points where 'four *Perceivable* guidelines' bear 15.5 points, 'five *Operable* guidelines' bear 19 points, 'three *Understandable* guidelines' bear 11.5 points, and 'the single *Robust* guideline' bears 4 points. Based on the 'Group Analysis' feedbacks from Table 4.1, the accessibility scores of bKash, Nagad, and Rocket have been calculated and shown in the following table.

**Table 4.2:** Accessibility score calculation of the MFS applications on selected four UIs (based on POUR principles/sub-parameters)

| Accessibility Principles and Guidelines with Allotted Score | bKash | | | | Nagad | | | | Rocket | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A1** | **A2** | **A3** | **A4** | **B1** | **B2** | **B3** | **B4** | **C1** | **C2** | **C3** | **C4** |
| *Perceivable information and user interface (15.5)* | | | | | | | | | | | | |
| 1. Text alternatives for non-text content (4) | 4 | | | | 3 | | | | 3 | | | |
| 2. Caption and another alternative for multimedia (4) | 4 | | | | 3 | | | | 3 | | | |
| 3. Content can be presented in different ways (4) | 1 | | | | 0 | | | | 0 | | | |
| 4. Content is easier to see and hear (3.5) | 3.5 | | | | 2.6 | | | | 2.6 | | | |
| *Operable user interface and navigation (19)* | | | | | | | | | | | | |
| 5. Functionality is available from a keyboard (4) | 4 | | | | 4 | | | | 4 | | | |
| 6. Users have enough time to read and use the content (4) | 4 | | | | 3 | | | | 4 | | | |
| 7. Content does not cause seizures and physical reactions (4) | 4 | | | | 4 | | | | 4 | | | |
| 8. Users can easily navigate, find content, and determine where they are (3.5) | 3.5 | | | | 2.6 | | | | 1.75 | | | |
| 9. Users can use different input modalities beyond the keyboard (3.5) | 0 | | | | 0 | | | | 0 | | | |
| *Understandable information and user interface (11.5)* | | | | | | | | | | | | |
| 10. Text is reliable and understandable (4) | 4 | | | | 3 | | | | 2 | | | |
| 11. Content appears and operates in predictable ways (4) | 4 | | | | 4 | | | | 4 | | | |

| Accessibility Principles and Guidelines with Allotted Score | bKash | | | | Nagad | | | | Rocket | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A1 | A2 | A3 | A4 | B1 | B2 | B3 | B4 | C1 | C2 | C3 | C4 |
| 12. Users are helped to avoid and correct mistakes (3.5) | 1.75 | | | | 0 | | | | 1.75 | | | |
| *Robust content and reliable interpretation (4)* | | | | | | | | | | | | |
| 13. Content is compatible with current and future user tools (4) | 4 | | | | 4 | | | | 4 | | | |
| **Total (50)** | **41.75** | | | | **33.2** | | | | **34.1** | | | |

The level of user accessibility of bKash, Nagad, and Rocket have been measured through above accessibility evaluation. The summary results of this accessibility evaluation is given in Fig. 4.4.

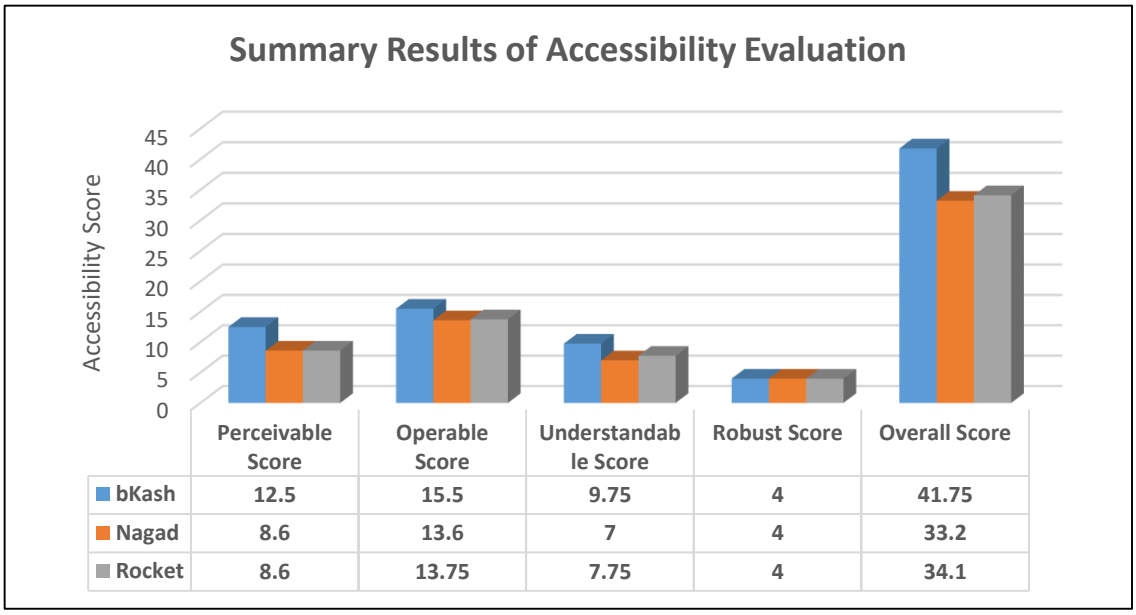



**Fig. 4.4:** Summary results of accessibility evaluation of MFS applications.

## 4.2 Analysis and Findings

From the accessibility evaluation by WCAG 2.1, it is identified that bKash has the highest level of accessibility among the MFS applications in Bangladesh as it scored 41.75 out of 50, i.e., the accessibility of bKash is 83.5%. The accessibility standards of both Nagad and Rocket are of almost equal standard. The accessibility percentage of Nagad and Rocket are 66.4% and 68.4% respectively. As such, necessary measures to improve the level of accessibility of Nagad and Rocket should be considered with due importance.

In the process of conducting the accessibility evaluation, the evaluators identified a number of accessibility issues in all the MFS applications. For example, in regards to Perceivability (Time based media), except bKash other mobile financial services do not provide QR Code to identify the account of the user. With reference to Operability (Other input modalities), all the applications are found to offer only PIN Code login facility. None of the MFS application offers other means of logging in like biometric logins. For Operability (Navigation), bKash and Nagad provides better navigation. On the contrary, Rocket (in many pages) do not display their current location. In Rocket application, the application crashes if the user tries to go back from certain pages.

In regards to Understandable (Reliability of text), Rocket application does not offer the user to choose preferable language on launching the application. For the principle of Understandable (Helping in avoiding mistakes), except bKash other financial applications do not provide early warning to users on sending money to invalid accounts. For the matter of Robustness (Incompatible), Rocket starts malfunctioning once the user clicks location tab on the homepage.

## 4.3 Chapter Summary

All MFS applications need to have more input modalities, e.g., biometrics, for making the applications more perceivable. Separate features for handicapped people/ people with special needs (e.g., text to speech feature in both Bengali and English languages, photo/ picture description, explaining things with the help of sign language, etc.) need to be integrated. Both Nagad and Rocket have more scopes of improvements in regards to their accessibility standards which include improving their interfaces, their features, and fixing the bugs. Options for making users aware of or blocking any wrong transaction (transaction in non-existing accounts) is available in bKash alone. This safety features must also be incorporated in other MFS applications.

# CHAPTER 5
# PROTOTYPE DEVELOPMENT AND SUS EVALUATION

This chapter discusses the revealed problems followed by development of prototypical UIs. These prototypes are relevant to specific UIs of the selected three MFS applications by which specific tasks can be performed. Prototypes have been developed considering the problems identified or findings from the usability and accessibility evaluations so that the usability and accessibility standard of the prototypical interfaces are near to perfection for users. At the end of this chapter, a SUS (System Usability Scale) evaluation is being conducted between relevant UIs of bKash, Nagad, Rocket, and the developed prototypical UIs. The output of the SUS evaluation presents the overall improvement of the MFS applications that could be achieved through this research work.

## 5.1 Problems Identified in Existing Applications

After completing the heuristic evaluation, semiotic evaluation, user study evaluation, and accessibility evaluation, the derived results are compiled and compared to draw following inferences related to the MFS applications:

- Though bKash is having the highest number of violations in heuristic evaluation, lowest average intuitiveness score in semiotic evaluation, and having few issues with error management, yet it is the most functional application among these three MFS applications which is reflected through its lowest average severity ratings in heuristic evaluation and highest overall user satisfaction in the user study evaluation. bKash has the highest accessibility score which makes it more usable by the users with special needs.
- Nagad is having the lowest number of heuristic violations and moderate average severity ratings in heuristic evaluation. It also showed moderate intuitiveness score in semiotic evaluation, and was found as the most user friendly application from the user study evaluation. However, Nagad falls behind bKash in terms of higher severity ratings in heuristic evaluation and low score in overall user satisfaction of user study evaluation. Accessibility score of Nagad is the lowest among the three applications which makes this application a least favored option for the users with special needs.

- Though Rocket is having highest average intuitiveness score in Semiotic evaluation and being one of the pioneer MFS applications in Bangladesh, it could not achieve much acceptance by the common people due to its higher severity ratings in heuristic evaluation, and relatively poor performance in terms of effectiveness and efficiency of user study evaluation. Rocket's accessibility score is little higher than Nagad but much lower than bKash making it another least priority option for the users with special needs.

The usability and accessibility problems that have been identified in the MFS applications are mentioned in Table 5.1.

**Table 5.1:** Identified usability and accessibility problems through different evaluations

| Serial No | Problems Revealed | Usability Evaluation | | | Accessibility Evaluation |
|---|---|---|---|---|---|
| | | Heuristic Evaluation | Semiotic Evaluation | User Study Evaluation | |
| 1 | Simplifying UI design | Yes | No | No | Yes |
| 2 | Adding more input methods like biometrics | Yes | No | No | Yes |
| 3 | Diminishing logical error | Yes | No | Yes | Yes |
| 4 | Delivering proper guidance | Yes | Yes | Yes | Yes |
| 5 | Designing Intuitive UI for better user understanding | Yes | Yes | No | Yes |
| 6 | Avoiding faulty transaction | No | No | Yes | No |
| 7 | Integrating separate features for users with special needs e.g. text to speech | No | No | No | Yes |

## 5.2 Proposed Design Considerations for Developing Prototypical UIs

To address the above mentioned problems, following design considerations are proposed to be considered by HCI practitioners for designing usable MFS applications in the context of Bangladesh:

- Flexibility need to be ensured in each step of the application.
- Some quick tools may be provided to accelerate the use by the expert users.

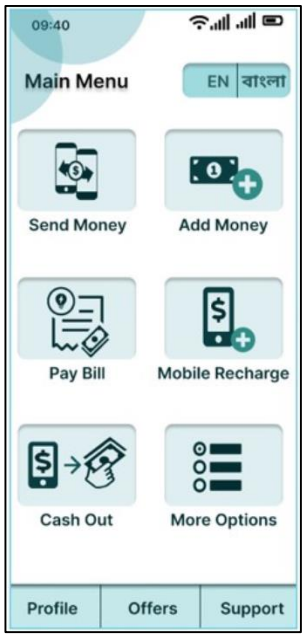
- Users should be able to access frequently needed actions easily and personalize the interface according to their needs.
- Consistency should be maintained throughout the application.
- Provision of error management should be carefully designed to handle the errors that may occur in reality.
- As mobile screen is small therefore, the overall user interface should be planned to ensure minimalist design while conforming to aesthetic view.
- As MFS application is directly related with financial transactions, thereby ensuring security measures is obligatory for any MFS application.
- The symbols used as interface signs/icons/logo should be designed in a way that they clearly represent the context of its use.
- The interface signs/icons/logo should be clear, concise, readable and finally intuitive so that they are coherent with their intended meanings.

## 5.3 Designing Prototypical UIs

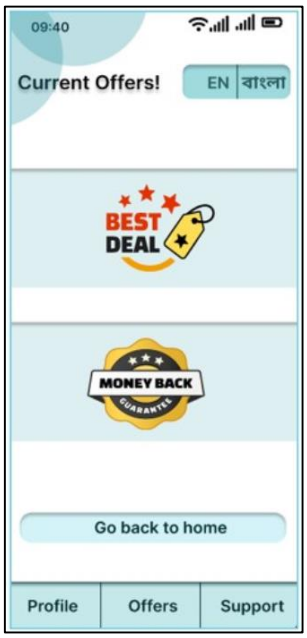
Keeping the design considerations in mind, some prototypical UIs (Fig. 5.1) have been developed as a possible solution to the usability and accessibility problems of the MFS applications by using *Figma* which is a web-based, affordable and scalable design tool.


Login page supporting both languages

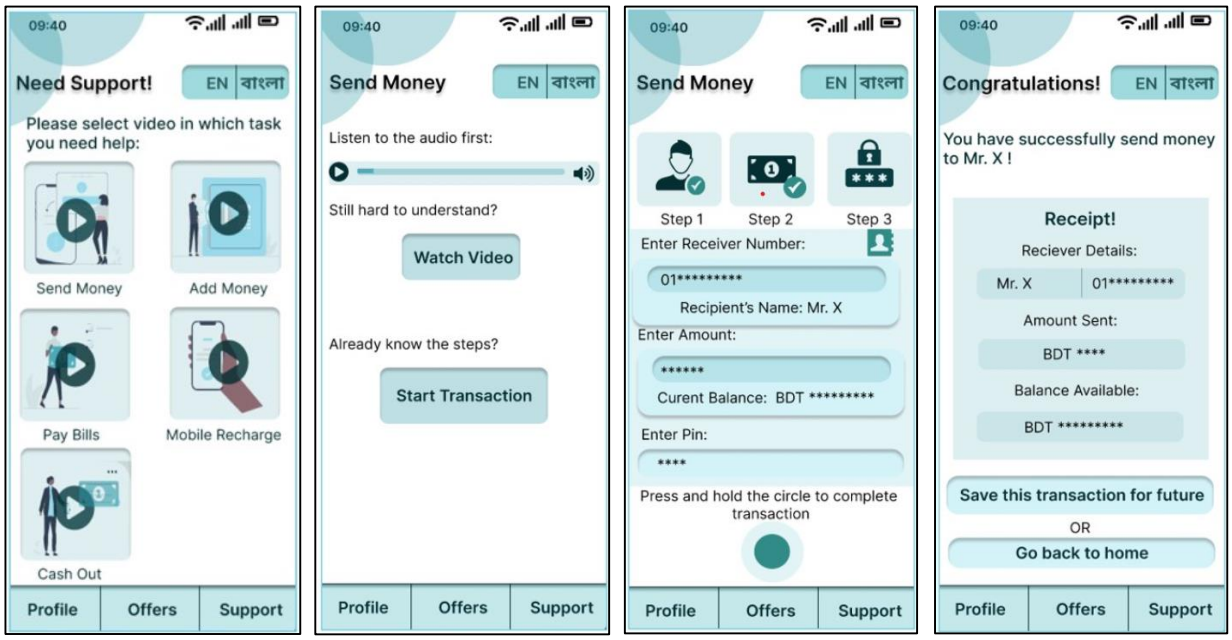

Profile with support option




Tasks with proper icon in Main Menu




Separate page for available offers




Video assistance for each task | First page for Send Money option | Send Money task authentication | Send Money successful

**Fig. 5.1:** Screenshots of developed prototypical UIs.

## 5.4 Evaluation through SUS Approach

The System Usability Scale (SUS) was measured as an evaluation metric to assess the usability and efficacy of a particular system/application. It consists of a ten item questionnaire with five response options for the respondents from 'Strongly Agree' to 'Strongly Disagree'. It is an effective tool to evaluate the performance of the MFS applications. SUS is a five step procedure that includes:

- Determining required sample size.
- Collecting user data.
- Calculating SUS scores.
- Interpreting the SUS scores of all the MFS applications.
- Analyzing the summary results of the SUS evaluation.

### 5.4.1 Participants' Profile

Prior to selecting the participants, all the prospective participants were briefed about the research study, its goal, and the tasks that they will be performing. On the condition of anonymity, their voluntary participation was ensured. Total 20 participants were selected

randomly from various places of Dhaka city who belong to diverse professions. Their age bracket was between 30 and 50 years. Education level of the selected participants ranges from Higher Secondary School to MA/MSc.

### 5.4.2 Study Procedure

The participants were briefed thoroughly about the 'Send Money' task to be completed with the help of three MFS applications (bKash, Nagad, and Rocket) and the prototypical UIs. After the brief, they were given 30 minutes time to explore the applications. Then users completed 'Send Money' operation by each of the applications. After every session, they filled up a SUS evaluation matrix consisting of ten questionnaires based on their UX. They chose the applications at random and they were given 15 minutes break after each evaluation session to avoid learning fatigue.

To calculate the final SUS score of an MFS application following steps are followed:

i. Out of ten questions, for odd number questions (positively phrased), users' response will be recorded as 'Strongly Disagree' = 1, 'Disagree' = 2, 'Neutral' = 3, 'Agree' = 4, and 'Strongly Agree' = 5. Score of odd number questions = [Response] – 1

ii. For even number questions (negatively phrased), users' response will be recorded as 'Strongly Disagree' = 5, 'Disagree' = 4, 'Neutral' = 3, 'Agree' = 2, and 'Strongly Agree' = 1.
Score of even number questions = 5 – [Response]

iii. Total Score = Addition of the scores of all 10 questions. Total score is calculated out of 40.

iv. Raw SUS Score = Total Score * 2.5 [multiplied by 2.5 to calculate the score in 100]

v. Final SUS Score = Average of Raw SUS Scores.

vi. Interpretation of SUS Scores:

| SUS Score | Grade | Status |
|---|---|---|
| > 80 | A | Excellent |
| 68 – 80.3 | B | Good |
| 68 | C | Okay |
| 51 - 68 | D | Poor |
| < 51 | F | Awful |

### 5.4.3 Analysis and Findings

All twenty participants sequentially completed the tasks and provided their responses in the SUS evaluation matrix sheet. Total 80 sheets were obtained and then the subsequent calculations were completed to find out the relevant SUS scores and raw SUS scores. Average of all raw SUS scores were calculated to find out the final SUS scores of all the applications. User responses on the performance of the prototypical UIs by one individual participant is shown in Table 5.2.

**Table 5.2:** Sample SUS Score calculation of Prototypical User Interfaces

| S/N | Questions | User Response | SUS Calculation |
|---|---|---|---|
| Q1 | I think that I would like to use this system frequently. | 5 | [5] – 1 = 4 |
| Q2 | I found the system unnecessarily complex | 2 | 5 – [2] = 3 |
| Q3 | I thought the system was easy to use | 5 | [5] – 1 = 4 |
| Q4 | I think that I would need the support of a technical person to be able to use this system | 2 | 5 – [2] = 3 |
| Q5 | I found the various functions in this system were well integrated | 5 | [5] – 1 = 4 |
| Q6 | I thought there was too much inconsistency in this system | 3 | 5 – [3] = 2 |
| Q7 | I would imagine that most people would learn to use this system very quickly | 5 | [5] – 1 = 4 |
| Q8 | I found the system very cumbersome to use | 1 | 5 – [1] = 4 |
| Q9 | I felt very confident using the system | 4 | [4] – 1 = 3 |
| Q10 | I needed to learn a lot of things before I could get going with this system | 2 | 5 – [2] = 3 |
| | | Total Score = | 34 |
| Raw SUS Score = Total Score * 2.5 = 34 * 2.5 = 85 | | | |

Having compiled all the data from all the participants, final SUS score of the selected MFS applications are calculated. Calculation of final SUS score of bKash, Nagad, and Rocket are shown in **Appendix E** and calculation of final SUS score of Prototypical UIs is shown in Table 5.3.

**Table 5.3:** Calculation of final SUS score of Prototypical Interfaces

| User | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Total | Raw SUS Score of Prototypes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | 5 | 2 | 5 | 2 | 5 | 3 | 5 | 1 | 4 | 2 | 34 | 85 |
| P 2 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 24 | 60 |
| P 3 | 4 | 3 | 3 | 4 | 4 | 2 | 4 | 3 | 4 | 5 | 22 | 55 |
| P 4 | 3 | 2 | 4 | 1 | 3 | 2 | 3 | 3 | 3 | 2 | 26 | 65 |
| P 5 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 39 | 97.5 |
| P 6 | 4 | 1 | 4 | 1 | 4 | 2 | 5 | 1 | 5 | 1 | 36 | 90 |
| P 7 | 3 | 1 | 5 | 2 | 5 | 1 | 5 | 4 | 5 | 1 | 34 | 85 |
| P 8 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 2 | 38 | 95 |
| P 9 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 2 | 4 | 1 | 37 | 92.5 |
| P 10 | 5 | 3 | 5 | 2 | 4 | 1 | 5 | 1 | 5 | 1 | 36 | 90 |
| P 11 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| P12 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 23 | 57.5 |
| P13 | 5 | 2 | 5 | 2 | 5 | 3 | 5 | 1 | 4 | 2 | 34 | 85 |
| P14 | 4 | 1 | 4 | 1 | 4 | 2 | 5 | 1 | 5 | 1 | 36 | 90 |
| P15 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| P16 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 1 | 32 | 80 |
| P17 | 5 | 2 | 5 | 2 | 5 | 3 | 5 | 1 | 4 | 2 | 34 | 85 |
| P18 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 1 | 32 | 80 |
| P19 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| P20 | 4 | 1 | 4 | 1 | 4 | 2 | 5 | 1 | 5 | 1 | 36 | 90 |
| Final SUS Score = Average of Raw SUS Scores = | | | | | | | | | | | | **85.08** |

Final SUS evaluation score of Prototypical UIs is 85.08%, whereas the same score of bKash is 79.32%, Nagad 76.6%, and Rocket 73.22%. As per the SUS evaluation grading system, the performance of Prototypical UIs is ‘Excellent’ whereas the performance of all the three MFS applications are ‘Good’ as shown in Fig. 5.2.

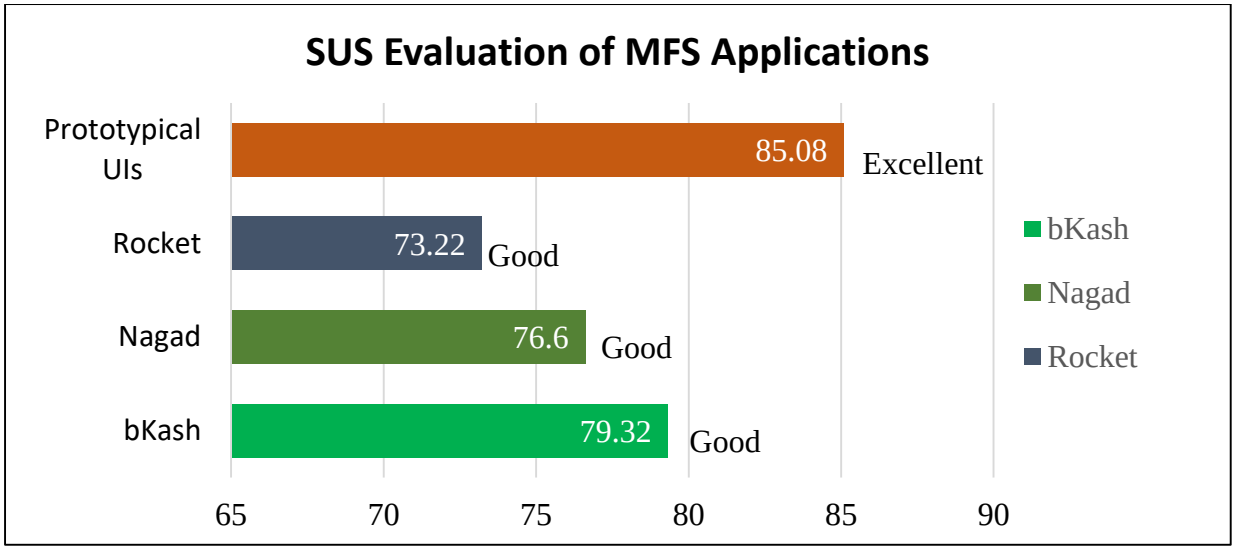



**Fig. 5.2:** SUS Evaluation of the selected of MFS applications and Prototypical UIs.

Analyzing the summary result of SUS evaluation, it is clearly conceivable that the developed prototypical UIs showed better performance than the existing major MFS applications in Bangladesh as the SUS score of prototypical UIs is higher than all other applications.

Based on the analysis of the SUS evaluation, the research shows that UI design in the prototype has been simplified as such the UX of the prototypical application is better than the MFS applications under study. Adding more input methods helped the prototypical application to take advantage and achieve more user satisfaction. Addressing the logical development or sequencing of tasks and events made the Prototype to be understood in a better way by the users. Utilizing more help functions like text, audio, and video help files eased the new users to adopt the Prototype easily. Efforts taken to make the Prototype design more intuitive helped the users to accept the application in the first go.

## 5.5 Chapter Summary

After summarizing all the usability problems that have been identified through usability and accessibility assessments, a set of prototypical interfaces were developed where all the problems were addressed as far as possible. Then a SUS evaluation was conducted on the selected MFS applications and the developed UIs. After calculating the SUS score of all four set of UIs, it is identified that the SUS score of the prototypical UIs is the highest which is

graded as ‘Excellent’ by the SUS evaluation, whereas the grading of the existing MFS applications are ‘Good’ which is one step below the grading of Prototypical UIs.

# CHAPTER 6
# CONCLUSION AND DISCUSSION

This section discusses the concluding remarks, divided into several segments. These include the main outcomes of the thesis, its implications, limitations, and areas for future exploration. The thesis outcomes are presented in a systematic manner initially, followed by a discussion of its implications. Subsequently, the limitations are addressed, along with potential avenues for future research.

## 6.1 Thesis Outcomes

This thesis work provided two main outcomes. The outcomes are briefly discussed below.

### 6.1.1 Revealed Usability and Accessibility Problems of Major MFS Applications

This research carried out detailed usability analysis of the three major MFS applications of Bangladesh through heuristic, semiotic, and user study evaluations and found out the usability problems of these applications. Besides, an accessibility analysis of the three major MFS applications of Bangladesh was conducted following WCAG guidelines and identified the accessibility limitations of these three applications. The revealed usability and accessibility problems showed that the UIs of the subject applications needed to be simplified, more input methods were suggested, logical errors to be reduced, more help materials for users to be introduced, UIs and icons to be more intuitive for the ease of use, cross-checking methods to be introduced for avoiding faulty transactions, and separate features like text to speech to be added in the applications for the users with special needs.

### 6.1.2 Effectiveness of Adopting Usability and Accessibility Guidelines in UI Designing

Considering the revealed usability and accessibility problems, this research identified a set of design considerations for developing prototypical UIs based on usability and accessibility guidelines. Then few prototypical UIs were developed following the design considerations focusing on specific task implementations. Then a SUS evaluation was conducted on the selected MFS applications for the study and the developed prototypical UIs. SUS evaluation score of Prototypical UIs was 85.08%, bKash 79.32%, Nagad 76.6%, and Rocket 73.22%. The

results of the SUS evaluation clearly demonstrated that adoption of the usability and accessibility guidelines in designing UIs brought effective results in terms of user interactions. The users were more comfortable using the developed prototypical UIs than that of the major MFS applications in Bangladesh. Therefore, this research proved that the overall usability and accessibility of the existing MFS applications can be greatly enhanced by properly adopting the usability and accessibility guidelines.

## 6.2 Thesis Implications

A few studies had been conducted focusing on usability and UX issues of different websites or web applications. Very limited studies were identified where usability studies of certain mobile applications were conducted. However, usability and accessibility evaluation of MFS applications is rarely available especially in the context of Bangladesh where these applications are extensively used by the common people of the country. In this perspective, this is a unique research work where the major MFS applications used in Bangladesh were evaluated through heuristic, semiotic, user study, and accessibility evaluation techniques and common usability and accessibility problems were identified. Based on the identified problems, a set of design considerations were formulated and following those design considerations, a number of prototypical UIs were developed in this research work. Through SUS evaluation it was further confirmed that the proposed design considerations really made a positive impact on the developed UIs as its usability standard surpassed the usability of existing MFS applications. No comparative study was found of this scale to find out more suitable design considerations for improving the usability and accessibility of MFS applications. The outcomes of this research strived to address this research gaps to some extent. Thus the outcomes of this research work have a great impact in the field of HCI and usability and accessibility of mobile applications.

## 6.3 Thesis Contributions

### 6.3.1 Contribution to UI Designers

The design considerations developed in this thesis would help the UI designers to develop any mobile application for common use.

### 6.3.2 Contribution to Usability Experts and HCI Practitioners

Usability experts might consider the derived usability and accessibility problems while developing any mobile application to be used online for financial transactions. The outcomes of this research would help the HCI practitioners to understand the present usability state and common problems of MFS applications in the context of Bangladesh. The findings and suggestions of this study would contribute to the HCI practitioners to design and develop future MFS applications with better usability and accessibility.

## 6.4 Limitations of the Thesis

### 6.4.1 Evaluation of Limited Number of MFS Applications

There are thirteen functional MFS applications in Bangladesh, of which, only three MFS applications were evaluated for usability and accessibility assessment. Although the selected three MFS application covers more than 95% MFS users of Bangladesh, inclusion of more number of MFS application for usability and accessibility evaluation could be more useful to bring out further usability and accessibility problems and for onward study to the solution of those problems.

### 6.4.2 Inadequate Number of Participants

Only thirty users were involved for the user study evaluation. Considering the mammoth user groups of the MFS applications, a sample size of thirty individuals was really small. For the SUS evaluation only twenty participants were selected for implementing certain tasks and providing feedback through the SUS ten questionnaires. In both the experiments, the sample size may be considered as inadequate. However, considering the issue of practically doing the experiments by the selected users which needs huge time for ensuring standard research environment and avoiding learning fatigue, the sample size had to be kept limited.

### 6.4.3 Limited Evaluation Methods Employed for Usability and Accessibility Evaluations

Among the four usability evaluation approaches i.e. analytical approach, empirical approach, formative approach, and summative approach, only two evaluation methods (analytical approach (heuristic evaluation and semiotic evaluation) and empirical approach (user study evaluation)) were employed to identify usability problems. Employing more number of evaluation techniques could help to find out more number of problems.

### 6.4.4 Development of Limited Number of Prototypical UIs

Development of a complete MFS application is a huge affair. There are many tasks to be performed by the applications which require huge effort and collaborations with many financial organizations which was not practically possible within the scope of this thesis work. As such, selected prototypical UIs were developed that suits the requirements of SUS evaluation technique.

### 6.4.5 Limited Number of Tasks Evaluated During Various Evaluations

During the user study evaluation, only two essential tasks (navigate to 'Send Money' option and completion of 'Send Money' operation) were evaluated by the participants. Besides, during SUS evaluation only one task ('Send Money' operation) was performed by the participants. If more number of tasks could be performed during these studies, more number of design and usability problems and insights could be identified.

## 6.5 Future Work

Future research would be conducted to resolve many open issues that were observed through this research. *Firstly*, more number of MFS applications may be included in the usability and accessibility evaluation of MFS applications for future research work.

*Secondly*, while conducting the user study evaluation and SUS evaluation, a small number of end users were involved, therefore future research may conduct these evaluations with a larger sample size of respondents from different corners of the society.

*Thirdly*, in future studies more number of evaluation methods that employ formative and summative approach may be employed along with analytical and empirical approach for the evaluation of MFS applications.

*Fourthly*, a future research may be carried out focusing on the development of a fully functional prototypical MFS application following all the HCI principles. The prototype may be incorporated into the real life particularly for the people who lack digital literacy for enhanced adoption of MFS applications in Bangladesh.

*Finally*, more number of tasks may be performed by the participants during user study evaluation and SUS evaluation so that identified results can be assessed more accurately.

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a415-65b109a207f5/%E0%A6%87%E0%A6%A8%E0%A7%8D%E0%A6%9F%E0%A6%BE%E0%A6%B0%E0%A6%A8%E0%A7%87%E0%A6%9F%E0%A6%97%E0%A7%8D%E0%A6%B0%E0%A6%BE%E0%A6%B9%E0%A6%95. [25 December 2023].

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## APPENDIX A

## HEURISTIC EVALUATION OF BKASH

**Table A.1:** Heuristic evaluation of bKash MFS Application

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| 1 | After completion of a successful mobile recharge, there is no option to continue with another mobile recharge. For this reason, if the user needs to do another mobile recharge, he/she is compelled to go back to Home page and start the process from the beginning. | H6 (Flexibility, Efficiency of Use, and Personalization) | 1.8 | After completion of a successful mobile recharge, the application should ask the user whether he/she wants to continue with another mobile recharge. If 'Yes', there should be a navigation button to directly go back to Mobile Recharge page. If 'No', then the user will be automatically navigated to the Home page. |
| 2 | After completion of a successful transfer of money (Send Money), there is no option to continue with another money transfer. For this reason, if the user needs to make another money transfer, he/she is compelled to go back to Home page and start the process again from the beginning. | H6 (Flexibility, Efficiency of Use, and Personalization) | 2 | After completion of a successful transfer of money (Send Money), the application should ask the user whether he/she wants to continue with another money transfer. If 'Yes', the user should be automatically navigated to the Send Money page. If 'No', then the user will be automatically navigated to the Home page. |
| 3 | After completion of a successful mobile recharge, there is no option to confirm the transaction of money/mobile recharge from that page. If there could be a 'Call' button or an 'SMS button', | H6 (Flexibility, Efficiency of Use, and Personalization) | 2 | There should have been a "Call" and an "SMS button" in the successful transaction page so that the user can instantly get a confirmation from the recipient regarding the reception of the mobile recharge money. |

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| | the user could have called/sent SMS to the recipient for confirmation of the reception of the money. | | | |
| 4 | There is no Back button (<-) for Notification and Transaction page. However, Back button is available with most of the pages. | H3 (Consistency and Mapping) | 1.4 | Back button should be incorporated with these two pages to maintain consistency with other pages. |
| 5 | During mobile recharge, if user provides invalid mobile number, the application is unable to prevent from proceeding next page. | H8 (Realistic Error Management) | 2 | Instead of identifying that the mobile number is invalid after completing the whole process, the application should be able to identify that the mobile number given as input is a wrong number. There should be a mobile number and mobile operator validation checker to prevent possible errors which will save users' time and bring efficacy to the system. |
| 6 | While sending money, if user provides invalid mobile number, the application is unable to prevent from proceeding next page. | H8 (Realistic Error Management) | 2.4 | Instead of identifying that the mobile number is invalid after completing the whole process, the application should be able to identify that the mobile number given as input is a wrong number. There should be a mobile number and mobile operator validation checker to prevent possible errors which will save users' time and bring efficacy to the system. |
| 7 | The home page of the application that | H4 (Good Ergonomics | 1.6 | In the home page, displaying of excessive |

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| | appears after Log In looks a bit clumsy and cluttered because of so many icons and irrelevant information/logo as well as advertisement that make the page quite untidy. The page also lacks in aesthetic view that is required to attract a user. | and Minimalist Design) and H7 (Aesthetic, Privacy and Social Conventions) | | information and design elements should be avoided. For example, advertisement of bKash, Suggestions and Offers are irrelevant or redundant for the home page of this application. These should have been avoided and all important icons/options should have been placed. The aesthetic view of this application also demands improvement. |
| 8 | No help, FAQ and documentation file is available with this application. Therefore, a new user is deprived of the facility of gaining firsthand knowledge about this application. | H2 (Match between the System and the Real World) | 2.8 | A novice user of this application would definitely look for the help options, FAQ and documentation file to clarify his/her queries. Therefore, a tab naming "Help" should be added under the Support Option of bKash Menu which will clarify matters like what does "Cash Out" mean or the meaning of the other Options. |
| 9 | Installation of a mobile application is the first step of using the application. In regards to installation of bKash App, it asks for National Identification Card (NID) scanning which is little cumbersome for a user. | H2 (Match between system and the real world) | 2 | Since every mobile number is registered against an NID Card, therefore, it is expected that the Mobile Financial Service Application to take the data of an individual from the database of the mobile operators. This can omit this step which creates discomfort for a user while installing the application. |
| 10 | bKash is connected to 22 Banks for internet banking among the 52 banks | H6 (Flexibility, Efficiency of Use, and Personalization) | 1.8 | bKash should be connected with more number of banks to allow its users to have |

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| | of Bangladesh which is less than half the banks available. It obstructs the users with diverse bank connectivity to get money to their bKash account from bank account. | | | flexibility of bringing money (Add Money) to their mobile account. |
| 11 | Zooming is not available in this mobile application. | H5 (Ease of input, screen readability and glanceability) | 3.6 | Zoom In and Zoom Out option should be incorporated |
| 12 | Icons are larger considering the labels, difficult to read | H4 (Good Ergonomics and Minimalist Design) | 2.8 | The icon labels text size should be increased and made readable by the users |
| 13 | Guideline not provided about the usage of each option and an entire task thoroughly. | H1 (Visibility of system status and findability of the mobile device) and H6 (Flexibility, Efficiency of Use, and Personalization) | 3.8 | Necessary guidelines about the usage of each option and an entire task should be added so that users can easily use the application. |
| 14 | If Bengali UI is selected, the keypad does not change from English to Bengali. It remains in English. No option for seeing numeric data on the UI by using Bangla Unicode | H6 (Flexibility, Efficiency of Use, and Personalization) | 2.8 | Considering the ease of use by the common people of Bangladesh, if the UI is selected in Bengali language, the keypad appearing should also be shown in Bengali. Necessary design modification in the application should be done. |
| 15 | Sometimes a user may press the ‘back’ button mistakenly while he/she is in the front page, then the user will be ‘Log Out’ automatically. No confirmation | H4 (Good Ergonomics and Minimalist Design) | 2 | A confirmation Textbox may appear asking the user whether he/she wants to log out. |

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| | textbox appears to ask the user before exiting the application. | | | |
| 16 | Home page UI is cluttered with Ads, Offers and Suggestions section | H4 (Good Ergonomics and Minimalist Design) and H6 (Flexibility, Efficiency of Use, and Personalization) | 2.2 | Although keeping Ads in the application relates to the business strategy of the bKash authority, however the space allocated for Ads, the number of Ads, and frequent change of Ads which distracts the MFS users should be taken into consideration by the concerned authority. |
| 17 | While entering the numeric pin, tapping the 'back' button eliminates all of the input digits rather than just one. | H5 (Ease of input, screen readability and glanceability) | 2 | The application server may be configured in a way so that whatever figure is typed in the MFS application by any particular user is not deleted automatically due to change of window. |
| 18 | A user can log out without using the 'Log Out' button merely by pressing the 'Back' button of the mobile. The 'Log Out' button on the navigation side panel seems useless. | H4 (Good Ergonomics and Minimalist Design) | 2.2 | A permanent 'Log Out' button can be placed in the front end lower part beside 'Home' button. |

## APPENDIX B

## HEURISTIC EVALUATION OF NAGAD

**Table B.1:** Heuristic evaluation of Nagad MFS Application

| Problem Number | Usability Problem | Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| 1 | After completion of a successful mobile recharge, there is no option to continue with another mobile recharge. For this reason, user is compelled to go back to Home page and restart another Mobile Recharge. | H6 (Flexibility, Efficiency of Use, and Personalization) | 2 | After completion of a successful mobile recharge, the application should ask the user whether he/she wants to continue with another mobile recharge. If yes, there should be a navigation button to directly go back to Mobile Recharge page. If No, then the user will use existing option of going back to Home page. |
| 2 | After completion of a successful money transfer (Send Money), there is no option to continue with another money transfer. For this reason, user is compelled to go back to Home page and restart the process of another Send Money | H6 (Flexibility, Efficiency of Use, and Personalization) | 1.8 | After completion of a successful transfer of money (Send Money), the application should ask the user whether he/she wants to continue with another money transfer. If yes, there should be a navigation button to directly go back to 'Send Money' page. If the user does not want to do another money transfer, then the user will use existing option of going back to Home page. |
| 3 | The font size of the Icon Names are quite small for the age group above 40 yrs (Figure-1). If the font size is increased from the mobile settings, | H5 (Ease of Input, Screen Readablility and Glancibility) | 1.6 | The font size of the Icon Names to be made bigger for readability of the screen by the people above 40 yrs of age. |

| Problem Number | Usability Problem | Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| | then the words in the Icon Names get broken and some part of the names become invisible (Figure-2). This is an inherent problem of the mobile application developed by Nagad. | | | |
| 4 | Although there are 06 state-owned commercial banks, 03 specialized banks and 43 Private Commercial Banks (PCB) in Bangladesh, Nagad is connected to only seven (7) PCBs of Bangladesh for internet banking. Therefore, the users are facing difficulty to bring money (Add Money) to their mobile financial account from the bank account. | H6 (Flexibility, Efficiency of Use and Personalization) | 2.8 | Nagad should be connected with more number of banks to allow its users to have flexibility of bringing money (Add Money) to their mobile account. |
| 5 | In the landing/home page, there is a 'Cash Out' option under the 'Services' heading. Again, there is a 'Shadhin Pay' option under the 'Payments' heading. Both the options do the same job or both the icons direct to the same page which is confusing for any user. Moreover, it has violated the minimalist design approach. | H4 (Good Ergonomics and Minimalist Design) | 2 | Either of 'Cash Out' or 'Shadhin Pay' should be kept. Two options leading to one single page should not be kept that confused the users. |

| Problem Number | Usability Problem | Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| 6 | Zooming is not available in this mobile application. | H5 (Ease of input, screen readability and glanceability) | 3.6 | Zoom In and Zoom Out option should be incorporated |
| 7 | Guideline not provided about the usage of each option and an entire task thoroughly. | H1 (Visibility of system status and findability of the mobile device) and H6 (Flexibility, Efficiency of Use, and Personalization) | 3.8 | Necessary guidelines about the usage of each option and an entire task should be added so that users can easily use the application. |
| 8 | Presence of so many icons on the homepage is confusing for the users | H4 (Good Ergonomics and Minimalist Design) and H6 (Flexibility, Efficiency of Use, and Personalization) | 2.8 | The homepage should be made free of so many icons which will be more user friendly. |
| 9 | Distracting advertisements which are not useful for users | H4 (Good Ergonomics and Minimalist Design) and H7 (Aesthetic, Privacy and Social Conventions) | 2 | Advertisements not useful for users may be discarded. |

## APPENDIX C

## HEURISTIC EVALUATION OF ROCKET

**Table C.1:** Heuristic evaluation of Rocket MFS Application

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| 1 | Irrelevant icons and advertisements at the top which distracts the users. | H4 (Good Ergonomics and Minimalist Design) and H7 (Aesthetic, Privacy and Social Conventions) | 2 | Primary attention of the users should be drawn to their primary tasks, meaning the option icons of Mobile Financial Services should be on top. Advertisement or other links should be given below the main tasks. For this, some Group Heading is also suggested. |
| 2 | Although there are 06 state-owned commercial banks, 03 specialized banks and 43 Private Commercial Banks (PCB) in Bangladesh, Rokcet is connected to only three (03) PCBs of Bangladesh for internet banking. Therefore, the users are facing difficulty to bring money (Add Money) to their mobile financial accout from the bank account. Here, the users are indirectly influenced to open a DBBL account for operating Rocket. | H6 (Flexibility, Efficiency of Use and Personalization) | 2.8 | Rocket should be connected with more number of banks to allow its users to have flexibility of bringing money (Add Money) to their mobile account. |
| 3 | After completion of a successful mobile recharge, there is no option to continue with another mobile recharge. Users receive a success/failure | H6 (Flexibility, Efficiency of Use, and Personalization) | 1.8 | After completion of a successful mobile recharge, the application should ask the user whether he/she wants to continue with another mobile |

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| | message and are automatically directed to Home page after completion of the mobile recharge. Therefore, users need to pass through additional steps for making another recharge. | | | recharge. If yes, there should be a navigation button to directly go back to Mobile Recharge page. If No, then the user will use existing option of going back to Home page. |
| 4 | After completion of a successful money transfer (Send Money), there is no option to continue with another money transfer. Users receive a success/failure message and are automatically directed to Home page after completion of the money transfer. Therefore, users need to pass through additional steps for making another money transfer. | H6 (Flexibility, Efficiency of Use, and Personalization) | 2 | After completion of a successful money transfer (Send Money), the application should ask the users whether he/she wants to continue with another money transfer. If yes, there should be a navigation button to directly go back to Send Money page. If No, then the user will use existing option of going back to Home page. |
| 5 | While doing Mobile Recharge from Rocket if destination mobile number is selected from one operator and while selecting Mobile Operator, if another Mobile Operator is selected, then the application cannot identify the mismatch or faulty data entry. | H8 (Realistic Error Management) | 2.4 | Instead of identifying that the mobile number is invalid after completing the whole process, the application should be able to identify that the mobile number given as input is a wrong number. There should be a mobile number and mobile operator validation checker to prevent possible errors which will save users' time and bring efficacy to the system. |
| 6 | If an user clicks on ‘About Us’, then the user is directed to a | H3 (Consistency and Mapping) | 1.4 | The link should be repaired and users should be able to access |

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| | webpage which cannot be reached (does not open). | | | the ‘About Us’ webpage when needed. |
| 7 | No help, FAQ and documentation file is available with Rocket. Therefore, a new user is deprived of the facility of gaining firsthand knowledge about this application through Help function. | H2 (Match between the System and the Real World) | 3 | A novice user of this application would definitely look for the help options, FAQ and documentation file to clarify his/her queries. Therefore, a tab naming "Help" should be added under the Others of Rocket Menu. |
| 8 | Though the session has expired, the application allows the user to interact with all the functionalities i.e. 'Send Money' until the final stage. After completing all the stages even after providing the PIN number, the transaction is denied as session has expired, which is a complete wastage of time and effort. | H6 (Flexibility, Efficiency of Use, and Personalization) | 3.8 | The application may be redesigned in such a way that, it will not allow any interaction of the user when the session has expired. User need to log in again to carry out any further interaction. |
| 9 | MFS applications are highly secured and always password protected. To increase its security, every session has a limited life if the device is left idle. However, in this application it is identified that there is a bug in the software. The application responses as per the command given to it even after the session time is over. Finally, before any transaction, it says that the session has already expired. | H8 (Realistic error management) | 3.2 | Like other secured apps, after the session time is over, the app should not work. It should ask for authentication password and it should work only after successful authentication. |

| Problem Number | Usability Problem | Evidence/ Violated Heuristics | Average Severity Rating | Possible Solution |
|---|---|---|---|---|
| 10 | If a user clicks on Transaction Limits from the Menu Bar, the Limits page is opened where some information are shown. But those information is not understandable for any new user since the presentation of data is confusing and necessary explanations are not given. | H2 (Match between System and the Real World) | 1.8 | The data shown in the Limits page should be written in way which is understandable by the common people of the country. |
| 11 | Even after setting the language to Bangla, the transaction limits page and the 'Tap for Balance' tab show the information in English, which may not be understandable by all users. | H3 (Consistency and Mapping) | 2 | Transaction Limit page and 'Tap for Balance' tab may be translated to Bangla for the ease of all the users. |
| 12 | Zooming is not available in this application. | H5 (Ease of input, screen readability, and glanceability) | 3.8 | Zooming option to be added to this application. |
| 13 | Icons are quite large considering the text size of the labels/icons which are difficult to read. | H4 (Good ergonomics and minimalist design) | 2.8 | Font size of the labels of the icons should be made bigger. |
| 14 | Guidelines not provided about the usage of each option and an entire task thoroughly. | H1 (Visibility of system status and findability of the mobile device) and H6 (Flexibility, the efficiency of use, and personalization) | 3.8 | The application need to be made more user oriented by giving hints, guidelines, and indications of how to use various options. |

## APPENDIX D

## ACCESSIBILITY EVALUATION BY AN INDIVIDUAL EVALUATOR

**Table D.1:** Output of accessibility evaluation of MFS applications by an individual evaluator

| Accessibility Principles and Guidelines | bKash | | | | Nagad | | | | Rocket | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A1** | **A2** | **A3** | **A4** | **B1** | **B2** | **B3** | **B4** | **C1** | **C2** | **C3** | **C4** |
| *Perceivable information and user interface* | | | | | | | | | | | | |
| 1. Text alternatives for non-text content | no | yes | yes | yes | no | yes | yes | no | yes | no | yes | no |
| 2. Caption and another alternative for multimedia | no | yes | no | yes | no | yes | yes | no | no | no | no | yes |
| 3. Content can be presented in different ways | no | no | no | yes | no | no | no | no | no | no | no | no |
| 4. Content is easier to see and hear | yes | yes | no | yes | no | yes | yes | no | yes | yes | yes | yes |
| *Operable user interface and navigation* | | | | | | | | | | | | |
| 5. Functionality is available from a keyboard | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| 6. Users have enough time to read and use the content | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| 7. Content does not cause seizures and physical reactions | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | no |
| 8. Users can easily navigate, find content, and determine where they are | yes | yes | yes | yes | no | yes | yes | no | no | yes | no | no |
| 9. Users can use different input modalities beyond the keyboard | no | no | no | no | no | no | no | no | no | no | no | no |
| *Understandable information and user interface* | | | | | | | | | | | | |

| Accessibility Principles and Guidelines | bKash | | | | Nagad | | | | Rocket | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A1** | **A2** | **A3** | **A4** | **B1** | **B2** | **B3** | **B4** | **C1** | **C2** | **C3** | **C4** |
| 10. Text is readable and understandable | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | yes |
| 11. Content appears and operates in predictable ways | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| 12. Users are helped to avoid and correct mistakes | yes | yes | yes | no | yes | no | no | yes | no | yes | yes | no |
| *Robust content and reliable interpretation* | | | | | | | | | | | | |
| 13. Content is compatible with current and future user tools | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |

## APPENDIX E

## SYSTEM USABILITY SCALE (SUS) EVALUATION MATRICES

**Table E.1:** Calculation of final SUS score of bKash

| User | User Response | | | | | | | | | | Total Score | Raw SUS Score of bKash |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | | |
| P1 | 5 | 2 | 5 | 2 | 5 | 3 | 5 | 1 | 4 | 2 | 34 | 85 |
| P 2 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 24 | 60 |
| P 3 | 4 | 3 | 3 | 4 | 4 | 2 | 4 | 3 | 4 | 5 | 22 | 55 |
| P 4 | 3 | 2 | 4 | 1 | 3 | 2 | 3 | 3 | 3 | 2 | 26 | 65 |
| P 5 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 39 | 97.5 |
| P 6 | 4 | 1 | 4 | 1 | 4 | 2 | 5 | 1 | 5 | 1 | 36 | 90 |
| P 7 | 3 | 1 | 5 | 2 | 5 | 1 | 5 | 4 | 5 | 1 | 34 | 85 |
| P 8 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 2 | 38 | 95 |
| P 9 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 2 | 4 | 1 | 37 | 92.5 |
| P 10 | 5 | 3 | 5 | 2 | 4 | 1 | 5 | 1 | 5 | 1 | 36 | 90 |
| P 11 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| P12 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 23 | 57.5 |
| P13 | 4 | 1 | 5 | 1 | 1 | 2 | 4 | 2 | 3 | 1 | 30 | 75 |
| P14 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 1 | 32 | 80 |
| P15 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 3 | 1 | 31 | 77.5 |
| P16 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| P17 | 3 | 2 | 4 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 28 | 70 |
| P18 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 1 | 32 | 80 |
| P19 | 3 | 1 | 5 | 2 | 5 | 1 | 5 | 4 | 5 | 1 | 34 | 85 |
| P20 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| Final SUS Score = Average of Raw SUS Scores = | | | | | | | | | | | | **79.32** |

**Table E.2:** Calculation of final SUS score of Nagad

| User | User Response | | | | | | | | | | Total Score | Raw SUS Score of Nagad |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | | |
| P1 | 5 | 2 | 5 | 2 | 5 | 3 | 5 | 1 | 4 | 2 | 34 | 85 |
| P 2 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 24 | 60 |
| P 3 | 4 | 3 | 3 | 4 | 4 | 2 | 4 | 3 | 4 | 5 | 22 | 55 |
| P 4 | 3 | 2 | 4 | 1 | 3 | 2 | 3 | 3 | 3 | 2 | 26 | 65 |
| P 5 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 39 | 97.5 |
| P 6 | 4 | 1 | 4 | 1 | 4 | 2 | 5 | 1 | 5 | 1 | 36 | 90 |
| P 7 | 3 | 1 | 5 | 2 | 5 | 1 | 5 | 4 | 5 | 1 | 34 | 85 |
| P 8 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 2 | 38 | 95 |
| P 9 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 2 | 4 | 1 | 37 | 92.5 |
| P 10 | 5 | 3 | 5 | 2 | 4 | 1 | 5 | 1 | 5 | 1 | 36 | 90 |
| P 11 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| P12 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 23 | 57.5 |
| P13 | 4 | 1 | 5 | 1 | 1 | 2 | 4 | 2 | 3 | 1 | 30 | 75 |
| P14 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 1 | 32 | 80 |
| P15 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 3 | 1 | 31 | 77.5 |
| P16 | 5 | 3 | 5 | 2 | 4 | 1 | 5 | 1 | 5 | 1 | 36 | 90 |
| P17 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 3 | 1 | 31 | 77.5 |
| P18 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 23 | 57.5 |
| P19 | 4 | 1 | 5 | 1 | 1 | 2 | 4 | 2 | 3 | 1 | 30 | 75 |
| P20 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| Final SUS Score = Average of Raw SUS Scores = | | | | | | | | | | | | **76.60** |

**Table E.3:** Calculation of final SUS score of Rocket

| User | User Response | | | | | | | | | | Total Score | Raw SUS Score of Rocket |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | | |
| P1 | 5 | 2 | 5 | 2 | 5 | 3 | 5 | 1 | 4 | 2 | 34 | 85 |
| P 2 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 24 | 60 |
| P 3 | 4 | 3 | 3 | 4 | 4 | 2 | 4 | 3 | 4 | 5 | 22 | 55 |
| P 4 | 3 | 2 | 4 | 1 | 3 | 2 | 3 | 3 | 3 | 2 | 26 | 65 |
| P 5 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 39 | 97.5 |
| P 6 | 4 | 1 | 4 | 1 | 4 | 2 | 5 | 1 | 5 | 1 | 36 | 90 |
| P 7 | 3 | 1 | 5 | 2 | 5 | 1 | 5 | 4 | 5 | 1 | 34 | 85 |
| P 8 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 2 | 38 | 95 |
| P 9 | 4 | 1 | 5 | 1 | 5 | 1 | 5 | 2 | 4 | 1 | 37 | 92.5 |
| P 10 | 5 | 3 | 5 | 2 | 4 | 1 | 5 | 1 | 5 | 1 | 36 | 90 |
| P 11 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 2 | 33 | 82.5 |
| P12 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 23 | 57.5 |
| P13 | 4 | 1 | 5 | 1 | 1 | 2 | 4 | 2 | 3 | 1 | 30 | 75 |
| P14 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 4 | 1 | 32 | 80 |
| P15 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 3 | 1 | 31 | 77.5 |
| P16 | 4 | 1 | 5 | 1 | 1 | 2 | 4 | 2 | 3 | 1 | 30 | 75 |
| P17 | 4 | 1 | 5 | 1 | 4 | 2 | 4 | 2 | 3 | 1 | 31 | 77.5 |
| P18 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 2 | 23 | 57.5 |
| P19 | 4 | 1 | 5 | 1 | 1 | 2 | 4 | 2 | 3 | 1 | 30 | 75 |
| P20 | 3 | 2 | 4 | 1 | 3 | 2 | 3 | 3 | 3 | 2 | 26 | 65 |
| Final SUS Score = Average of Raw SUS Scores = | | | | | | | | | | | | **73.22** |

**Table E.4:** Summary result of SUS Evaluation

| MFS Application | SUS Score | Grade | SUS Status |
|---|---|---|---|
| bKash | 79.32 | B | Good |
| Nagad | 76.60 | B | Good |
| Rocket | 73.22 | B | Good |
| Prototype | 85.08 | A | Excellent |