User-Centered-Design of a UI for Mobile Banking Applications

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Abstract. A rapid increase in the number of smartphone users and wireless internet subscribers has brought about a digital revolution. Today, mobile devices serve not only as a medium of voice communication, but are also used to streamline daily activities. For instance, mobile banking allows clients to conduct financial transactions remotely using a mobile device such as a smartphone or tablet. As the influence of mobile technology continues to grow, financial institutions need to develop applications that guarantee customer usability. Ergo, there is a need to explore the role user interface design plays in enhancing the usability of a mobile application. This document describes the design and evaluation processes of the user interface of a mobile banking application that provides three functions: payments, balance inquiries and transfers. An experiment is carried out to test two different user interface prototypes. The prototypes differ in the implementation of Nielsen heuristics' for user interface design. Prototype A is designed empirically, whereas prototype B is based on the application of Nielsen's rules. Usability tests results demonstrate that credit union customers appraise the user interface designed according to the heuristics as more usable than the empirical one.

Keywords: User centered design · User interface · Mobile banking application Usability · Heuristics

1 Introduction

Latin America is undergoing a process of expansion in the use of Information and Communication Technologies (ICT), characterized by a growth in the number of Internet users and, above all, the explosion of cellular mobile telephony [1]. The banking industry has become aware of this trend towards mobility betting strongly on the development of mobile banking (m-banking), a service that allows customers to perform financial transactions remotely by using a smartphone or tablet [2, 3]. It differs from online banking in that it uses an app, provided by the financial institution for the customer to login into a bank's mobile website to carry out banking transactions, payments and text message (SMS) banking [3]. In 2016 [4] estimated 1.2 billion m-banking users in the region and reported that 90% of the banks have at least 3 mobile technologies in their relationship with customers, from which mobile apps reached almost 96% of use.

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Ecuadorian renowned banks have adopted m-banking, however, this is not the case of credit unions.[1] According to [5] the number of credit unions in Ecuador grew 12.8% in relation to 2015; this indicates that credit union membership is on the rise. At the moment, credit union members need to wait in lines for long periods of time at the institution to perform basic transactions such as reviewing the account balance in their savings account [6, 7]. This is impractical and leads to time loss, in turn, there may be customers who prefer to open an account at an institution that provides mobile banking apps and access their accounts through their smartphones from anywhere in the world. The advent of smartphones provides an opportunity for credit unions to innovate their processes and provide a better service to their customers [1–3, 8].

Mobile app interfaces use touchscreens as the main source of input. Their design usually follows heuristics or "rules of thumb" [9, 10] originally intended for desktop software. However, traditional user interface design may not be totally compatible with the mobility context, it presents different constraints to developers. For instance, the controls and keyboards on smartphones can be particularly difficult to read and understand because mobile screens are smaller [11]. Additionally, mobile apps are often used in non-work settings, meaning that there is a high chance that the user may face distractions or problems like limited connectivity or a draining battery. Therefore, it is important for mobile app developers to ensure that their applications provide customer usability.

1.1 Usability

The term usability refers to the degree of ease with which consumers use a software application to achieve a specific goal [12]. ISO 9241-11 officially defines it as "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 studies [12, 13] have been carried out in different contexts and several models have been proposed to quantify and evaluate usability in Human-Computer Interaction. Recently the mobile context has gained increased research attention, findings in [3, 9, 14] suggest that mobile user interface design is a critical factor in achieving customer usability.

1.2 Related Work

The foundations of Human-Computer Interaction research and practice were established over 20 years ago, yet they remain an active area of study. Gould and Lewis [9] stressed three principles of design in 1980 which included "an early and continuous focus on users and their tasks". Since the involvement of end-users throughout the design process of software products, several studies [10, 13–17] have explored the influence of user interface design in software usability. The majority of them coincide

[1] A credit union is a financial non-profit organization which main role is to provide a safe space for savings and loans at reasonable rates; commonly established by people with a common background. Their main appeal to members is that any profit earned by the institution is either invested back into the credit union or paid out to members as a dividend.

in the application of Nielsen Heuristics to build and test usability of software products. Nielsen Heuristics include ten rules: (1) Visibility of system status, (2) Match between system and the real world, (3) User control and freedom, (4) Consistency and standards, (5) Error prevention, (6) Recognition rather than recall, (7) Flexibility and efficiency of use, (8) Aesthetic and minimalist design, (9) Help users recognize, diagnose, and recover from errors, and (10) Help and documentation [15].

This study aims to determine if Nielsen Heuristics exert an influence on the level of usability of a mobile banking application. To do so, this paper focuses on two main objectives: (i) to design two (2) different user interfaces prototypes for the same mobile banking app; one which lacks design rules and another which follows Nielsen Heuristics to support a user centered design approach. (ii) to test the usability of each user prototype by analyzing Key Performance Indicators and surveying credit union customers regarding the ease of use of each of the user interface.

2 User-Centered-Designed-Interface

The mobile banking application design followed the User Centered Design (UCD) methodology. The main concept of UCD is that only by understanding the domain of work in which users are engaged, usability can be enhanced and human-computer interaction facilitated [14]. UCD is standardized in ISO 13407 and describes four essential UCD activities to follow: (1) "Understand and specify the context of use"; (2) "Specify the user and organizational requirements"; (3) "Produce design solutions"; and (4) "Evaluate designs against requirements". This section describes each of the activities in the methodology for the deployment of the mobile banking application user interfaces. Activities 1 and 2 are grouped together as one, named Context of Use and activities 3 and 4 are described individually.

2.1 Context of Use

The target audience in this study are customers of the credit unions in Guayaquil, Ecuador. To obtain the number of representative users needed for the sample, a fieldwork was carried out in which each of the establishments considered in this study were visited to determine the total number of members for each one of them and add them up to figure out the total population. It should be noted that the group of credit unions listed in this study are the ones which were willing to provide all the required information; some credit unions were discarded because they do not provide the m-banking service and thus could not be included in the mobile banking application. Table 1 shows the names and number of members for the credit unions considered in this research.

The total number of members is used to calculate the sample. As stated in [6] the formula to calculate the sample in finite populations is:

$$n = \frac{Nk^2 p \,.\, q}{e^2(N-1) + k^2 \,.\, p \,.\, q} \tag{1}$$

Table 1. Credit Unions included in the m-banking app.

	Credit Unions	Number of members
1	Armada Nacional	11,000
2	Universidad de Guayaquil	7000
3	Águilas de Cristo	820
4	Los Andes Latinos Ltda.	1,500
5	C.T.E.	1,735
6	La Dolorosa	9000
7	Esperanza y Desarrollo	530
	Total Credit Union Members	**31,585**

$$n = \frac{31.585 \times 1,96^2 \times 0,5 \times 0,5}{0,05^2 \times (31.585 - 1) + 1,96^2 \times 0,5 \times 0,5} = 379,55 \rightarrow 380$$

The number of representative users that will participate in the prototyping and testing of the mobile banking application are 380 customers.[2] This is the same population for which [6] evaluated the predisposition of credit union users in Guayaquil to use a mobile banking app for their transactions. As suggested by [3, 4, 7, 8] among the various banking transactions, the most commonly included in m-banking are balance inquiries, transfers and payments. Therefore the mobile banking app should allow the user to access their account and perform at least the three banking features mentioned above. To identify, clarify, and organize the mobile banking application's user requirements, uses cases of the UML methodology are applied. A use case is made up of a set of possible sequences of interactions between a software system and its users in a specific environment to achieve a particular goal [18]. The use cases for the login and payments features of the m-banking app are described below in Tables 2 and 3 respectively.

According to [1–3, 5] among the available mobile operating systems, the two dominant platforms of the market share globally are Android (70%) and iOS (21%). In Ecuador Samsung Galaxy models are the most popular around users in the sample [6]. Their average screens size is between 5.0 and 5.5 in., so the Android prototypes are created within that screen dimensions. For the iPhone series, the most demanded models in 2017 were the iPhone 6 and iPhone 7 with a screen size of 4.7 in. and are also prototyped.

2.2 Nielsen Heuristics

This research focuses on the application of Nielsen's Usability Heuristics for User Interface Design within the UCD Methodology. Partly, because it involves less number

[2] Where: n = sample size, N = population, k^2 = 1.96 (constant that must not be less than 95%), e = 0.05 maximum allowable error^2, p = 0.50 (probability that the outcome will occur) and q = 0.50 complementary probability.

Table 2. Login use case

Use Case	UC – 1 Login
Descriptions	Entry of the parameters (username and password) required to access the mobile app
Actions	Once the user has logged in, the user can check his balance, make payments and transfer money among the various credit unions
Assumptions	The user must hold an account in a credit union to log in and access the app functionalities
Steps	1. User must enter their username in the first text box 2. Then, enter the corresponding password in the second text box 3. Press the "ingresar" button of the application
Variations	No variations are considered for the process

Table 3. Payments Use Case

Use Case	UC – 4 Payments
Descriptions	The customer pays for a commodity using their smartphones
Actions	User selects a payment method and pays for a service or commodity
Assumptions	The user has logged in into the app
Steps	1. User selects a payment method: credit card or savings account balance 2. They select the service or commodity they need to pay for 3. The payment goes through and credit/balance is updated 4. A notification message shows up indicating the payment was successful
Variations	The user does not have enough credit and a popup warning message appears indicating the transaction cannot be completed

of guidelines and for the fact that it was the most popular UCD approach in the 90s. Because of the nature of the mobile banking app and findings in [6, 7] regarding consumer preferences rules 1, 2, 3, 5 and 8 are selected to build and test the prototypes in this study. The selected heuristics are detailed in Table 4.

2.3 Produce Design Solutions

The term prototype refers to a modifiable working example through which a new model or a new version of an existing product can be derived [9]. Originating from User-Centered Design, prototyping has also become a popular method for user-based validating design concepts in service design and development [19]. The principal use of prototyping is to help the representative customers and developers agree on the software requirements. To create and test the two sets of prototypes for each operating system, the online usability tool Quant-UX was employed. This software provides the means to design, test and analyze interactive prototypes; its main advantage is that it allows real time execution of the prototypes as if the users were testing a real app [20]. For each operating system a set of two interfaces are prototyped. Prototype A lacks design rules whereas Prototype B is created by following the five selected guidelines in

Table 4. Nielsen Heuristics applied to the UCD

Principle	Description
Visibility of system status (S) **(S)**	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time
Coincidence between the system and the real world (R) **(R)**	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order
User control and freedom (C) **(C)**	Users often choose system functions by mistake and will need an "emergency exit" clearly marked to leave the unwanted state without having to go through an extended dialogue. Support undo and redo
Error prevention (E) **(E)**	Error messages is a careful design that prevents a problem from occurring in the first place. Eliminate error-prone conditions or check them and present users with a confirmation option before committing to action
Aesthetic and minimalist design (D) **(D)**	Dialogues should not contain information that is irrelevant or rarely needed. Each additional unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility

Nielsen Heuristics. Each of the interfaces consists of a total of seven screens. For the purposes of this document, two screens are analyzed; the Login screen and the Payments Screen, for which each Use Case is documented in the previous section. A legend including the abbreviation of each heuristic is used to specify where in the screen Nielsen guidelines are applied.

Android Prototypes: Figure 1 portrays the Login and Payments views for Prototype A. These screens were created empirically. The Login screen shows the logo at the top of the screen and the title "IDENTIFICACION DEL USUARIO" below it. There exists two buttons, login (ingresar) and register (registrarse). The payments screen for Prototype A displays the logo, screen title "PAGOS" and 5 buttons. The first button allows the customer to select a credit card to pay for commodities, the other button pays for each of commodity using the savings account. An arrow shaped button is located at the top of the screen to go back to the previous view.

Figure 2 shows the Login and Payments views for Prototype B. These were created following Nielsen's heuristics. Both screens display the m-banking app name and logo at the top of the screen. This is standardized through all of the screens in the app. The titles "IDENTIFICACION DEL USUARIO" and "PAGOS" remain in the same position. In the Login screen, popup windows with warning texts appear next to the username and password textboxes to prevent the customer from entering wrong information. The first button in the Payments screen is replaced by two circled shaped checkboxes to select whether the customer would like to pay for commodities using a

Fig. 1. Android Prototype A views

credit card or their credit union savings account. The rest of the buttons are replaced by a vertical scroll viewer that allows the user to select which commodity they will be paying. The arrow shaped button at the top of the screen is now located at the bottom of the screen, with the sign "ATRAS" The application of Nielsen Heuristics is labeled through the semaphore like indicators. The login page in Prototype A is enhanced in the design of Prototype B by the application of the Error Prevention Heuristics, labeled E in Fig. 2. The remaining Heuristics are applied in the Payments Screen.

Fig. 2. Android Prototype B views

iOS Prototypes. The same user interface prototypes were built for the iOS Operating System. Figure 4 shows iOS Prototype A, the user interface which lacks design rules. The Login and Payments provide the same features as in the Android prototype in Fig. 1, with the slight variation in the Payments view where the button to select the payment method is omitted. For the iOS platform when selecting the commodity to pay, a popup window appears to use the payment data stored on the phone or the credit union savings account. Additionally icons indicating the type of commodity to pay are shown along with the name of each basic service. The arrow shaped button is located at the top of the screen to go back to the previous view.

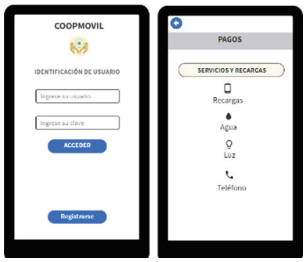

Fig. 3. iOS Prototype A views

Figure 4 shows the Login and Payments views for iOS Prototype B. It resembles the view for the Android Platform in Fig. 2. The Login view applies the Error Prevention Heuristics and the Payments view applies all the remaining four heuristics. The visibility of System Status is applied through a Text Label "Cómo desea pagar" that indicates the customer that a payment is about to be performed. The view in Fig. 3 is modified to Match the Real World (heuristic labeled R) by asking the customer how they will like to make the payment (this is suited so that it matches the views in ATMs). The scroll view is also included in Prototype B in order to select the commodities to pay for. This feature corresponds to the Minimalistic Design Heuristic (D) and also matches real world touchscreens found at credit union establishments. To enhance user control and freedom the back button is located at the top with "ATRAS" (back) sign to indicate that the payment can be cancelled (Control heuristic labeled C).

Fig. 4. iOS Prototype B views

3 Prototype Testing

After designing a total of 7 screens for each of the prototypes, it was important to test their usability. The Quant-UX provides the means to simulate the operation of the prototypes. The links to each of the prototypes simulators were included in a Google

Form[3] and sent to the WhatsApp number or email of each of the credit union customers that were selected to participate in the user centered design.

The usability evaluation of each prototype is double-factored. To determine which prototype offers the best user experience, an analysis of the First-click-heat map of the views is executed. The interpretation of these results is later backed-up by a survey to the credit union members.

3.1 Quant-UX First Click Heatmaps

Quant-UX provides a testing feature named Heat Maps. A Click Heat Map is a well-established method to analyze user interaction, they are fairly easy to read and help user interface designers corroborate ideas about primary and secondary tasks and detect the spots where unexpected behavior and other usability issues might occur. Click heat maps visualize where the users have clicked. The more the users click on a certain area, the hotter (more reddish) the area gets. Thus, the elements in the area are likely important for the user [20].

In this user-centered design the tasks for each interface is identified and prioritized in use cases for each operation. The primary widgets[4] are those that should be visualized and clicked first, according to the order of steps listed in the use case. When evaluating the user interface design, primary widgets should be easy to find and clicked frequently.

The Key Performance Indicators in this analysis are: Widget Clicks, First Clicks and Time-Before-Clicks. Widget-Clicks indicate how many times a certain widget was clicked. The gauge shows the absolute number of clicks, the position of the ring shows the relation to all other widgets in the prototype. First Widget Clicks indicate how many times a certain widget was clicked directly after a screen was loaded; they first show which widgets catch the most attention of the users. The gauge shows the absolute number, and the position visualizes the relation to the screen loads. The Time Before Click displays how many seconds the users took in average until they interacted the first time with the given widget. In general elements in the top are expected to have shorter times the elements at the bottom of a screen [16, 20]. A comparison of Prototype A vs. Prototype B for the Login and Payments Views of each of the operating systems is detailed below.

Android Comparisons of Prototype A vs. Prototype B

Login View: In this view, as stated in the Use Case in Table 2 the user should start the action by entering the username and password if they have already registered their information in the app. The TextBox2 widget that is meant for the user to enter their username is the widget with the least Time-Before-Click.

The image in Fig. 5 shows that Prototype A has a shorter Time Before Click (5 s) than the same element in Prototype B (7 s). However it also depicts that the TextBox2

[3] A full-featured forms tool that comes free with a Google account. It allows the user to add standard question types, drag-and-drop questions and customize the form with simple photo or color themes, and gather responses in Forms or save them to a Google Sheets spreadsheet.

[4] A component of an interface that enables a user to perform a function or access a service.

widget in Prototype A has a Widget Click KPI of 81 and a First Clicks KPI of 51. Prototype B indicates a Widget Click KPI of 38 and a First Clicks KPI of 30. The ratio of First Click/Widget Clicks is smaller in Prototype A (0.62) than in Prototype B (0.78) meaning that out of the total clicks, in Prototype B the probability of TextBox2 of being clicked first is greater.

Based on this quantification Prototype B is considered to provide a higher degree of usability when compared to Prototype A.

Payment View: In Fig. 6 the heat map in the left side (Prototype A) displays a greater number of "hot" areas compared to Prototype B. This indicates that credit union customers scrolled around more in Prototype A than in Prototype B.

The widget with the smallest Time Before Click in Prototype A is "Button", which displays the "Mis Tarjetas" option. This matches the Payments Use Case in Table 3 which states that the user should first select the payment method. The Time Before Click KPI is 5 s. In Prototype B, the RadioBox widget set for the "Mis Tarjetas" option has a Time Before Click of 4 s, meaning it took less time for the credit union customers to identify where to start the Payment Use Case. This interpretation is backed up by the fact that by calculating the First Click/Widget Click ratio for each of the prototypes, Prototype A (0.13) shows a smaller ratio than Prototype B (0.72). This suggest that there's a higher chance in Prototype B for the user to click the widget that corresponds to the first step in the Payments Use Case. According to this heat map analysis, Prototype B would most likely provide the highest degree of usability.

Fig. 5. Android Prototype A vs Prototype B Login View

iOS Comparisons of Prototype A vs. Prototype B

Login View: There is an interesting observation regarding this view. The first element clicked in both Prototypes is not the TextBox2 widget as in the Android platform. As seen in Fig. 7, the item with the least Time Before Click in Prototype A was the Button2 which corresponds to the Register button, which is clicked 4 s after the view is loaded.

Fig. 6. Android Prototype A vs Prototype B Payments view

Prototype B displays much more hotspots than Prototype A. The Info Button located at the top of the view has the shortest Time Before Click (1 s). The First Click/Widget Clicks ratio for the Info Button Prototype B (0.80) is very high compared to the ratio of element TextBox2 (0.16) in Prototype A. This most likely means that the credit union users that were being surveyed probably simulated the prototypes in such a realistic way that they intended to actually register their accounts and look for information on how to interact with the mobile banking application, as sated in the Use Case in Table 2.

Based on this analysis it is possible to argue that even though none of the prototypes match the operations listed in the Login Use Case in Table 2, there is a need to clear out customers doubts by adding an info button or help label. Prototype B includes a help label at the bottom of the screen, meaning that this would be the most usable prototype. This interpretation is supported by the fact that the info button has the lowest Time Before Click KPI. It is suggested that the help label is deleted and the content that it displays should be moved to the top at the info button.

Payments View: Figure 8 shows that regarding the payments view, the first click hot spots resemble those of Android; although the Time Before Click KPI is smaller for both prototypes in the iOS platform.

The hottest hotspot in prototype A is Icon3, which is the widget that allows the customer to recharge credit in their phones or cable TV service. It has a Time Before Click KPI of 2 s. By dividing the First Click KPI over the Widget Clicks KPI for that element, the ratio is 0.73. Prototype B displays the RadioBox widget meant to select the payment method “Mis Tarjetas” as the one with the hottest spot and thus the one with the smallest Time Before Click (5 s). The First Click/Widget Clicks ratio for this element is 0.48.

Comparing these data with the Payments Use Case in Table 3 it can be stated that Prototype B would have a higher degree of usability as perceived by the customer.

Fig. 7. iOS Prototype A vs Prototype B Login view

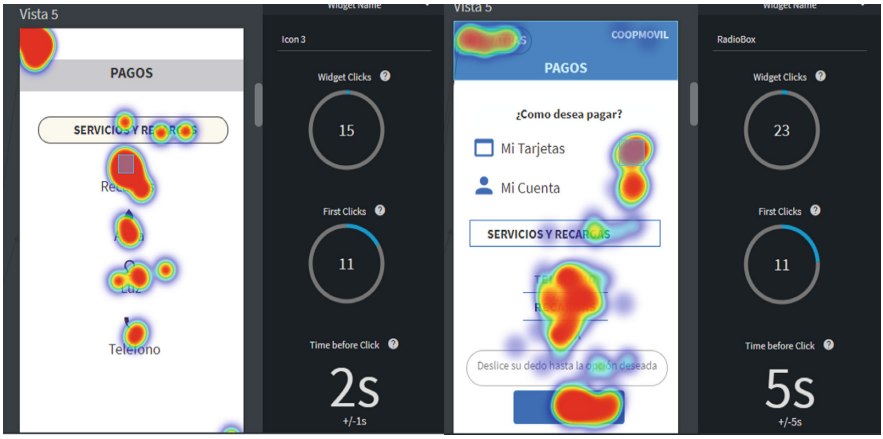

Fig. 8. iOS Prototype A vs Prototype B Payments view

After comparing the Login and Payments Views Heat Maps of Prototypes A and B for both of the operating systems and determining Prototype B would most likely present the highest degree of usability.

3.2 Survey Results

A survey is used to validate the results in the First Click Heat Map analysis. This consisted of four questions regarding the level of comfort credit union customers perceived when simulating the prototypes. There were only two possible answers for each question: Prototype A or Prototype B. The questions address each of the 5 Nielsen Guidelines selected for this study and are listed below

Q1: Which of the two prototypes provides a better visibility of the system status?
Q2: Which of the two prototype presents more understandable phrases or dialog boxes for the use of the mobile application?
Q3: Which of the two prototypes provided more control to browse the app and enter data?
Q4: Which of the two prototypes provides better error prevention?
Q5: In general terms, which of the two prototypes was the most intuitive and user-friendly?

Android Survey Results:
As shown in Fig. 9, for the Android Operating System, Prototype B is considered the most usable in the evaluation of each of the Nielsen Heuristics by credit union customers. All of the answers to the questions score above 60% acceptance. The question

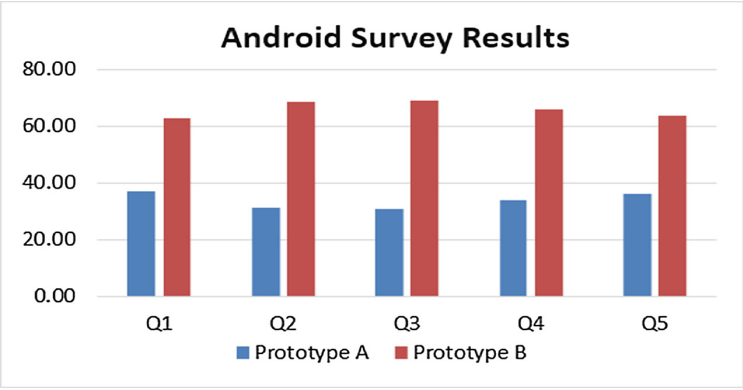

Fig. 9. Android survey results

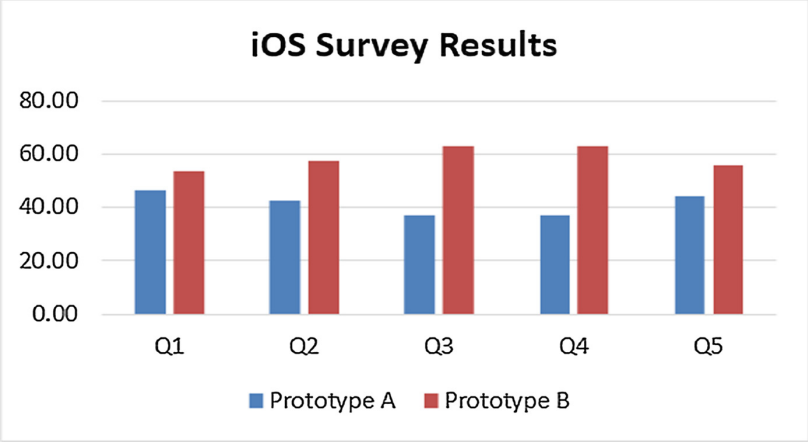

Fig. 10. iOS survey results

with the highest percentage is Q3 with 69.2% meaning that the Control heuristic is the most appreciated by credit union customers in the Android platform.

In iOSystem, Prototype B is also considered the most usable in the evaluation of each of the Nielsen Heuristics by credit union customers. As described in Fig. 10, all of the answers to the questions score above 50% acceptance. The questions with the highest percentage are Q3 and Q4 with 63% meaning that Control and Error Prevention are the most valued by the customers for this operating system.

4 Conclusions

The main objective of this research was to apply the User Centered Design approach in order to build and test two interface prototypes, one which lacks design rules and another which follows five out of the ten Nielsen Heuristics.

To successfully accomplish this goal, it was necessary to understand the context of use of the mobile application. Establishing a representative group of credit union customers to collect needs from, proved invaluable to asses user requirements and define software functionalities through the Use Case methodology.

After defining the mobile banking application needs, the interface prototypes for each Use Case were successfully designed in Quant-UX; which was also used later to test the level of usability of each prototype through Key Performance Indicators in First Click HeatMaps. Though First Click HeatMaps provide meaningful information, the interpretation of this KPI is very subjective. Thus, it was important to support this interpretation with the survey, in which Nielsen Heuristics prove effective in enhancing customer usability of user interfaces designed for a mobile context, regardless of its operating system. Prototype B, which followed the usability guidelines in its design, is perceived as easier to use by costumers in both Android and iOS. This perception matches our analysis of First Click HeatMaps which validates the study and the use of the User Centered methodology.

The principal contribution of this study is that the use of the prototyping tools and the application of the UCD Methodology provided a way to test usability and confirm findings in [10, 13–17] in a practical setting, without the need to build the mobile banking app and deploy it in the financial market.

The study can be replicated in other financial institutions or other industries. It is suggested that future work includes development of the mobile application to address further concerns regarding actually executing the transactions.

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