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Investigating the Impact of Human-Centered Interface Design on the User Experience of Mobile Device Users

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by

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Investigating the Impact of Human-Centered Interface Design on the User Experience of Mobile Device Users by Ruchir Gupta

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Abstract

Title:

Investigating the Impact of Human-Centered Interface Design on the User Experience of Mobile Device Users

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In order to investigate the intricate interaction between interface design, user technological proficiency, and other components of the user experience, this research study used a mixed-method approach. The beginner user group—those with little experience or expertise with technology—were the main target audience. The important discovery emphasizes the substantial influence that careful design can have on improving the effectiveness and usability of interfaces for non-tech-savvy individuals. When using the suggested Interface B instead of the current Interface A, beginner participants' task completion times significantly improved, according to the user study. This underlines the significance of creating with the needs of the target audience in mind and underscores the critical role that human-centered design plays in bridging the gap between beginner and expert users. The study's conclusions show that there is a more nuanced relationship between interface complexity and user performance than initially thought.

The idea that the only way to optimize the user experience is by lowering complexity is called into question by the observed adaptability of users to new design components. Rather, it highlights how important it is to take users' familiarity and pre-existing mental models into account when creating interfaces. The examination into cognitive load yielded inconsistent findings, suggesting the need for a more detailed knowledge of the ways in which different interface design elements impact distinct components of cognitive burden. This further emphasizes how crucial it is to use multimodal assessment techniques in order to fully capture the subtleties of the user experience. Moreover, the results concerning task completion times and user satisfaction contradict common assumptions, indicating that a variety of factors other than interface complexity or simplicity affect these results. This emphasizes how crucial it is to use a comprehensive, human-centered design methodology. Future research can further contribute to a deeper knowledge of the intricate relationship among interface design, user experience, and technological aptitude by resolving the constraints of the current study and investigating new avenues for investigation.

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Acknowledgements

I extend my heartfelt appreciation to Dr. Thomas C. Eskridge for his invaluable mentorship, guidance, and expert insights in Human-Centered Design. His mentorship has been an indispensable compass, illuminating my path throughout this study. His wisdom and support have refined my understanding of this field and inspired me to reach for new heights in my endeavors.

It is with deep gratitude that I acknowledge the guidance of Dr. Troy R. Weekes. His unwavering support and encouragement have been instrumental in shaping the trajectory of this study. His commitment to my academic growth and dedication to pushing the boundaries of knowledge in human-centered design have been constant sources of inspiration.

Furthermore, I express my profound gratitude to the Florida Institute of Technology for their unwavering support. Their resources, encouragement, and commitment to academic excellence have provided me with an environment conducive to learning and growth, enriching my educational journey profoundly.

This study stands as a testament to the collective support, guidance, and encouragement I have received from these esteemed mentors and institutions, which have been pivotal in shaping my academic pursuits in the realm of Human-Centered Design.

Dedication

This thesis is dedicated to the relentless spirit of innovation and empathy that drives the pursuit of human-centered solutions.

To my beloved family, whose unwavering support, understanding, and sacrifices from across oceans, all the way from India, have been the cornerstone of my academic journey. Your enduring belief in me has sustained and elevated my determination to explore the intricate facets of Human-Centered Design, striving to make a tangible difference in the world.

To my esteemed professors, Dr. Thomas C. Eskridge and Dr. Troy R. Weekes, whose profound guidance, patience, and unwavering commitment have not just imparted knowledge but have sculpted my understanding of the transformative potential of design. Your mentorship has ignited a passionate flame within me, propelling me to delve deeper into the realms of empathy-driven creation.

To the individuals whose stories, insights, and experiences have breathed life into this work, serving as beacons that illuminate the path toward understanding the diverse needs and aspirations of humanity. Your willingness to share your narratives has been the catalyst, reminding me constantly of design's real impact and significance in improving lives.

This thesis is a tribute to the collaborative effort of all those who believe ardently in the transformative power of design to enrich and elevate the human experience. It is an amalgamation of shared knowledge, collective efforts, and a profound commitment to shaping a more empathetic, inclusive, and meaningful world through the lens of Human-Centered Design.

Chapter 1

Introduction

Given the speed at which technology is developing today, mobile devices have become a necessity [8]. They have completely changed how we interact, communicate, and move globally. They unquestionably provide great ease and many alternatives for accessing the digital world to use services, gather information and consume entertainment. But amid this digital transformation, there is a large, but frequently ignored, group: non-tech-savvy people [90, 29]. Non-tech-savvy individuals, as defined in this study, are characterized by a lack of proficiency (measured through objective measures) or comfort (measured through subjective measures) in using contemporary technology. This determination is made based on self-perception surveys where participants disclose their perceived level of tech-savviness. Tech-savviness is not necessarily binary; individuals may exhibit varying degrees of proficiency across different aspects of technology. Therefore, tech-savviness is assessed on a spectrum rather than as a strictly binary classification. This study focuses on their difficulties interacting with a growing aspect of technology, mobile interfaces. Mobile device interactions have specific usability challenges associated with them when being accessed by non-tech-savvy users, such as finding menu icons, scrolling through menus, or switching between tabs on mobile interfaces [54]. Even tasks that seem simple to tech-savvy people may be complex or perplexing for this group of non-tech-savvy people, such as updating apps or distinguishing between touchable and non-touchable screens. Their discomfort or lack of knowledge of the subtleties of mobile devices characterizes their experiences, which frequently escape the attention of interface design techniques [44, 12].

The demands and experiences of non-tech-savvy people are sometimes overlooked during the design process [29]. This oversight can result in straightforward interfaces for tech-savvy users but provide substantial challenges for individuals who need to learn more about technology or simply do not find current interfaces intuitive enough to perform everyday tasks. Recognizing this demographic and understanding their issues with technology offers a chance to meet their particular needs through interface design. By using human-centered design, we can come up with standards and interfaces that cater to a more extensive range of users — both tech-savvy and not — and can result in more inclusive designs[57]. This approach does not aim to simplify interfaces but to make them more intuitive and accommodating for all users based on their needs, behaviors, and goals, regardless of technological proficiency, by reducing factors like cognitive load, and enabling higher user satisfaction and ease of use [9].

In a nutshell, recognizing the existence and relevance of non-tech-savvy users during the design process is critical for building interfaces that are accessible and human-centered in this age of ubiquitous mobile technology [9, 31, 62].

The emphasis here is on prioritizing non-tech-savvy users' experience within the complex tapestry of interface design [74, 3, 57, 56]. Understanding and tackling this group's mobile experience difficulties is critical in an age where mobile technology pervades practically every aspect of modern life [71]. This approach acknowledges that while technology can empower, it may also unintentionally alienate those who are struggling to grow more aware and comfortable with its complexities. [9, 31, 56].

By focusing on this often overlooked demographic, this thesis seeks to better understand their particular experiences, issues, and interactions with mobile interfaces. This strategy in this thesis goes beyond simply accommodating these users; it involves redefining design standards to ensure that interfaces are intuitive, accommodating, and accessible to a wide range of users, regardless of technological ability [48].

Ultimately, the goal is to promote a design mindset that prioritizes diversity by empathizing with the target user segment and making mobile device interfaces and interactions more usable. It's about establishing the way for interface designs that appeal to tech-savvy users to also be inviting to people who find technology intimidating. This proactive approach benefits users who are not tech-savvy and intends to improve the overall landscape of interface design principles, resulting in more human-centered experiences that appeal to a broader audience [21, 26, 44].

The methodological framework used in this thesis takes a data-driven approach, using surveys to gather information from multiple perspectives across age groups [25]. This survey technique serves as a foundation, ensuring a comprehensive understanding of the many viewpoints, behaviors, and issues encountered by non-tech-savvy users in their interactions with mobile devices [16]. Through this meticulous exploration, the research records surface-level device interactions before delving deeper to uncover the rich layers that define these consumers' interactions with technology and identifying common usability challenges faced by the users along with their preferences [57].

The approach of this thesis extends beyond surface observations. The survey results are analyzed using advanced tools such as cluster analysis to identify various groups based on comfort levels and technological proficiency [75]. This sophisticated categorization, generated from survey data, is critical in understanding the range of users' technical proficiencies. It aids in identifying various user personas, ranging from those who are reasonably comfortable with technology to those who are substantially less proficient [41]. This granular insight serves as the foundation for designing and developing human-centered interfaces [90].

Combining survey data with analytical tools such as cluster analysis, the study understands the broader landscape of non-tech-savvy users' experiences. It breaks down this data to identify specific clusters or groups with varying tech-savvy levels [25, 75]. This data-driven approach ensures a more targeted and nuanced design strategy, allowing the resulting interface designs to respond to the varied demands and behaviors of diverse segments of this demographic rather than a homogeneous "non-tech-savvy" group. Finally, it lays the groundwork for a more nuanced and empathetic approach to interface design that connects with the wide range of users in the non-tech-savvy cohort [90].

The primary goal of this thesis is to create a thorough and iterative interface design approach meticulously developed to meet the demands of non-tech-savvy users [24]. This technique combines several elements, including user feedback, recognized usability principles, and empirical data. By combining these features, the study hopes to design interfaces that prioritize user experience, effectively addressing and reducing the mobile device interaction pain points experienced by people with limited technical expertise [65, 37, 50, 81, 45].

Following the construction of these empathetic interfaces [8], the research moves on to in-person studies with volunteers who identify as non-tech-savvy. These experiments are methodically designed to quantitatively assess the impact of interface enhancements. The research attempts to show these revised interfaces' transformative potential on user experiences by evaluating specific metrics such as user satisfaction, cognitive load (the mental effort required to execute tasks), and task completion time [81, 34].

The study uses these rigorous evaluation methods to demonstrate qualitative improvements in user experience and a quantitative impact on key performance parameters. This method evaluates the usefulness of the proposed interfaces and sheds light on how targeted interface changes might substantially improve the mobile interactions of non-tech-savvy users [37]. Finally, the goal is to pave the way for more inclusive and human-centered interface designs that cater to the different needs of all users, independent of technological proficiency [57, 19].

This thesis is an in-depth account of a thorough investigation of the complex world of non-tech-savvy mobile interactions. It captures aspects of this excursion, beginning with a comprehensive survey of different demographics and ending with precisely segmenting consumers based on their technological proficiency (Figure 1.1). The thesis explores the evolution of interface design solutions to improve the user experience for this sometimes disregarded audience [20].

This research goes beyond simple documentation. It does not exist in isolation but rather within the larger context of interface design and the broader landscape of technological inclusion [91, 37], which is discussed in Chapter 2. It strongly promotes an inclusive design approach that encourages accessibility for all users, regardless of technology proficiency [2]. By advocating this ideal, the thesis hopes to pave the way for a future in which technology becomes an empowering force, enabling fair access and usability for people with varying levels of technological familiarity [57, 23].

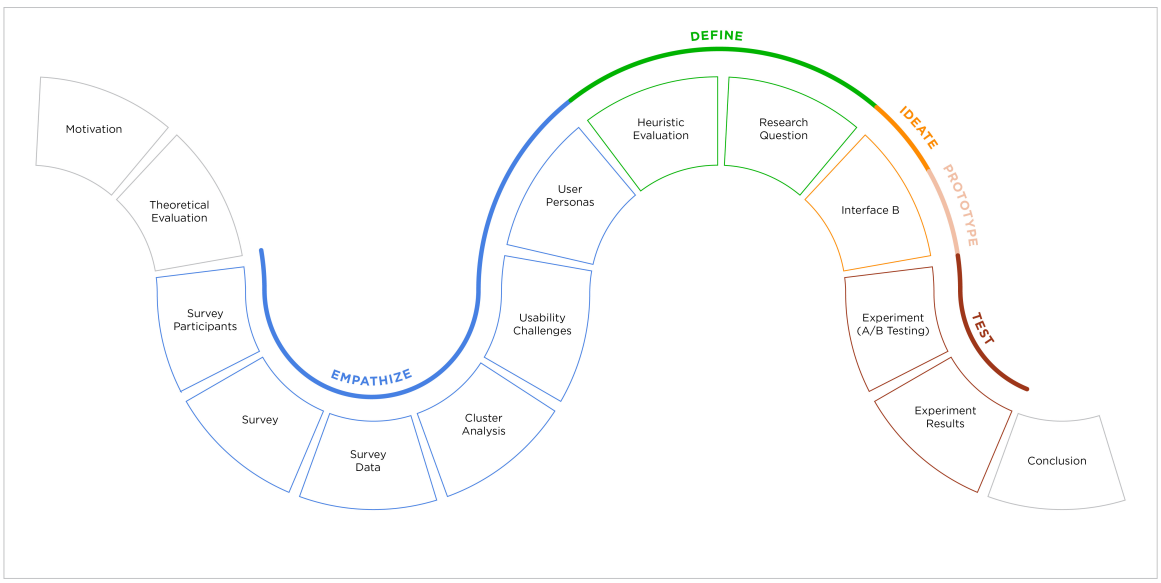

Figure 1.1: Using the d.School Design Thinking approach by the Institute of Design at Stanford, this thesis strongly promotes an inclusive human-centered design approach that encourages accessibility for all users, regardless of technology proficiency [19].

Chapter 2

Literature Review

The rapid advancement of technology has signaled a dramatic digital transformation in the use of technological devices such as smartphones and desktops, radically altering how people engage with information and communication technologies (ICTs) in modern society [78, 18, 32]. However, in this age of technological innovation, personalization, and miniaturization, a sizable fraction of users encounter substantial difficulties navigating modern mobile device interfaces. This diverse category of people, known as "non-tech-savvy" [90], includes users who experience varied degrees of discomfort, unfamiliarity, or limited ability when interacting with modern technology. This "digital gap" creates substantial barriers for these users, limiting their access to and effective use of digital tools such as navigation, communication, online banking, social networking, etc. [91, 50, 45, 17]. As a result, this exclusion worsens socioeconomic disparities since non-tech-savvy people confront barriers to accessing critical services and opportunities in an increasingly digital-centric technological ecosystem. [62, 29].

The terms "digital gap" or "digital divide" refer to significant disparities in access to, use of, and proficiency with information and communication technologies (ICTs), such as computers, cell phones, and other digital devices [50, 32]. This multidimensional divide includes variations in hardware availability, internet connectivity [16, 42], and the capacity to explore and use digital tools and applications properly [8]. Within this approach, non-tech-savvy people appear as a sizable cohort who need help embracing and productively engaging with modern technology. The research on the digital divide highlights technological differences and broader societal repercussions. It emphasizes how this disparity exacerbates socioeconomic disparities by limiting access to critical resources and opportunities for less technologically skilled people [45, 17].

The literature on this subject emphasizes the difficulties encountered by non-tech-savvy individuals. Studies have highlighted the wide range of obstacles this group experiences, including difficulties understanding interface designs and navigating the various functionalities of current mobile devices [3, 74, 17]. Furthermore, research focuses on the broader consequences of digital exclusion, exposing how it contributes to socioeconomic inequality by limiting access to education, career prospects, healthcare services, and civic engagement platforms [91].

Digital inclusion has emerged as a critical subject in this discussion. Scholars advocate for interventions to bridge the digital gap, highlighting the necessity of developing inclusive digital environments that meet all users' various needs and abilities. The literature suggests that human-centered design techniques, educational initiatives, and policy actions can improve digital literacy and accessibility. [50].

The impact of the digital divide on societal structures and inequality has also received attention, with research looking into its implications for social justice, economic involvement, and democratic engagement. There is a growing consensus in the literature that tackling the issues faced by non-tech-savvy users is a critical step toward establishing a more fair and inclusive society. [1, 10, 71, 37].

Studies in this field highlight the varied character of the digital divide, shedding light on the variables that contribute to these gaps. Individuals' technological proficiency and access to digital resources are influenced by the socioeconomic situation, geographic location, education level, age, and cultural background [48, 12, 29, 26].

The literature focuses on the obstacles that non-tech-savvy people encounter when navigating increasingly complex digital interfaces. It dives into their difficulties in adopting and effectively utilizing digital solutions tailored to mobile devices due to a need for more knowledge and comfort with technology. Scholars also emphasize the significance of this divide for the engagement and inclusion of non-tech-savvy individuals in all aspects of society, highlighting their possible exclusion from critical services and opportunities [8, 65].

Addressing the digital divide has been a hot topic in academic circles, with publications arguing for measures to eliminate inequities in technology access and skill. The proposed strategies include activities to improve digital literacy, promote inclusive design principles, and implement policies to ensure fair access to technology resources. Furthermore, the literature emphasizes the importance of joint efforts between governments, educational institutions, and technology providers in bridging the divide and creating a more inclusive digital world for all people, particularly those not tech-adept [50, 32, 40, 28, 73, 38, 42].

Addressing the demands of non-tech-savvy users has become increasingly important in interface design, with a growing corpus of research focusing on this topic [53, 95]. Scholars and designers alike understand the need to use a human-centered approach to design that prioritizes inclusivity and usability [54, 90, 29].

Studies dive deeply into this population's multiple issues, highlighting their struggles to understand and effectively engage with mobile devices [95, 30, 5]. These issues include difficulties understanding app functionality, navigating complex interface designs and web applications, and keeping up with the rapid growth of technological trends. Furthermore, the literature emphasizes the critical importance of human-centered design principles in minimizing these issues, advocating for intuitive and accessible interfaces that bridge the gap between technology and users of diverse technological familiarity. Finally, this body of research emphasizes the crucial need to develop user-friendly and inclusive interfaces that cater to non-technical users' different needs and abilities in an increasingly digital environment [58, 43, 51, 39].

Another study at the School of Design, The Hong Kong Polytechnic University [54] conducted a usability study on 1002 interactions on mobile navigation behavior concerning design patterns highlighting key aspects such as visual design, ease of understanding, interaction, and navigation. The results of the study indicated how users struggled with tasks such as searching for text tabs when tabs were not noticeable enough, tab scrolling (44% failure rate) among tab bars and tab menus, especially when it involved horizontal scrolling, finding entry points for side drawers specifically the hamburger icon. Users also faced difficulties differentiating between touchable and non-touchable screens and additional challenges when scrolling through simultaneous menus. Findings from the results also outline the usability challenges and issues users face due to "old habits" leading to instinctive actions for navigation across tabs and screens within interfaces. The study further discusses the need to provide visual cues indicating interaction direction.

Understanding user needs, goals, habits, preferences, and barriers encountered within these interfaces is critical in addressing the usability issues experienced by non-tech-savvy people in mobile engagements. Surveys done across various demographics and age groups are a popular way in the literature to extract nuanced insights regarding the complexities of non-tech-savvy user experiences [16]. These surveys, which are meticulously created to include common patterns and procedures, are critical instruments for evaluating the presence of user difficulties and pain points and determining the nuanced demands and preferences of persons navigating mobile interactions and app usability. Scholars and researchers emphasize the importance of these surveys as essential tools, providing a thorough understanding of the varied features of non-tech-savvy users' interactions with mobile devices. They offer a structured approach for capturing various viewpoints, behaviors, and constraints encountered, which outlines subsequent design ideas and standards to address the highlighted difficulties. In essence, the literature emphasizes the importance of surveys in illuminating the intricacies of user experiences and demands, giving vital information for creating more inclusive and human-centered mobile interfaces for non-technical users by empathizing with the end users [43, 30, 51].

Cluster analysis techniques have been developed for use in interface design research, particularly for segmenting users based on their varied levels of technological proficiency. The research emphasizes the need to use these strategies to divide people into separate clusters, defining clear boundaries between less and more tech-savvy sectors. Notably, these analyses frequently produce bimodal distributions, showing significant disparities in technological ability between user groups [67, 52, 83, 14]. This segmentation technique is useful in understanding how technology interfaces influence people differently depending on their level of technical proficiency. By segmenting these groups, researchers get valuable insights into the various issues that different user groups face, offering light on how technology may overwhelm or provide obstacles unique to each competency level [68, 59, 22]. This deep understanding, resulting from cluster analysis, has far-reaching consequences for interface design since it offers actionable insights into adapting interfaces to the different demands and proficiencies of non-technical users. Finally, in the literature, cluster analysis approaches are valuable tools, providing insights critical for building interfaces that accommodate users' varied range of technological familiarity [81, 34].

Recent studies emphasize the importance of segmenting consumers based on their varied tech-savvy levels to enhance interface designs to cater to diverse user needs. This categorization structure divides users into groups: Beginners, Intermediates, Masters, and Experts, each with various levels of technological familiarity and ability [41]. Recent studies emphasize the importance of segmenting consumers based on their varied tech-savvy levels. To enhance interface designs to cater to diverse user needs. These classifications are a critical foundation for efficiently adapting interface designs and aligning capabilities and features with each user category's unique demands and preferences. The literature on the subject underlines the importance of this segmentation technique since it allows designers and researchers to understand the complex distinctions in user behaviors, preferences, and obstacles experienced during mobile interactions. Understanding these diverse user segments enables designers to create more targeted and specialized interface solutions, ensuring that the interface meets users' unique needs at all levels of technological ability. This approach allows for a more human-centered and accessible technical landscape. [13, 77, 68, 59, 22].

In improving user experiences, A/B testing stands out as a commonly used methodology. This method thoroughly compares established interface systems, designated Interface A, with freshly built prototypes, labeled Interface B. The literature in this area emphasizes the importance of conducting in-person tests, especially with non-tech-savvy consumers, to assess the efficacy of interface enhancements. These tests track vital parameters like user satisfaction, cognitive load, and task completion time. The empirical evidence gathered from these assessments provides significant insights into the tangible influence of interface changes on the experiences of non-technical users [92, 15]. Researchers underline the significance of this methodology in evaluating the impact of interface enhancements, which enables a data-driven knowledge of how these changes affect user interactions and satisfaction levels. Finally, A/B testing emerges as a vital tool in the literature, providing empirical confirmation and insights into the practical implications of interface enhancements on the experiences of non-technical users traversing digital interfaces [76, 11, 89, 49].

In conclusion, the literature on non-tech-savvy users and interface design emphasizes the significant impact of the digital divide on people's access to and competency with technology. The rapid expansion of technology has revolutionized societal interactions, but it has also increased the gap between those adept in technology and those unfamiliar with its complexity. Non-tech-savvy users, representing a diverse group with varied technology expertise, confront considerable challenges in navigating and utilizing current digital interfaces, worsening societal disparities by limiting access to critical services and opportunities [78, 18, 32].

Several recurring themes appear throughout the literature. There is a strong emphasis on the varied nature of pain points faced by non-tech-savvy individuals, which range from difficulties understanding interface designs to difficulties engaging with complicated features of current technologies. Second, the notion of the digital gap is firmly embedded, emphasizing gaps in access to electronic resources such as mobile devices and their broader societal implications for education, employment, healthcare, and civic participation [95, 30].

Scholars advocate for solutions that bridge the digital gap, emphasizing the relevance of inclusive design principles, educational programs, and policy interventions to improve digital literacy and accessibility and inclusive and human-centric design features that address users' paint points, needs, and behavioral patterns. Furthermore, segmentation tactics based on varied levels of technical proficiency and approaches such as surveys, A/B testing, and cluster analyses help understand user behaviors, preferences, and challenges in mobile interactions. These methodologies provide actionable information necessary for building human-centric interfaces that meet the different needs of non-technical users.

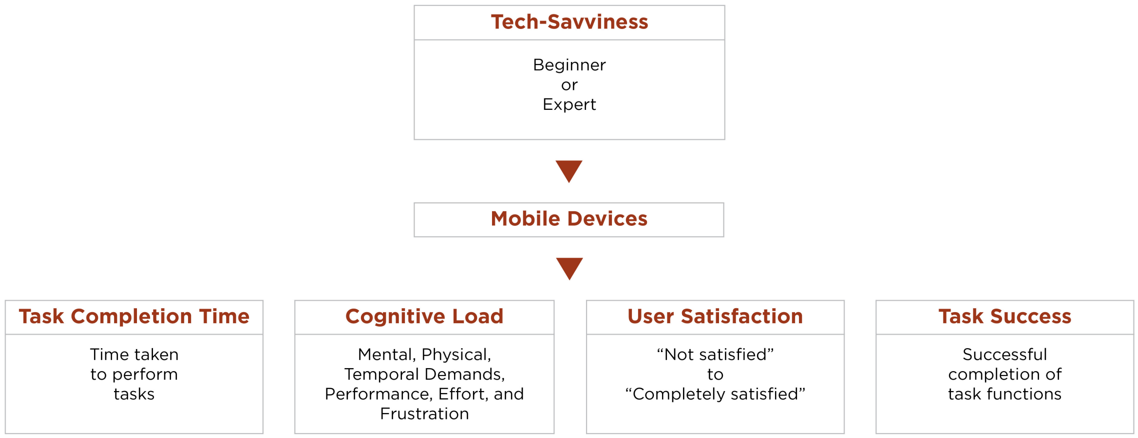

Figure 2.1: The study presents a theoretical evaluation framework for understanding how users perceive and accept technologies. This paradigm directs the investigation of user happiness as a critical factor in the acceptance and success of the proposed human-centered mobile interface (Interface B). The study combines cognitive load theories, acknowledging that a mobile interface's cognitive demands substantially impact the user experience. Furthermore, it helps to frame the assessment of participants' mental effort, contributing to a more complete knowledge of how technology interacts with the cognitive processes of non-tech-savvy users.

In essence, the literature emphasizes the importance of inclusive design approaches and collaborative efforts in addressing the usability issues faced by non-technical users. Developing intuitive, accessible interfaces and promoting digital inclusion benefits this population while creating a more equitable and inclusive digital landscape for all people, regardless of technological ability. As technology advances, fostering inclusion in interface design becomes critical to ensuring that technology empowers all users in an increasingly digital-centric society, making it more human-centric.

The theoretical evaluation framework for the study is illustrated in (Figure 2.1), which identifies user segments based on their tech-savviness as the target user population and shows how the variables of the study are related to each other.

Chapter 3

Survey and Interface Design

This research followed a mixed-method design with a survey questionnaire to identify the current usage and challenges faced by non-tech-savvy mobile device users, followed by a usability study to determine the impact of the proposed interface design. In this chapter, we present the survey, survey analysis, and interface design, and then present a usability analysis of the design in Chapter 4.

3.1 Survey Methodology

The methodology adopted for this thesis revolves around a meticulous process of defining, understanding, and addressing the challenges users encounter in their interactions with mobile devices.

3.1.1 Defining User Groups

The study begins by defining the target audience: non-tech-savvy individuals who use mobile devices. To understand the complexities of their experiences, a detailed survey was created [21]. This survey aims to gain nuanced insights about this user group's traits, usability challenges, and preferences. This survey is essential for discovering and ultimately resolving pain points and needs inherent in mobile interactions because it validates the current challenges that users confront [24].

3.1.2 Participants

For the study, we contacted 150 potential participants through emails, social media, and professional networks in business settings. Of these, 103 responded, with 31 completing the entire survey. The final sample ranged in age from 19 to 70 years (Figure 3.1).

Descriptive analysis showed a mean participant age of 39.8 years with a standard deviation of 16.3 years. This reflects the sample's age diversity, adding depth to the dataset and strengthening the study's findings.

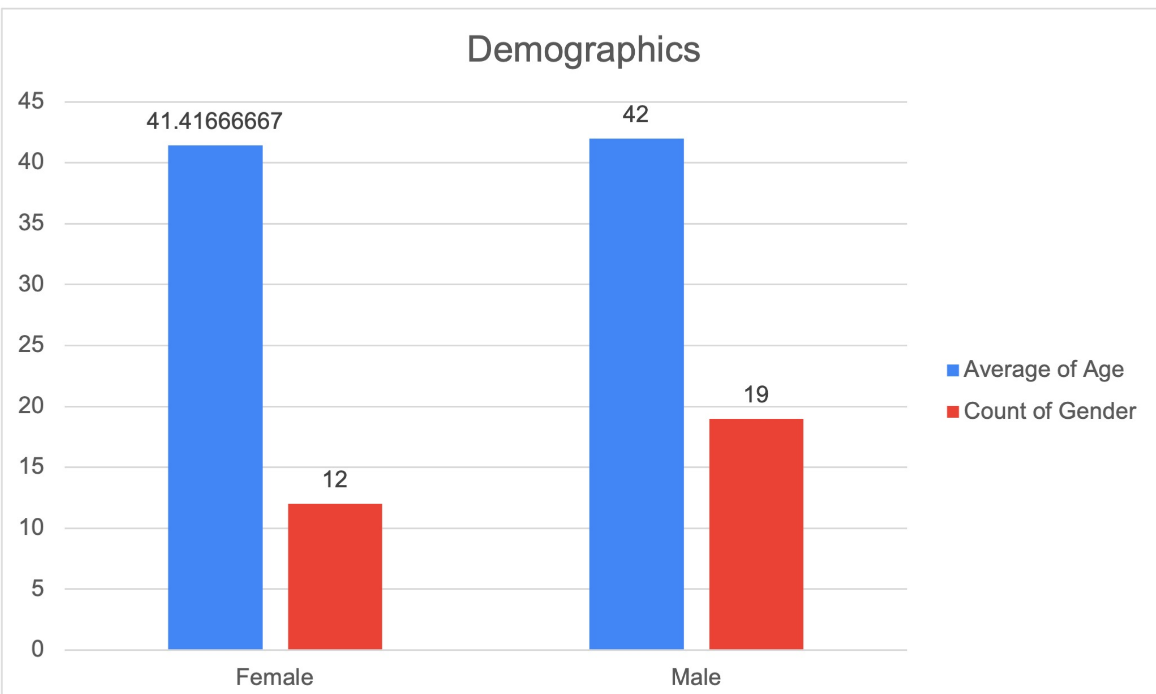

Figure 3.1: Survey Demographics - Of the 103 participants, 31 successfully finished the survey. The age range of the final sample spanned from 19 to 70 years old.

3.1.3 Data Analysis

Following the survey, the researcher delved into the particular challenges faced by specific user groups in mobile device usage. The selection of these groups was based on survey results that highlighted significant usability issues. The common usability challenges included within the survey were included after a review of existing literature revolving around non-tech-savvy users, and users were additionally also inquired about any other challenges that were not included in the list of common challenges. A classification technique (user segmentation through k-means clustering) was then employed to categorize users by tech-savviness into four groups: Beginners (not tech-savvy), Intermediates (slightly tech-savvy), Experts (tech-savvy), and Masters (proficient in all functions and adept at keeping up with technological changes) [41]. This categorization allowed for a nuanced understanding of user competencies and requirements (Figure 3.2, 3.3, 3.4 and 3.5). With these insights, the research moved into phases dedicated to developing targeted solutions and interfaces that address the unique obstacles encountered by users with different levels of tech expertise.

3.1.3.1 Cluster Analysis

This study takes a rigorous approach focusing on cluster analysis to provide a thorough understanding of the spectrum of technological proficiency among users. The primary goal is to segment users based on their tech-savvy ratings, dividing them into distinct clusters representing varying levels of technological proficiency. To begin this process, each user is assigned a tech-savviness score, which is calculated based on their survey responses to commonly occurring usability challenges while interacting with mobile devices and ranges from 1 (non-tech-savvy) to 5 (expert). Respondents whose average score ranged between 0 to 1.5 were assigned to the Expert group, 1.51 to 2.25 were assigned to the Master group, 2.26 to 2.99 were assigned to the Intermediate group,

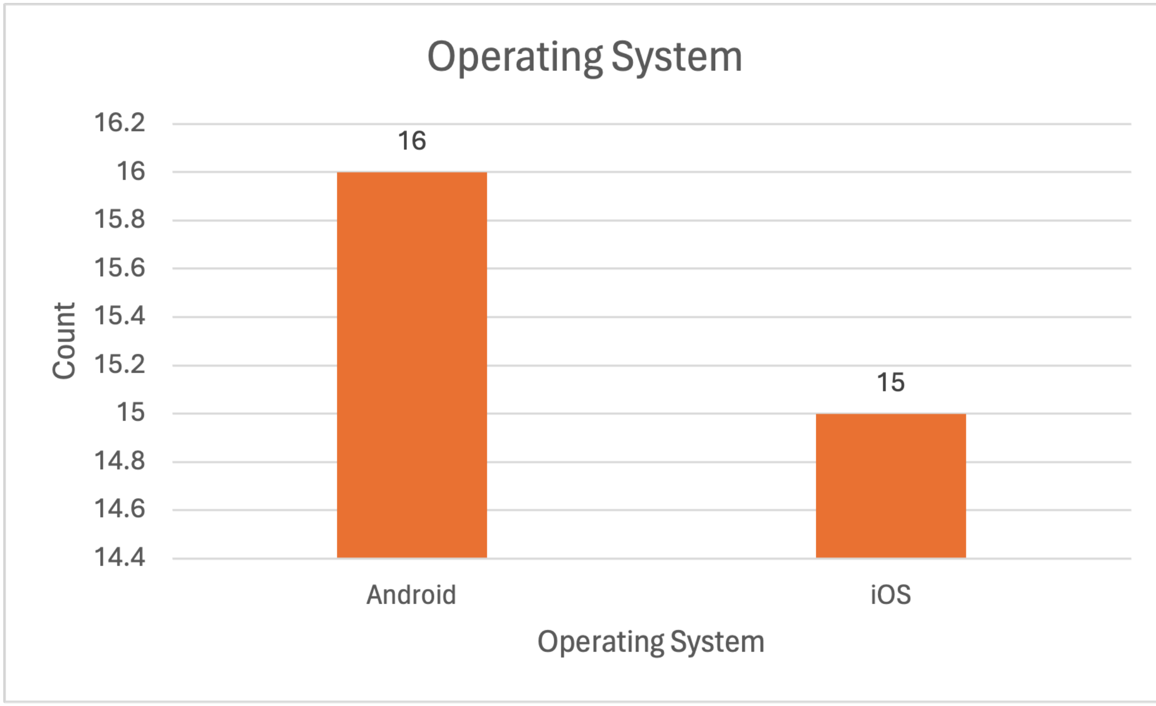

Figure 3.2: User Preferences - 16 of the 31 respondents indicated their choice of operating system as Android, and 15 indicated iOS.

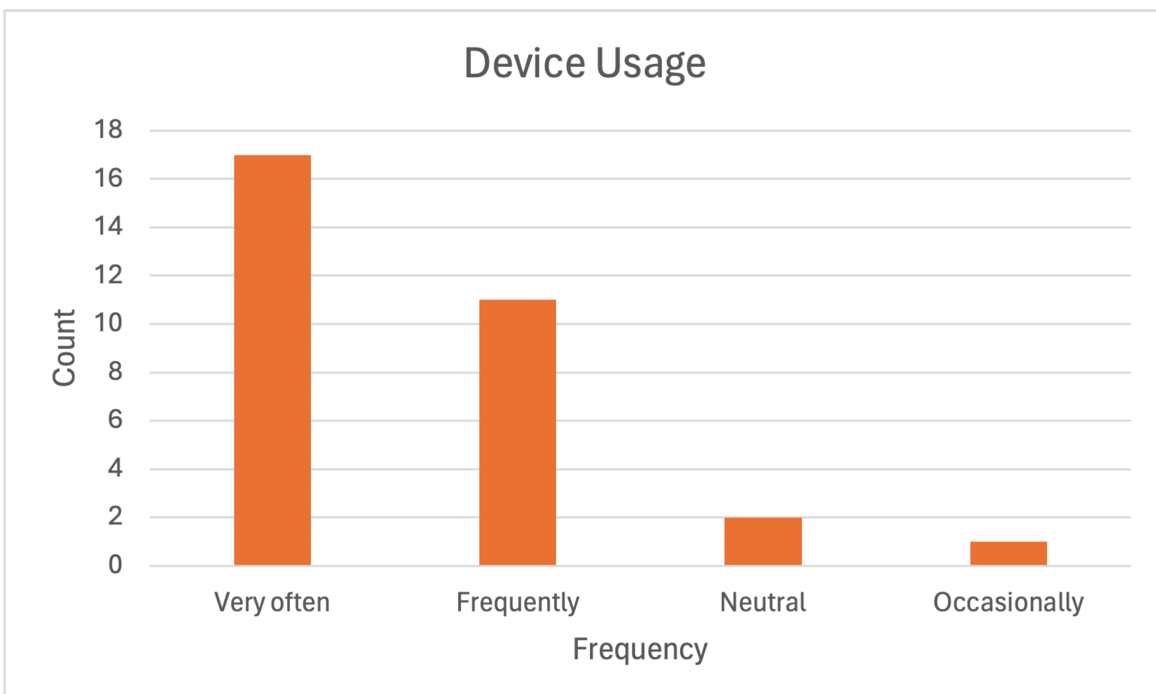

Figure 3.3: Respondents self-reported the frequency of their usage of mobile devices.

and 3 to 5 were assigned to the Beginner group, and the challenges and tech-savviness were further analyzed, as indicated in Figures 3.6, 3.7, 3.8 and 3.9. Using a k-means clustering method determined using the Elbow Method. 10 iterations over different values of k (number of clusters) from 1 to 9 and calculate the inertia (sum of squared distances to the closest cluster center) for each k (Figure 3.10), which shows the four cluster segments at an inflection point based on tech-savviness - beginners, intermediates, masters and experts as depicted in Figure 3.11 [75, 67, 52, 83, 14]. Further cluster consolidation (Figure 3.12) breaks down the clusters (k) into three clusters: one for intermediates and masters named Group 0, beginners are segmented into Group 1 and Group 2 represents experts. This was done to ensure that we target the group facing the challenges most often (Beginners) and also focus on future design solutions for extreme case scenarios. Consequently, we intend to address challenges faced by the other segments facing the challenges less often.

Following cluster formation and consolidation, a thorough evaluation of each cluster's features is conducted, including an analysis of the average tech-savviness scores within each cluster and an assessment of the range of scores to understand the distribution of technical skills. Statistical tests, particularly the Shapiro-Wilk test for normality [82, 27, 70] followed by a MANOVA test or Friedman's test [93, 72, 47] based on whether the data was parametric or non-parametric, are then used to examine the significance of the differences observed between the identified clusters and determine if the variations in tech-savvy levels are statistically significant. Interpreting these cluster analysis results is critical, as it provides insights into the distribution of technical proficiency among users and identifies various user groupings based on their app competency levels. This methodological framework seeks to uncover the subtle differences in tech-savviness among user groups, paving the way for specialized interface design techniques and recommendations that respond to the different technological

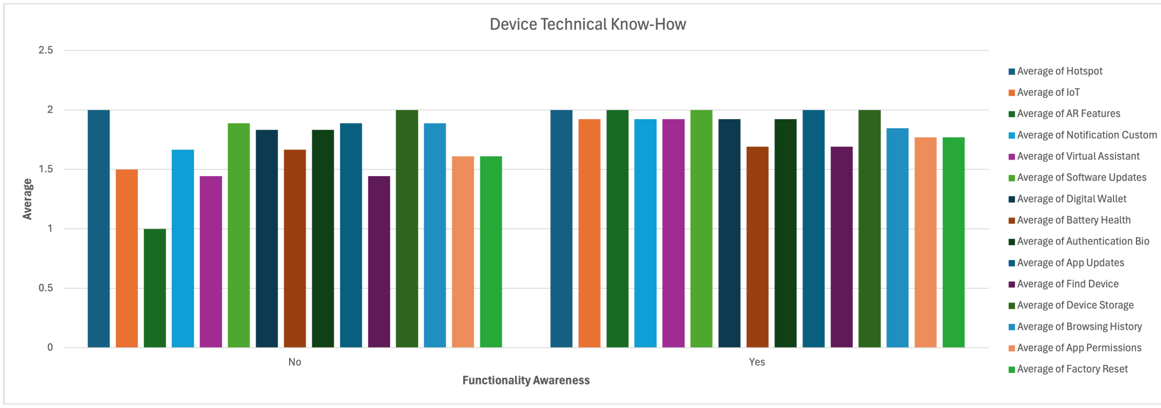

Figure 3.4: Technical Know-How - Survey respondents indicated their existing technical know-how based on specific functionalities across operating systems.

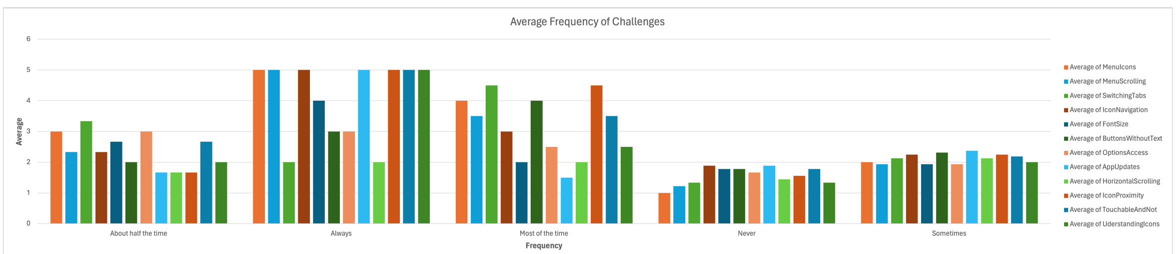

Figure 3.5: Usability Challenges - Respondents were asked to report the frequency of common challenges based on a Likert scale.

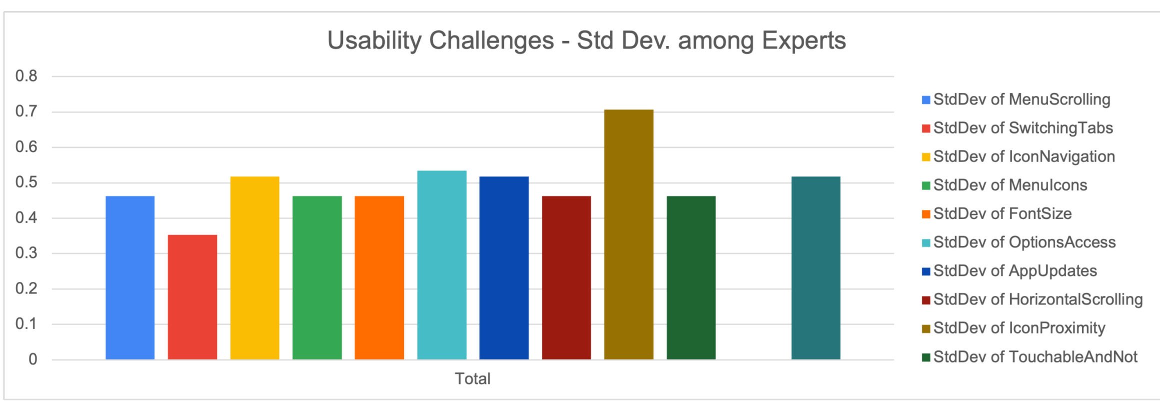

Figure 3.6: Respondents who were assigned to the Expert group reported facing frequent usability challenges with icons in close proximity.

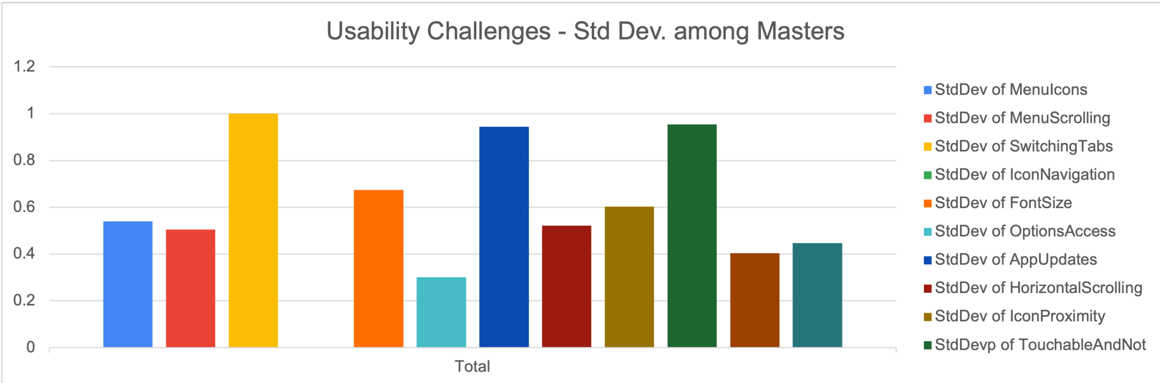

Figure 3.7: Masters frequently faced usability challenges such as switching between tabs, finding functionalities after app updates, and distinguishing between touchable and non-touchable screens.

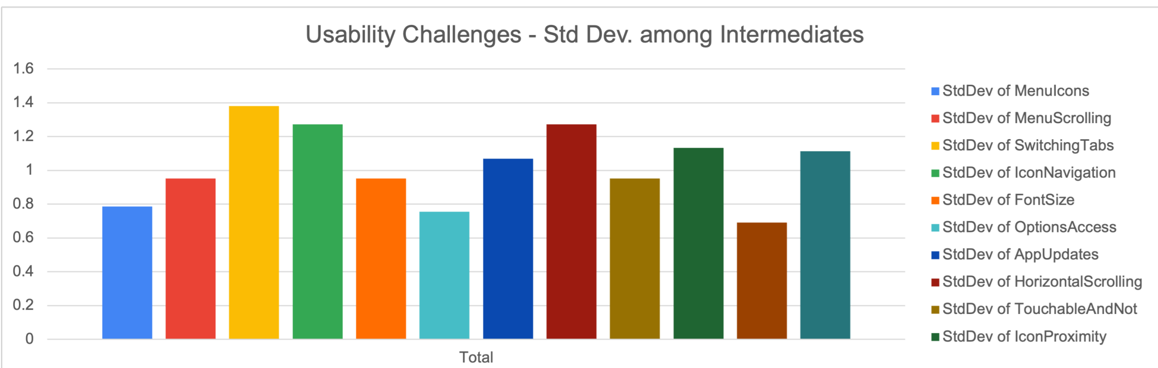

Figure 3.8: Intermediates reported facing usability challenges like switching between tabs, navigating icons, and horizontal scrolling.

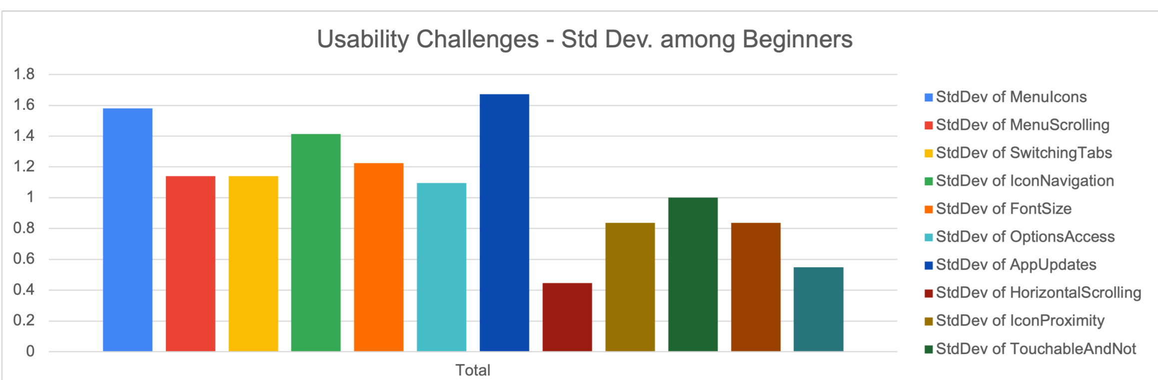

Figure 3.9: Beginners indicated facing challenges such as understanding menu icons, navigating between icons, and finding functionalities after app updates often.

proficiency identified among non-tech-savvy users.

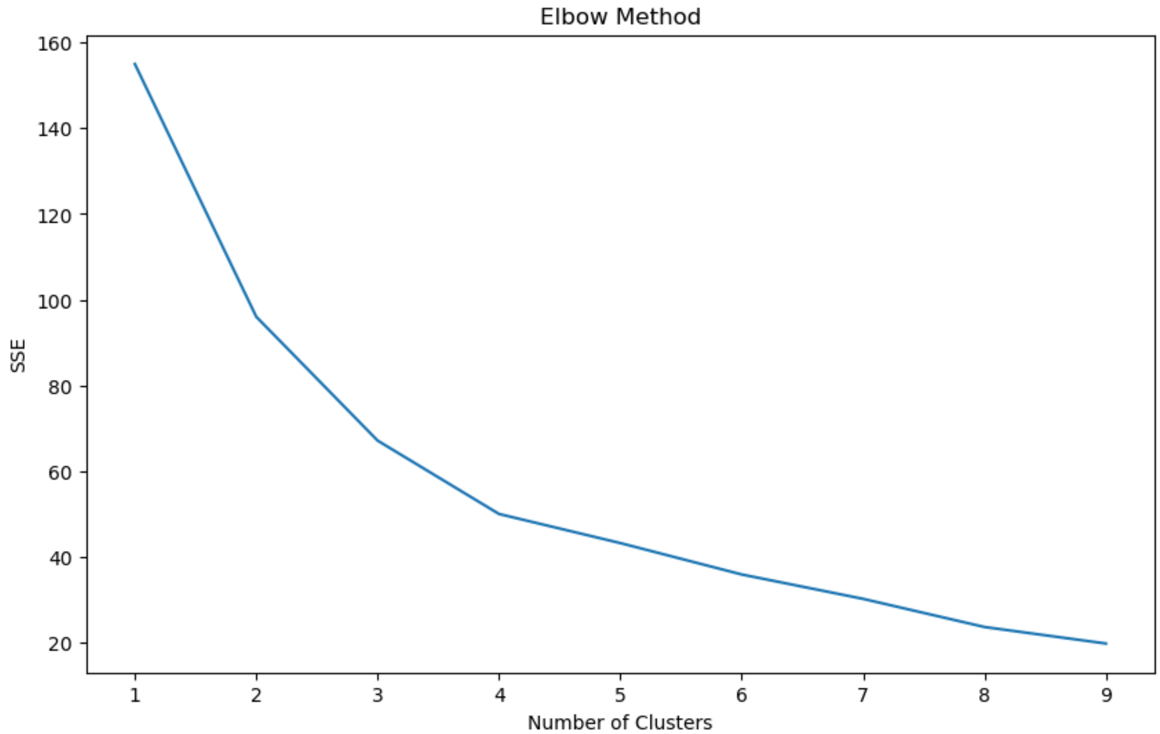

Figure 3.10: Elbow Plot - Iterations over different values of k (number of clusters) from 1 to 9 and calculate the inertia (sum of squared distances to the closest cluster center) for each k.

3.2 Survey Results

Several steps were undertaken to ensure accuracy and relevance when analyzing the collected data from Qualtrics. Initially, responses from 103 participants were exported to MS Excel from Qualtrics, and after removing incomplete responses, there where 31 responses remaining. Subsequently, these complete responses were converted to numerical values, establishing a basis for quantitative analysis - the responses indicating the lowest to highest rating were converted to numeric values 1 to 5, respectively. With 1 representing a lower frequency of challenges faced (least often) and 5 representing the

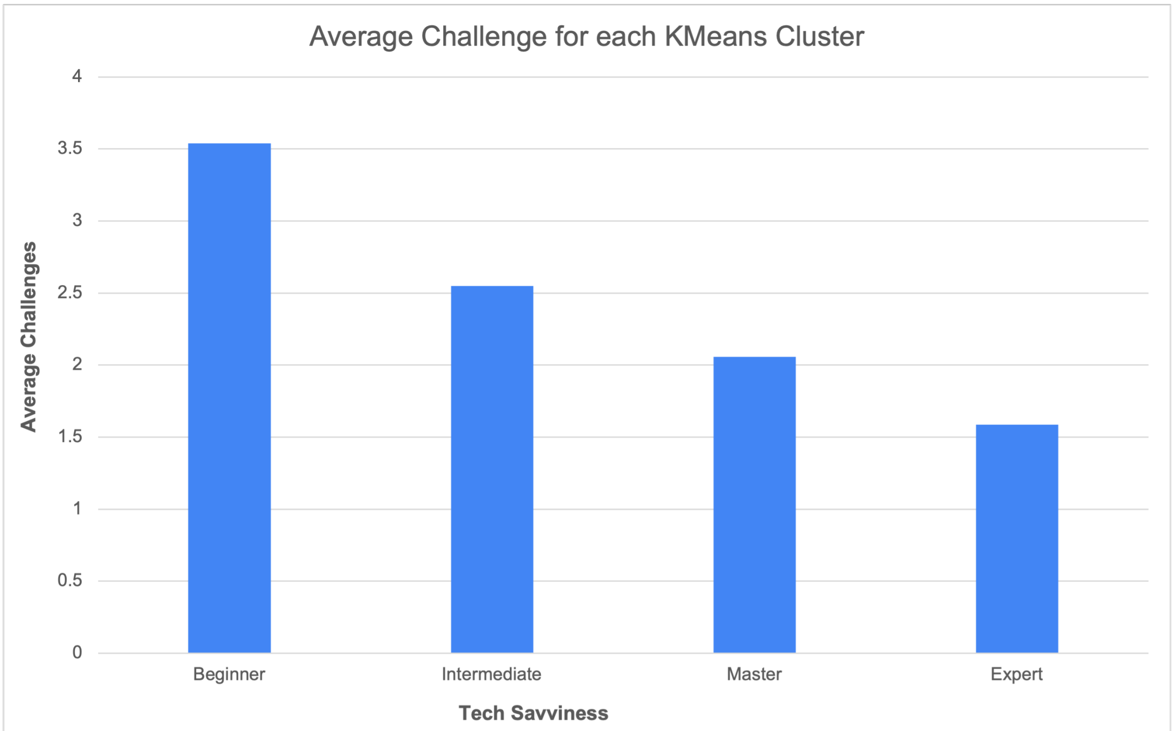

Figure 3.11: The k-means clustering method was utilized to categorize users into four distinct segments based on their level of tech-savviness - beginners, intermediates, masters, and experts, by considering usability challenges.

highest frequency of occurrence of challenges for users when interacting with mobile device interfaces (Figure 3.6, 3.7, 3.8 and 3.9). To enhance clarity and eliminate unnecessary complexity, unwanted text was meticulously removed, retaining only the essential numeric data. This was done by removing demographic information for the purpose of the analysis, along with converting responses for questions with yes or no answers to values of 1 or 2, respectively. Each participant was assigned a unique numerical identifier for systematic tracking and analysis.

The dataset underwent further analysis to derive valuable insights. Usability challenges faced by participants were assessed by calculating the average occurrence of problems for each participant, termed "Challenge". Simultaneously, the average tech know-how for each participant, "Know-how," was computed [82]. Employing another

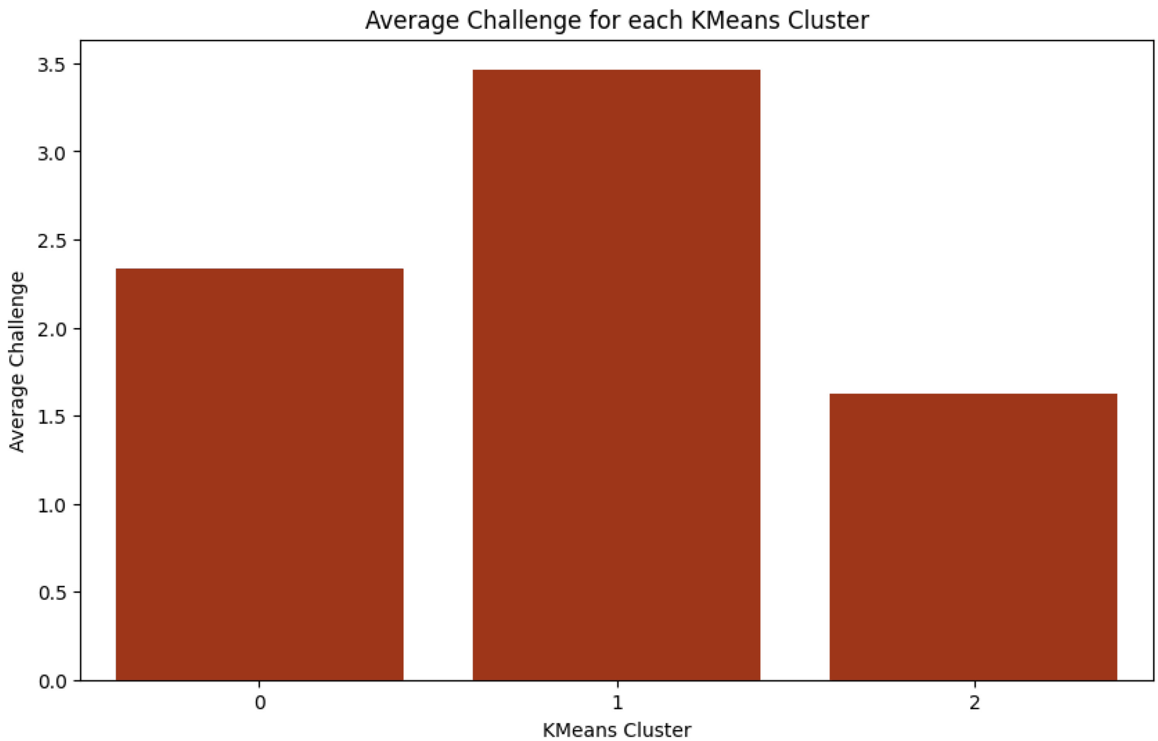

Figure 3.12: Upon cluster consolidation, Group 1 (Beginners) emerged as comprising respondents encountering the most challenges, while Group 2 (Experts) represented those facing the least challenges. Participants in Group 0 were excluded from subsequent analyses.

use of K-means clustering, participants were categorized into three groups based on challenges. The three groups were formulated based on the inclusion and exclusion criteria for the research and consisted of beginners (Group 1), intermediates and masters (Group 0), and experts (Group 2). These clusters facilitated a nuanced understanding of user experiences and perceptions.

3.2.1 Clustering

Upon clustering (Figure 3.12), Group 1 emerged as comprising respondents encountering the most challenges, while Group 2 represented those facing the most minor challenges. To align with the exclusion criteria, participants in Group 0 (consisting of intermediate and masters) were excluded from subsequent analyses. A noteworthy observation was that participants in Group 1 predominantly exhibited characteristics associated with non-tech-savvy individuals (Beginners), while Group 2 primarily comprised tech-savvy individuals (Experts). Despite challenges, device usage and technical know-how presented inconclusive results. However, it was discerned that participants in Group 1 (Beginners) tended to overestimate their technical proficiency. Participants indicated how they were proficient with mobile devices but still agreed to the commonly occurring usability challenges. For instance, users indicated they weren't sure how accessibility features worked or where to access them on their respective devices.

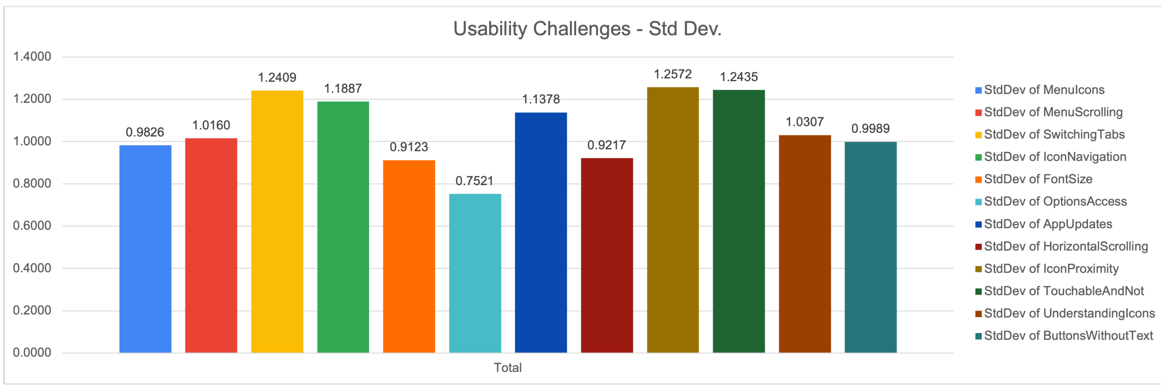

Figure 3.13: Common Usability Challenges - Respondents showed notable differences in their experiences with tasks such as switching between tabs or apps, navigating close-proximity icons, finding old options after app updates, dealing with icons near the screen's edge, and distinguishing touchable from non-touchable screens.

3.3 Discussion

In the realm of usability challenges, switching between tabs or apps to perform functions, navigating between different icons in close proximity, searching for old options post-app updates, icons placed too close to the screen's edge, and discerning touchable from non-touchable screens displayed the most significant variance among respondents

3.13. Users also indicated the need for consolidating necessities (such as phone calls, messages, contacts, reminders, and calendar events) into a single interface. These findings lay the groundwork for subsequent analyses, comparisons, and identifying key characteristics and patterns within response groups.

The standard deviation for each usability challenge appears to show the difference between the frequencies of occurrence between each of the 12 challenges. Notably, challenges exhibiting minimal variance were pinpointed for potential exclusion from future surveys, such as horizontal scrolling, scrolling through the menu, icons without text, and buttons without text as depicted in Figure 3.13. The initial cluster analysis provided foundational inferences, such as the occurrence of common usability challenges, including switching between tabs, navigating between icons, looking for old options after app updates, and distinguishing between touchable and non-touchable screens, delineating distinct user groups based on challenges and shedding light on their technological expertise and usage patterns. This data-driven approach enabled the identification of critical characteristics and patterns within responses among groups like the apps used commonly for communication, surfing the internet, phone calls, scheduling reminders and events on the calendar and social media apps, and associated usage patterns such as sending messages, saving contacts, scheduling events and reminders, making calls, etc., forming the basis for subsequent inferences and the development of user personas (Figure 3.14,3.15 and 3.16).

These personas have been developed by focusing on the key usability challenges and inferences drawn from the survey responses and heuristic evaluation on existing interfaces (Figure 3.17, 3.18, 3.19 and 3.20), which indicate the specific usability issues faced by smartphone users of varying tech-savviness. This study focuses on the beginner group, comprised of non-tech-savvy individuals, and details potential scenarios between two kinds of interface interactions - Android and iOS users. A detailed heuristic evaluation combined with the survey insights leads to two persona types - Margaret (Figure 3.14) and Glen (Figure 3.15). These personas help assess, design, and simulate usage scenarios to develop task flows for the proposed interface design, further facilitating design standards and guidelines for a human-centered interface design.

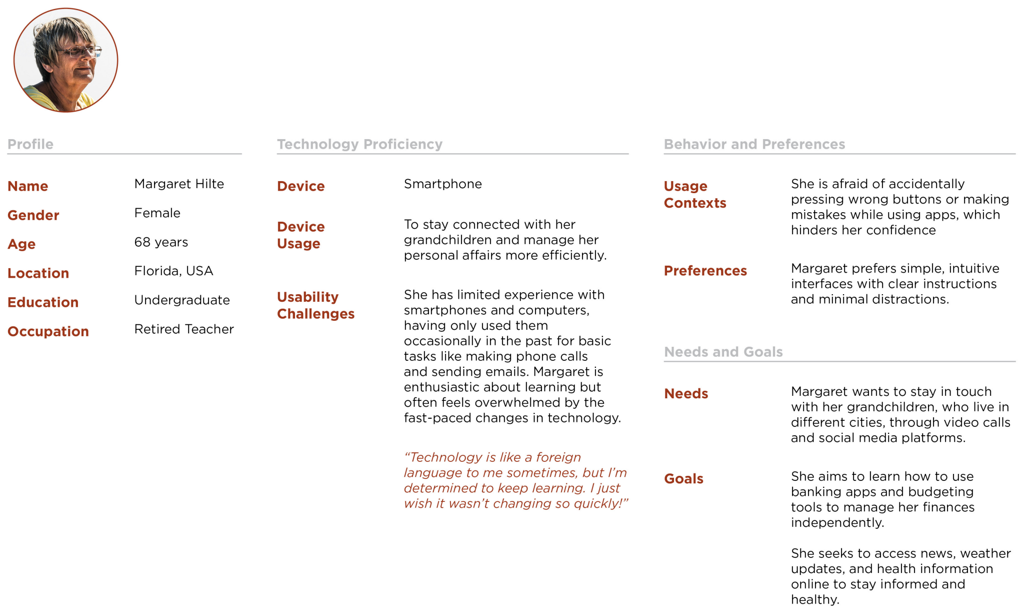

Figure 3.14: User Persona: Beginner (Non-tech-savvy) - Margaret Hilte is a 68-year-old retired teacher. Margaret prefers simple, intuitive interfaces with clear instructions and minimal distractions. She values patience and support from family members or caregivers when learning new technologies. Margaret finds the fast-paced technological changes confusing and often feels overwhelmed by new features and updates. [85].

3.4 Challenges with Current Interface

3.4.1 Scenarios for Margaret Hilte

1. **Managing Recent Calls:** Margaret wants to call her grandson back, but when she opens the 'Recents' screen, she finds it overwhelming with icons, text, and condensed information (Figure 3.17). She struggles to locate the specific call

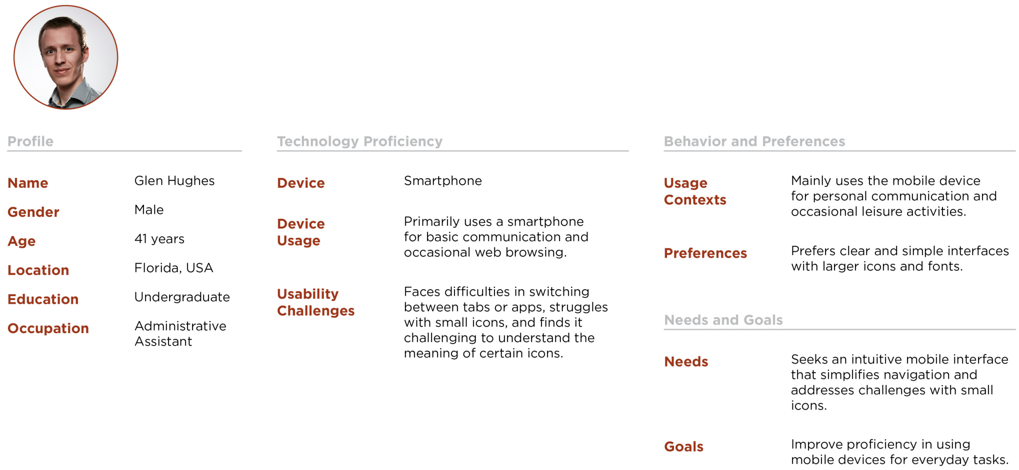

Figure 3.15: User Persona: Beginner (Non-tech-savvy) - Glen Hughes is a 41-year-old administrative assistant. Glen primarily communicates by smartphone but finds it difficult to switch between tabs or apps due to the small icons. His preferences skew toward straightforward and simple interfaces, making him an ideal representation of non-tech-savvy users seeking intuitive mobile experiences [88].

entry she needs and accidentally taps on the wrong item, leading to frustration and confusion.

2. **Understanding Call Information:** Margaret receives a call from an unknown number, but the caller ID and call direction icons (incoming/outgoing arrows) are unclear to her. She hesitates to answer the call, unsure if it's an incoming or outgoing call, and misses an important call from her doctor's office.
3. **Dialing a Number:** Margaret needs to call her friend's new phone number, but when she opens the 'Keypad' screen, she finds it cluttered with various options and suggestions. The number keys are placed too close together, making it challenging for her to accurately dial the number, leading to multiple mistakes and increasing her frustration.
4. **Scheduling Appointments:** Margaret wants to schedule a doctor's appoint-

Profile

Name	Olivia Philips
Gender	Female
Age	29 years
Location	New York, USA
Education	Graduate
Occupation	Software Engineer

Technology Proficiency

Device	Smartphone, Tablet
Device Usage	Utilizes a smartphone and tablet for work, coding, and staying up-to-date with the latest tech trends.
Usability Challenges	Rarely encounters issues, highly adaptive to new interfaces.

Behavior and Preferences

Usage Contexts	Integrates mobile devices seamlessly into both personal and professional life.
Preferences	Enjoys exploring advanced features and functionalities, values efficiency in interface design.

Needs and Goals

Needs	Appreciates a dynamic and feature-rich interface that supports multitasking and productivity.
Goals	Stay informed about technological advancements, explore cutting-edge apps, and contribute to technology communities.

Figure 3.16: User Persona: Expert (Tech-Savvy) - Olivia Philips, a 29-year-old software developer with a Master's degree in computer science, fits the profile of an expert (tech-savvy) user. Olivia easily integrates smartphones and tablets into both personal and professional environments. Her choices are consistent with dynamic and feature-rich interfaces, mirroring the expectations of tech-savvy users who appreciate efficiency and advanced features. [87].

ment, but when she opens the 'Calendar' app, she finds it challenging to navigate. The dates on the leftmost and rightmost columns are too close to the edge of the screen, making them hard to read and select. Additionally, she cannot find an option to view the entire year, making it challenging to plan her appointments effectively.

3.4.2 Scenarios for Glen Hughes

- **Identifying Call Direction:** Glen needs to return a missed call, but when he opens the 'Recents' screen, there is no clear differentiation between incoming and outgoing calls. He struggles to determine whether the call he wants to return is incoming or outgoing, leading to confusion and frustration.
- **Dialing a Number:** Glen wants to call a new contact. However, when he

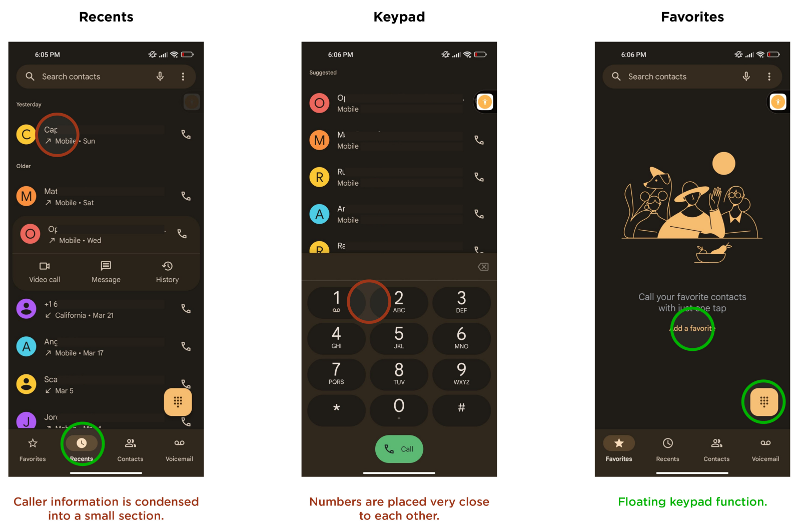

Figure 3.17: In the Android interface, the 'Recents' screen condenses a lot of information into one screen, with a mix of icons and text. The caller ID and incoming or outgoing call icons (arrow) can easily be misinterpreted. Additionally, the 'Keypad' screen contains a lot of information, such as the keypad and suggested calling options, which increases clutter. The number keys are also placed very close to each other.

opens the keypad tab, there is no underlying visualization to represent where the numbers will be displayed as he types them. He accidentally misses a digit or enters the wrong number, causing further frustration and the need to start over.

- **Navigating Contacts:** Glen needs to call a specific contact, but when he opens the contacts page, the text is placed right at the edge of the screen on both the left and right sides. As he scrolls through the list, it becomes difficult to read the contact names, and he risks accidentally tapping on the wrong contact due to the lack of spacing.
- **Scheduling Appointments:** Glen wants to schedule an important meeting. Still, when he opens the calendar app, he finds that the functionalities and interaction patterns are very close to the edge of the screen. This makes it challenging for him to accurately tap on the desired date or event, leading to potential errors

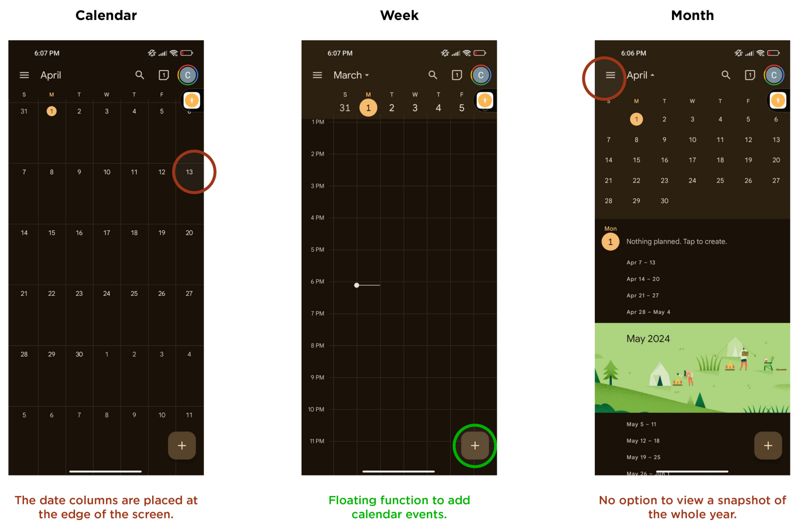

Figure 3.18: Android: Within the 'Calendar' screens, the dates on the leftmost and rightmost columns are placed too close to the edge of the screen. Furthermore, there is no option to view a snapshot of the whole year.

and frustration.

- **Viewing the Year:** Glen wants to plan his upcoming work schedule for the year, but he struggles to find a clear visualization representing the yearly calendar view. Without this feature, he finds it difficult to get an overview of the entire year and plan his tasks and appointments effectively.

3.5 Proposed Interface Design

The data gathered from the survey and the scenarios that were subsequently developed led to the assumption that in interface design, it's not necessarily the structure of the app but the elements listed below that are least partially responsible for the problems that non-tech-savvy users are facing.

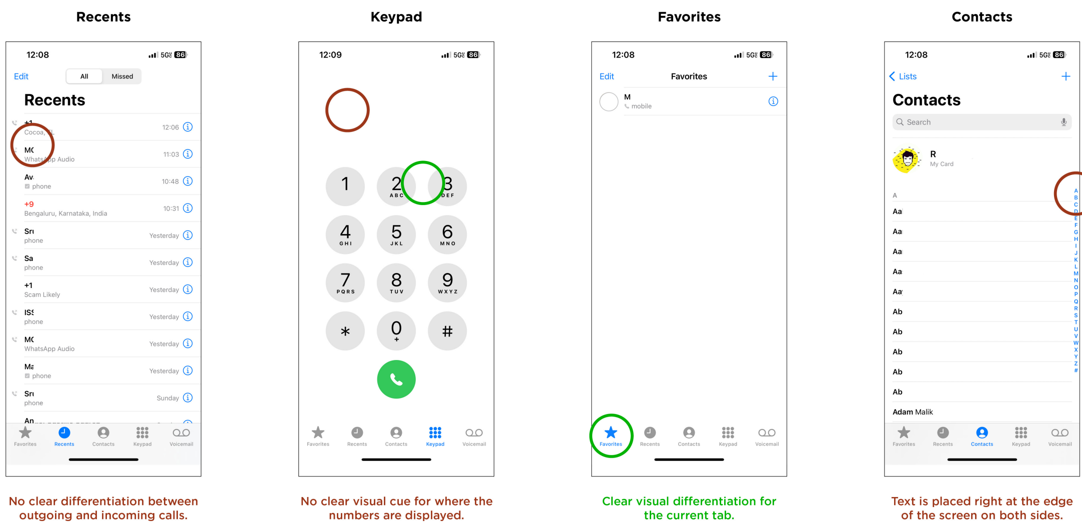

Figure 3.19: In the iOS interface, within the 'Recents' screen, there is no clear differentiation between outgoing and incoming calls. In the keypad tab, there is no underlying visualization to represent where the numbers will be displayed, leaving room for error and adding to the cognitive burden. On the contacts page, the text is placed right at the edge of the screen on both the left and right, making it difficult to scroll through the contacts list.

3.5.1 Graphic and User Interface Patterns

The proposed interface screens will include the following elements describing the reasoning for specific design choices and decisions:

- Font - Gotham is widely accepted as a highly legible font, providing digital and print media clarity. The font has been used in both traditional and contemporary settings, ranging from user interface design to publications and political and social awareness campaigns [33, 80, 46, 4]. This font was chosen for its wide range of applications and legibility.
- Text Size - The font sizes range from 16px to 18px, adhering to industry standards and scholarly recommendations for high inclusivity [46, 7, 6, 55].
- Color Palette - The color palette consists of primary tones and shades of red

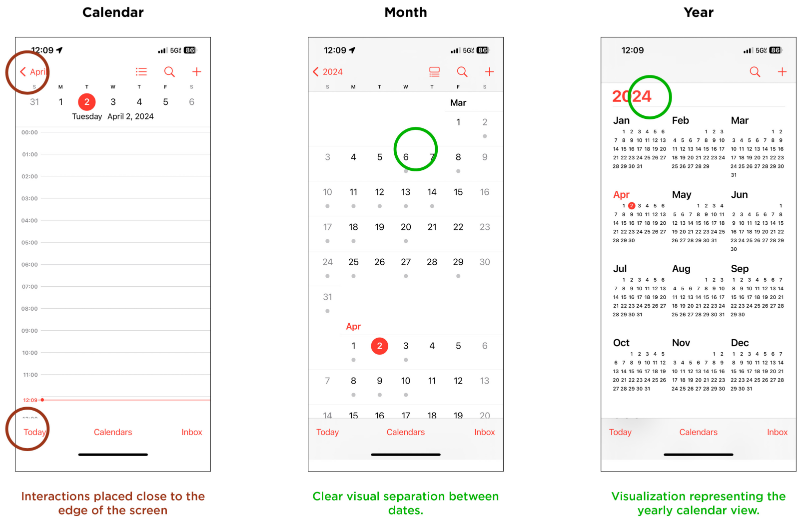

Figure 3.20: iOS: In the calendar app, the functionalities and interaction patterns are placed very close to the edge of the screen. However, there is a clear visualization representing the yearly calendar view.

(with a hue of orange), green, and tones of grey. These colors complement the positive and negative spaces in the interface visualization, grabbing attention when necessary and facilitating the execution of commands and functionalities through accessible and clear features [94, 35].

- Buttons and Icons - Standard Android and iOS buttons and icon styles are used for better recognition and usability. [69, 36, 63, 66].

3.5.2 Proposed Human-centered Design Features and Guidelines

The proposed interface design (Figure 3.22, 3.23) and 3.24) aims to put the user's experience first by reducing cognitive load and simplifying interactions as per the needs, goals, and preferences indicated by users in their responses. The interface's basic design aims to focus on the simplicity and usability of everyday tasks on mobile devices while employing high-contrast color schemes for user-friendly navigation. The design aims to facilitate speed and efficiency by minimizing interactions, and maximizing feature accessibility, with the goal of appealing to a diverse user base and fostering inclusion and intuitiveness. Robust visual cues and many feedback systems further aim to reduce errors and efficiently direct users. Easy adaptability within interfaces such as Android or iOS is aspired to be ensured by many access points and recognizable design cues taken from pre-existing interfaces. Notably, features like app updates could be integrated to maintain consistency and familiarity for users. Text and icons are arranged thoughtfully to reduce clutter. The bottom menu bar's floating tabs simplify navigation by removing the need for additional clicks. The ultimate goal is to provide non-tech-savvy users with a simplified, all-in-one interface plugin or app that simplifies key features and improves user accessibility. Subsequent iterations will strive to integrate new features and improve current ones in response to testing and user input.

3.5.3 Interface Usability Guidelines

The researcher developed the suggested interface adjustments and interactions using Jakob Nielsen's usability principles as the fundamental framework [64]. Nielsen's heuristics offered a collection of accepted guidelines for assessing and improving usability, guaranteeing that the interface successfully satisfied user needs and handled typical usability problems [60]. By using usability heuristics to evaluate the existing and proposed interfaces, the experimenter concentrated on enhancing essential elements, including error prevention, consistency, adaptability, and visibility of the system state. For instance, streamlining navigation by keeping commonly used tabs floating in the bottom menu bar directly aligned with Nielsen's principles of consistency and efficiency of use. Similarly, the emphasis on clear feedback, minimal design, and user control reflected Nielsen's heuristics related to error prevention, aesthetic design, and user con-

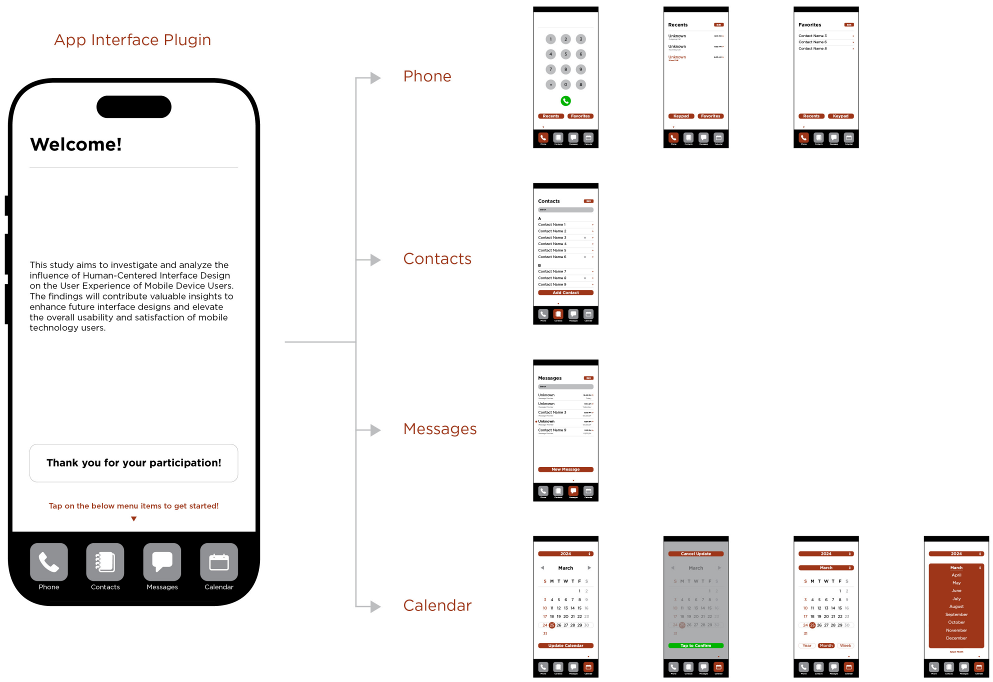

Figure 3.21: Interface B embodies the newly conceived solution or redesigned interface to alleviate usability issues, such as switching between tabs, navigating between icons, icon proximity, and distinguishing between touchable and non-touchable screens.

trol and freedom, respectively. The experimenter ensured a human-centric approach by basing the interface improvements on Nielsen's usability heuristics [69, 36, 64].

1. **Visibility of system status -** Within the proposed interface, users are made aware of the system's current state and available options, aiming at reducing the cognitive burden and streamlining interactions by presenting the features all in one screen, reducing the need to navigate between different screens or apps to access basic functions.

2. **User control and freedom -** The minimal design and high-contrast color palette aim to empower users to navigate effortlessly, reducing time spent accessing features and executing commands while providing clear feedback on touchable

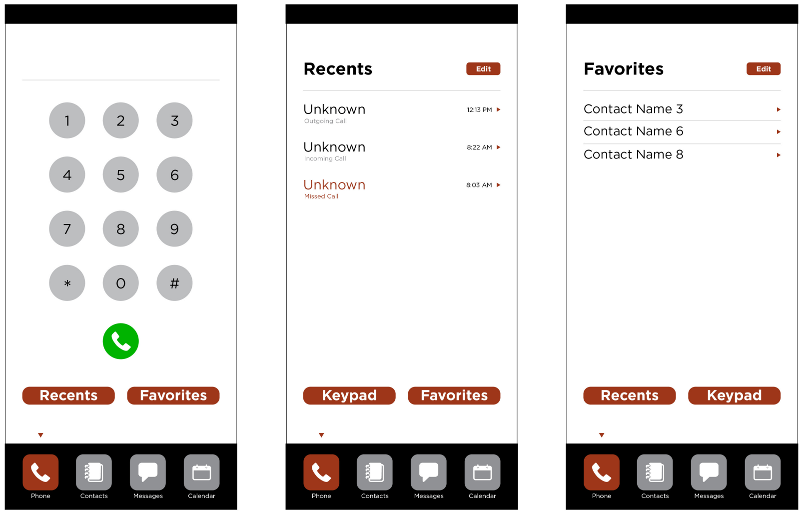

Figure 3.22: Interface B - Navigate to Phone and switch between tabs: Recents, Keypad and Favorites.

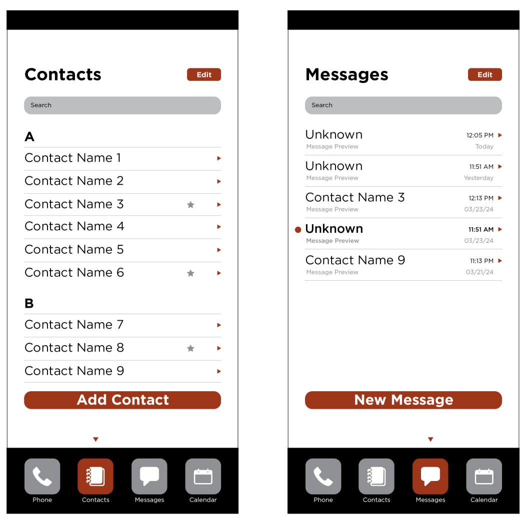

Figure 3.23: Interface B - Toggle between Contacts and Messages tabs.

elements in comparison with non-touchable elements.

3. **Consistency and standards -** The interface adheres to existing design standards of both iOS and Android platforms through the usage of industry-standard

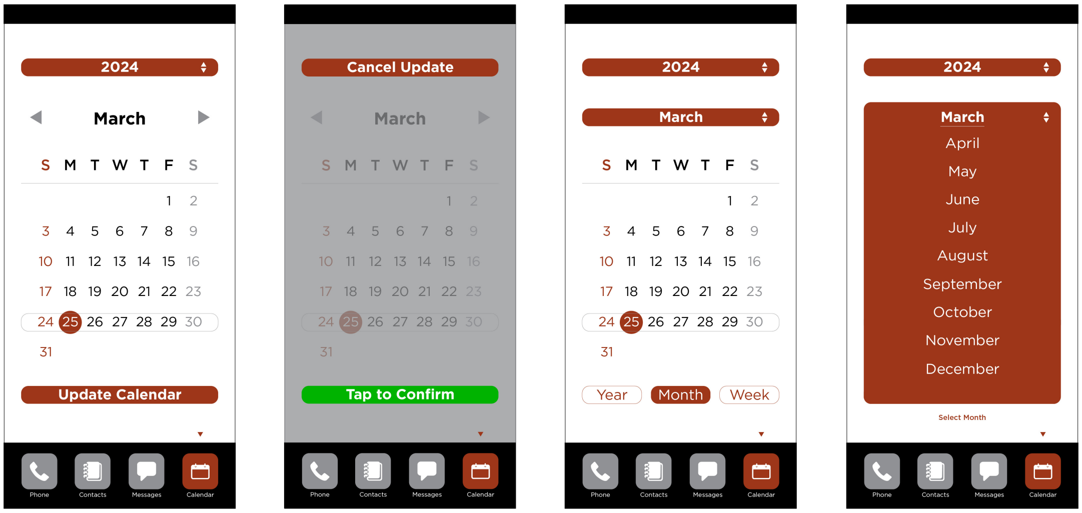

Figure 3.24: Interface B - Update Calendar (New feature: fewer interactions when changing month). Toggle between Year, Month, and Week views and change the month from March to April

interface patterns and 12-column grids, with the objective of ensuring users can easily recognize and interact with familiar patterns.

4. **Flexibility and efficiency of use -** Offering multiple ways to access features and keeping commonly used tabs floating in the bottom menu bar intending to maximize efficiency, catering to a wider range of user preferences and needs.

5. **Recognition rather than recall -** By consolidating necessities into a single interface, users are spared from the cognitive effort of remembering multiple apps for various functions, as indicated in the survey, enhancing usability for less tech-savvy individuals.

6. **Aesthetic and minimalist design -** The intentional placement of icons and text away from screen edges and slightly enlarged font sizes maintains focus on the app's functionality while ensuring visual clarity and ease of interaction.

7. **Help users recognize, diagnose, and recover from errors -** The interface

provides clear feedback on touchable elements and avoids placing icons or text too close to the edge, minimizing the risk of accidental actions and enhancing user confidence.

8. **Help and documentation -** In future iterations, the interface aims to further enhance the user experience by incorporating additional functionalities and refining existing features based on user feedback and usability testing.

Chapter 4

User Study

4.1 Overview

This chapter addresses the research question and hypotheses, experiment design, usability tasks, flow and measurements, and data analysis to conduct the user study based on the survey's inferences.

4.2 Research Question

How does implementing a tailored human-centered mobile device interface, designed to address the specific challenges faced by non-tech-savvy individuals, impact user satisfaction, task completion time, and cognitive load compared to the standard mobile device interface?

4.3 Hypotheses

- **H1a -** There will be a significant difference in task completion time between participants with different levels of tech-savviness.
- **H1b -** Task completion time will increase for beginners as the complexity and demands of the interface increase.
- **H2a -** Cognitive load will vary significantly based on tech-savviness, with either Beginners or Experts experiencing lower cognitive load when interacting with Interface B in comparison with Interface A.
- **H2b -** Cognitive load will increase for beginners as the complexity and demands of the interface increase.
- **H3a -** User satisfaction will significantly differ based on tech-savviness, with either Beginners or Experts reporting higher satisfaction levels when interacting with Interface B in comparison with Interface A.
- **H3b -** User satisfaction will decrease as the complexity and demands of the interface increase for beginners.
- **H4a -** Task success will significantly differ based on tech-savviness, with either Beginners or Experts demonstrating higher success rates when interacting with Interface B in comparison with Interface A.
- **H4b -** Task success will be significantly higher in Interface B compared to Interface A.

4.4 Experiment Design

4.4.1 Method

The study employed a mixed design, also known as a split-plot design, to investigate the effects of tech-savviness and interface type on subjective and task performance measures. The experiment involved two variables: a between-participants variable and a within-participants variable.

The between-participants variable was tech-savviness, which had two levels: beginner and expert. Participants were divided into separate groups based on their self-reported level of technological proficiency using 12 common usability challenges indicated in the survey. The beginner group consisted of individuals with limited experience and familiarity with technology, while the expert group comprised participants with advanced technological skills and knowledge. Beginners reported their struggles with commonly occurring challenges and rated how often they faced those specific challenges. Experts, on the other hand, reported how they barely faced these common challenges.

The within-participants variable was interface type, which had two levels: Interface A (existing) and Interface B (proposed). All participants in the beginner and expert groups interacted with both interfaces.

By employing a mixed design, the study aimed to examine the following effects:

- **Main Effect of Tech-Savviness:** The influence of participants' tech-savviness level (beginner or expert) on their subjective and task performance measures, independent of the interface type.
- **Main Effect of Interface Type:** The impact of the interface type (A or B) on participants' subjective and task performance measures, regardless of their tech-savviness level.

This approach enabled a more robust analysis of the effects of interface type while accounting for individual variations in performance.

Between-Particpants: Independent Variable

- **IV1 -** Tech-savviness (Two conditions - Beginner and Expert)

Within-Particpants: Independent Variable

- **IV2 -** Mobile Interface (Two levels - Interface A and B)

Dependent Variables

- **DV1 -** Task completion time - Task completion time refers to the time it takes for a participant to perform a designated task using the mobile interface. This variable is measured objectively using a timer.
- **DV2 -** Cognitive load - Cognitive load represents the mental effort and workload experienced by participants while interacting with the mobile interface. It is measured subjectively using six questions in the NASA Task Load Index (TLX) method. It assesses workload on six sub-scales: mental demands, physical demands, temporal demands, own performance, effort, and frustration [34].
- **DV3 -** User satisfaction - User satisfaction is a subjective measure of how satisfied participants are with their mobile interface experience. It is measured subjectively using ten questions and a Likert scale, ranging from "0 - Not satisfied at all" to "4 - Completely satisfied." [81, 96]
- **DV4 -** Task success - Task success refers to the extent to which a participant accomplishes the designated task using the mobile interface. This variable is measured in binary, indicating whether the participant can perform the task functions successfully. It is recorded as "0 - Failure" if the participant fails to complete the task functions and "1 - Success" if the participant can successfully perform them.

4.4.2 Usability Tasks, Flow and Measurements

4.4.2.1 Tasks

Task 1 - Opening the Application

- Objective - Determine how well the user can find and open the application.
- Instructions - Open the application on the mobile device.
- Measures - Task completion time, Task success.

Task 2 - Switching Between Tabs

- Objective - Evaluate the participants' ability to switch between different tabs within the application.
- Instructions - Switch between different tabs or sections within the application to perform a specific function.
- Measures - Task completion time, Task success, Cognitive load, and User satisfaction.

Task 3 - Navigating Between Icons

- Objective - Evaluate the participant's ability to navigate between different icons, particularly those placed closely together.
- Instructions - Navigate between icons placed closely on the screen to perform a specific action.
- Measures - Task completion time, Task success, Cognitive load, and User satisfaction.

Task 4 - Distinguishing Touchable Screens

- Objective - Evaluate the participant's ability to distinguish between touchable and non-touchable screens.
- Instructions - Identify and interact with screens, distinguishing between those that are touch-responsive and those that are not.

- Measures - Task completion time, Task success, and User satisfaction.

Task 5 - Interaction Precision and Efficiency

- Objective - Evaluating the impact of icon proximity on user interaction efficiency. by minimizing the number of interactions required to perform the task.
- Instructions - Identify and navigate to a different screen using specific interactions when icons are placed close to one another.
- Measures - Task completion time, Task success, Cognitive load, and User satisfaction.

4.4.2.2 Task Flow Script

The task flow script comprised the instructions given to the experiment participants by the experimenter to measure the dependent variables.

1. Open the App - Existing or proposed interface (Invision Plugin).
2. Navigate to Phone and switch between tabs: Recents, Keypad, Favorites, and Contacts (Figure 3.22 and 3.23).
3. Go to Calendar to check the current week's date range and today's date.
4. Toggle between Year, Month, and Week views.
5. Change the month from March to April (Figure 3.24).

4.4.2.3 User Flow

The flow simulates a natural progression of tasks, mimicking real-world usage scenarios. Each task helps to learn the user's interaction capabilities and limitations.

1. The flow starts with the basic task of opening the application and ensuring users are familiar with the app.
2. Tasks 2 (Switching Between Tabs) and 3 (Navigating Between Icons) build on the navigation theme, gradually increasing complexity.

3. Task 4 brings attention to a critical challenge – distinguishing touchable screens.

This user flow seeks to provide a smooth progression through tasks while keeping a logical and intuitive order. Participants will traverse frequent problems encountered by non-technical users, gaining helpful input into the effectiveness of the proposed human-centered mobile interface.

4.4.2.4 Task Complexity

Tasks are ranked based on complexity, considering factors such as the number of interactions required, cognitive load involved, and the potential for the occurrence of errors while interacting with the interface and performing the assigned task. The scale followed for judging task complexity was as follows:

- **Simple -** Tasks that are straightforward with minimal cognitive load and few interactions required (Limited to 1 interaction).
- **Moderate -** Tasks that may involve some cognitive effort or multiple interactions (between 1 or 2 interactions) but are still manageable.
- **Complex -** Tasks that require significant cognitive effort, multiple steps, or precise interactions (more than 2 interactions).

Based on this scale, the rank ordering for Tasks 1-5 in terms of complexity:

1. Task 1 - Opening the Application: This task is ranked the simplest as it involves a single action.
2. Task 5 - Interaction Precision and Efficiency: While this task involves evaluating the impact of icon proximity on interaction efficiency, it is considered relatively moderate compared to others as it involves only 2 interactions.
3. Task 2 - Switching Between Tabs: This task requires moderate cognitive effort as participants need to navigate between different tabs within the application and involves 2 interactions at the most.

4. Task 4 - Distinguishing Touchable Screens: This task involves distinguishing between touchable and non-touchable screens, which introduces some complexity depending on the clarity of screen elements and their interpretation.
5. Task 3 - Navigating Between Icons: This task could be the most complex as it requires participants to navigate between closely placed icons, which could potentially increase cognitive load and potential for errors along with multiple possible interactions.

4.4.3 Experiment

Within user interface research methodology, A/B testing serves to assess the comparative effectiveness of interface designs. This approach involves the deployment of two interfaces: Interface A represents the existing mobile interface or system, while Interface B embodies the newly conceived solution or redesigned interface aimed at alleviating issues found in Interface A. Users drawn from the designated user group are randomly assigned the order in which they will interact with both interface versions. This randomized allocation facilitates a comparative assessment, enabling users to engage with and evaluate both Interface A and Interface B. Through this structured comparison, the research endeavors to discern and quantify the tangible impact of interface modifications on user experiences among the chosen user group. The objective is to derive empirical evidence that substantiates the efficacy of the newly proposed interface enhancements, thereby informing and validating the iterative process of interface design tailored to address the needs of non-tech-savvy users.

4.4.3.1 Experiment Setting

The experiment took place in a controlled setting to ensure that data was collected consistently and accurately. The setting included specific areas with mobile devices for user interaction and data collection tools.

4.4.3.2 Physical Space

Dedicated spaces within the controlled environment were designed to resemble a user-friendly, pleasant, and distraction-free environment. Each location was standardized to provide uniformity across user interactions while minimizing external effects. This was done by isolating the task stations and making sure the participants were not disturbed during the course of the experiment.

4.4.3.3 Mobile Devices

Participants used their own mobile devices, such as smartphones, with Interface A (representing the existing mobile interface posing identified challenges) and were provided smartphones outfitted with Interface B (the proposed solution or revised interface).

4.4.3.4 Task Stations

Each designated location was outfitted with the given mobile devices displaying Interface B. Participants utilize the interfaces to complete specific tasks to highlight the usability challenges encountered by non-tech-savvy users and to navigate the proposed interface.

4.4.3.5 Data Collection Tools

Timers recorded the task completion time for each task in seconds recording the time from start to finish post the verbal indication of task completion by the participant to the experimenter. Participants were also given survey questionnaires to evaluate their perceived cognitive load (using the NASA Task Load Index) and user satisfaction (using Likert scale-based questions).

4.4.3.6 Randomization

Participants were randomly allocated to task stations, ensuring a fair distribution across both interface types. Randomization reduces bias and accounts for practice effects.

4.4.4 Participants

A total of 34 potential participants were contacted, and 31 participants were recruited through professional networks in academia and industry. They were categorized based on their tech-savviness into two groups of 15 beginners and 16 experts. The participants ranged in age from 16 to 67, with an average age of 33 and a standard deviation of 12.5 years, reflecting a wide age range and diverse demographic sampling.

4.4.4.1 Inclusion and Exclusion Criteria

The study's methodology defined the inclusion and exclusion criteria to ensure the experimental groups were clear-cut and consistent. We included participants as either Beginners—those with limited tech experience—or Experts—those well-versed in advanced technology. This selection aimed to distinctly compare groups at each end of the tech proficiency scale.

Three individuals with Intermediate or Master-level tech skills were excluded to preserve group homogeneity and eliminate potential confounding factors. This deliberate selection strategy serves the study's objective to closely examine the diverse experiences and behaviors between markedly different user groups, thereby yielding insights into the impact of interface design on users with varying technological competencies.

4.4.5 Procedure

In the methodology of this thesis, data collection and analysis form a comprehensive framework encompassing objective and subjective measures to assess the effectiveness of interface designs. The data collection process captures various facets, including task completion time, cognitive load, and user satisfaction, across Interface A (existing system) and Interface B (newly proposed solution). To begin, the investigator adopts a binary effectiveness measure, evaluating the user's ability to perform task functions successfully. Task completion time, a crucial objective metric, is objectively measured through timers initiated upon task commencement by the experimenter and terminated upon user indication of task completion for each task. The times for the tasks are recorded in seconds for each of the 5 tasks from the beginning to the completion of each task upon verbal communication from the participants. Subjective evaluations of cognitive load rely on the NASA Task Load Index (TLX) [34], utilizing a structured questionnaire format to assess workload across six sub-scales. Furthermore, user satisfaction, another subjective metric, is gauged through Likert scale-based questionnaires designed to elicit participant ratings regarding their satisfaction levels [81, 96].

The participants perform each of the tasks first on either interface A or B, depending on the group they are assigned to, and after completion of the experiment, the data gathered determines the tech-savviness, further facilitating the data analysis (Figure 4.1).

As per the sequencing of the experiment procedure (Figure 4.2), participants engage in typical mobile tasks as defined in Section 4.4.2, subsequently providing satisfaction ratings after the tasks. Similarly, they undergo a set of tasks to measure cognitive load. They are timed while performing designated mobile functions to determine task completion times for each interface A and B (Figure 3.21).

Post the experiment, participants are assigned a tech-savviness score based on the frequency of occurrence of the 5 usability challenges identified earlier and partitioned into either the Beginner group if the score for each of the participants ranged between 2.5 to 5 or the Expert group if the score ranged from 0 to 2.49. This range differs from the initial clustering range since this was based solely on the 5 challenges identified with notable differences in the user experience when interacting with mobile devices.

Figure 4.1: To address the feedback and streamline the challenge features in the experiment, the study will adopt a quasi-experimental design. The experiment will involve a 2 (Interface: A, B) by 2 (Tech-Savviness: Beginner, Expert) repeated measures design, considering two levels of the independent variable (Interface) and two conditions of the tech-savviness (Beginner and Expert). The participants perform each of the tasks first on either interface A or B, depending on the group they are assigned to, and after completion of the experiment, the data gathered determines the tech-savviness, further facilitating the data analysis.

- **Introduction and Consent -** Study's purpose and informed consent.
- **Demographic Survey -** Collect demographic information.
- **Pre-Experiment Tech Savviness Assessment -** Categorize participants into two groups without disclosing this information.
- **Control (Interface A) -** Participants interact with the existing mobile interface (Interface A).
- **Post-Experiment Tech Savviness Disclosure -** Participants disclose their perceived tech savviness after completing all the tasks.
- **Treatment (Interface B) -** Participants interact with the proposed human-centered mobile interface (Interface B).
- **Dependent Variable Measurements -** Record task completion time, task success, cognitive load, and user satisfaction.
- **Post-Experiment Questionnaire -** Participants answer questions related to their experience and preferences.
- **Tech Savviness Self-Perception Survey -** Participants disclose their self-perceived tech savviness.

Figure 4.2: Sequencing - This experimental design ensures a smoother flow, discreetly categorizes participants based on variance-indicative questions and includes post-experiment self-perceived tech-savviness disclosure to enrich the study's insights.

Chapter 5

Results and Discussion

This chapter outlines and discusses the results from a user study that assesses beginner and expert tech users' performance using standard and human-centric interfaces. It presents data on task completion times, NASA-TLX scores, and user satisfaction levels, highlighting their effects on user performance, cognitive load, and overall satisfaction. The chapter then analyzes these results to extract valuable insights, culminating in practical design guidelines for developing mobile interfaces suited to users with limited tech expertise.

5.1 User Study Results

5.1.1 DV1 - Task Performance

The task performance measured the time the user took to complete the task. Beginner and expert mobile users performed five tasks on two types of interfaces, and task completion time was measured in seconds as indicated in Table 5.1 and 5.3 respectively. Before running statistical tests, it was essential to understand whether the data was normally distributed, and the Shapiro-Wilk test of normality was conducted [82, 27, 70]. If the p-value of the data was more than 0.05, it was parametric or normally distributed; else, it was non-parametric (Figure 5.1, 5.2, 5.3 and 5.4). The paired-sample T-Test was performed on parametric, whereas the Wilcoxon-Signed-Ranked (WSR) Test [93, 72] was conducted on non-parametric data (Table 5.2, 5.4 and 5.5).

Beginner (n=15)	T1	T2	T3	T4	T5
Mean A	3.867	14.2	13.47	16.4	6.33
STD A	1.80	5.3	5.27	11.99	2.63
Mean B	2.4	12.4	9.133	8.53	5.267
STD B	2.44	5.8	1.8	2.33	2.34

Table 5.1: Beginner Performance: Descriptive Outcomes for Task Completion Time for Beginner Group on Interfaces A and B for each task.

Beginner (n=15)	T1*	T2	T3*	T4*	T5
Test	T-Test	T-Test	WSR	WSR	WSR
Test Statistic	df = 14	df=14	z=2.668	z=2.794	z=1.726
P	**0.002**	0.13	**0.008**	**0.006**	0.08

Table 5.2: Beginner Performance: Statistical Outcomes of Task Completion Time for Beginner Group on Interfaces A and B for each task. T1 through T5 represent the tasks in each of the columns and the Z and P values are indicated in the rows for the statistical test performed for each of the interface types based on the data set normality.

Expert (n=16)	T1	T2	T3	T4	T5
Mean A	5.81	14.93	12.75	16.69	6.37
STD A	6.29	6.46	7.13	11.16	2.58
Mean B	3.75	11.81	8.5	9	5.75
STD B	3	4.4	3.05	3.05	2.86

Table 5.3: Expert Performance: Descriptive Outcomes for Task Completion Time for Expert Group on Interfaces A and B for each task.

Expert (n=16)	T1*	T2*	T3*	T4*	T5
Test	WSR	T-Test	T-Test	WSR	WSR
Test Statistic	z=2.223	df=14	df=14	z=2.641	z=1.664
P	**0.027**	**0.005**	**0.009**	**0.009**	0.09

Table 5.4: Expert Performance: Statistical Outcomes for Task Completion Time for Expert Group on Interfaces A and B for each task. T1 through T5 represent the tasks in each of the columns and the Z and P values are indicated in the rows for the statistical test performed for each of the interface types based on the data sets normality.

Interface B - Performance	T1	T2	T3	T4*	T5
Test	WSR	WSR	T-Test	T-Test	T-Test
Test Statistic	z=-1.659	z=-0.419	df=14	df=14	df=14
P	0.105	0.7	0.592	**0.777**	0.614

Table 5.5: Task Performance (Task Completion Time) outcomes between Beginner and Expert group using proposed interface B for each of the tasks.

5.1.2 DV2 - Cognitive Load

The study examined the cognitive load experienced by beginner users when interacting with interfaces A and B using the NASA TLX method (Table 5.6 and 5.8). The results showed that the cognitive load distributions for both interfaces were non-parametric among beginner users ($p < 0.05$) as depicted in Table 5.7, 5.9 and 5.10.

Beginner (n=15)	Mental	Physical	Temporal	Performance	Effort	Frustration
Mean A	11.67	3.33	21.67	56.67	20	15
STD A	12.90	8.8	20.84	34.67	14.01	15.81
Mean B	10	1.67	3.33	55	5	6.67
STD B	15.81	6.45	8.8	33	10.35	11.44

Table 5.6: Cognitive Load: Descriptive Outcomes of Cognitive Load measures for Beginner Group on Interfaces A and B for the 5 tasks.

Beginner (n=15)	Mental	Physical	Temporal*	Performance	Effort*	Frustration
Test	WSR	WSR	WSR	WSR	WSR	WSR
Test Statistic	z=0.405	z=1	z=2.521	z=0.254	z=2.666	z=1.826
P	0.766	1	**0.01**	0.86	**0.003**	0.089

Table 5.7: Cognitive Load: Statistical Outcomes of Cognitive Load Measures for Beginner Group on Interfaces A and B for the 5 tasks. The column represents the 6 components of the NASA TLX method for measuring cognitive load in each of the columns and the Z and P values are indicated in the rows for the statistical test performed for each of the interface types based on the data sets normality.

Expert (n=16)	Mental	Physical	Temporal	Performance	Effort	Frustration
Mean A	10.93	1.56	17.19	79.69	12.5	9.37
STD A	15.73	6.25	17.60	22.76	15.81	15.48
Mean B	6.25	1.56	4.69	87.5	9.37	4.69
STD B	14.43	6.25	10.08	22.36	17.97	10.08

Table 5.8: Cognitive Load: Descriptive Outcomes of Cognitive Load measures for Expert Group on Interfaces A and B for the 5 tasks.

Expert (n=16)	Mental	Physical	Temporal*	Performance	Effort	Frustration
Test	WSR	WSR	WSR	WSR	WSR	WSR
Test Statistic	z=1.09	z=0	z=2.366	z=-1.183	z=0.592	z=1.095
P	0.345	0	**0.015**	0.24	0.588	0.345

Table 5.9: Cognitive Load Outcomes: Expert User Group's Cognitive Load measures on Interfaces A and B for the 5 tasks.

5.1.3 DV3 - User Satisfaction

The study also examined user satisfaction with the two interfaces, A and B, using a subjective Likert scale measure (Table 5.11 and 5.13). The results showed that the user satisfaction distributions for both interfaces A and B among beginner users were non-normal (p ¡ 0.05) as indicated in Table 5.12, 5.14 and 5.15.

Cognitive Load	Mental	Physical	Temporal	Performance*	Effort	Frustration
Test	T-Test	WSR	WSR	T-Test	WSR	WSR
Test Statistic	df=14	z=0	z=-0.405	df=14	z=-1.095	z=0.405
P	0.546	1	0.766	**0.002**	0.345	0.766

Table 5.10: Cognitive Load Index measuring cognitive load outcomes between Beginner and Expert Groups using proposed Interface B. The column represents the 6 components of the NASA TLX method for measuring cognitive load in each of the columns and the Z and P values are indicated in the rows for the statistical test performed for each of the interface types based on the data sets normality.

Beginner (n=15)	Ease	Clarity	Intuitive
Mean A	2.87	3.73	3
STD A	0.99	0.46	1
Mean B	3.4	3.67	3.33
STD B	0.83	0.82	0.9

Table 5.11: Beginner Satisfaction: Mean scores for Beginner Group on Interfaces A and B for the tasks.

Beginner (n=15)	Ease*	Clarity	Intuitive
Test	WSR	WSR	WSR
Test Statistic	z=-2.521	z=0.447	z=-1.4
P	**0.002**	1	0.152

Table 5.12: Beginner Satisfaction: Statistical Outcomes for Beginner Group on Interfaces A and B. The column represents the 3 components of the satisfaction Likert scale ratings for measuring cognitive load in each of the columns, and the Z and P values are indicated in the rows for the statistical test performed for each of the interface types based on the data sets normality.

Expert (n=16)	Ease	Clarity	Intuitive
Mean A	3.19	3.63	2.94
STD A	0.75	0.5	0.93
Mean B	3.31	3.5	3.06
STD B	0.87	0.82	0.93

Table 5.13: Expert Satisfaction: Mean scores for Expert Group on Interfaces A and B for the tasks.

Expert (n=16)	Ease	Clarity	Intuitive
Test	WSR	WSR	WSR
Test Statistic	z=-0.56	z=0.365	z=-0.706
P	0.608	0.85	0.492

Table 5.14: Expert Satisfaction Outcomes: Expert User Group's task satisfaction on Interfaces A and B. The column represents the 3 components of the satisfaction Likert scale ratings for measuring cognitive load in each of the columns, and the Z and P values are indicated in the rows for the statistical test performed for each of the interface types based on the data sets normality.

User Satisfaction	Satisfaction Ease	Satisfaction Clarity	Satisfaction Intuitive
Test	T-Test	WSR	WSR
Test Statistic	df=14	z=0.524	z=1.183
P	0.709	0.665	0.24

Table 5.15: User Satisfaction Outcomes: Comparison Between Beginner and Expert Groups Using Proposed Interface B.

5.1.4 DV4 - Task Success

Examination of task success rates, a binary outcome, revealed no significant difference among the interface types for beginners. The only significant difference was between Android and iOS users since Android doesn't have a year option when toggling between the year, month, and week views in Google Calendar while performing task 4, where users could not successfully perform the task functions due to the inability to access the year view in the calendar app as outlined in Table 5.16 and 5.17.

Beginner (n=15)	T1	T2	T3	T4	T5
Mean A	1	1	1	0.67	1
STD A	0	0	0	0.48	0
Mean B	1	1	1	1	1
STD B	0	0	0	0	0

Table 5.16: Beginner Task Success: Descriptive Outcomes for Task Success for Beginner Group on Interfaces A and B for each task.

Expert (n=16)	T1	T2	T3	T4	T5
Mean A	1	1	1	0.47	1
STD A	0	0	0	0.52	0
Mean B	1	1	1	1	1
STD B	0	0	0	0	0

Table 5.17: Expert Task Success: Descriptive Outcomes for Task Success for Expert Group on Interfaces A and B for each task.

5.1.5 MANOVA Analysis of Tech-Savviness and Its Impact on Dependent Variables

A one-way MANOVA [47] was used to investigate the relationship between participants' tech-savviness and their mobile device interface user experience with both the existing and proposed interfaces, in addition to the paired t-tests and Wilcoxon signed-rank tests performed for parametric and non-parametric data, respectively. Multiple dependent variables (DV1 to DV4) could be analyzed simultaneously due to this multivariate technique, which also helped to compensate for Type I error inflation that may occur when using multiple t-tests.

The one-way MANOVA [79] offered a thorough grasp of how participants' level of tech-savviness affected their overall experience with the mobile interfaces by considering the four dependent variables as a set. The one-way MANOVA specifically evaluated whether beginner and expert users across both interface conditions differed significantly in terms of task completion time (Table 5.18 and 5.19), cognitive load (Table 5.20 and 5.21), user satisfaction (Table 5.22 and 5.23), and task success rates.

This analysis offered a more nuanced understanding of the relationship between user characteristics and interface usability by revealing not only the individual effects of tech-savviness on each dependent variable but also possible interactions between tech-savviness and interface type.

		Df	Sum Sq	Mean Sq	F-value	P
T1	Tech-Savviness	1	29.31	29.313	1.3279	0.2586
	Residuals	29	640.17	22.075		
T2	Tech-Savviness	1	4.21	4.21	0.1196	0.732
	Residuals	29	1021.34	35.219		
T3	Tech-Savviness	1	3.98	3.976	0.1	0.7541
	Residuals	29	1152.73	39.749		
T4	Tech-Savviness	1	0.6	0.64	0.0048	0.9453
	Residuals	29	215.733	7.4391		
T5	Tech-Savviness	1	0.013	0.0134	0.002	0.9648
	Residuals	29	197.083	6.796		

Table 5.18: **Interface A - Time Performance Summary**

		Df	Sum Sq	Mean Sq	F-value	P
T1	Tech-Savviness	1	14.11	14.1097	1.8718	0.1818
	Residuals	29	218.6	7.5379		
T2	Tech-Savviness	1	2.67	2.6722	0.1196	0.732
	Residuals	29	766.04	26.4151		
T3	Tech-Savviness	1	3.105	3.1054	0.4849	0.4918
	Residuals	29	185.733	6.4046		
T4	Tech-Savviness	1	1.686	1.686	0.2266	0.6376
	Residuals	29	215.733	7.4391		
T5	Tech-Savviness	1	1.809	1.8086	0.2623	0.6124
	Residuals	29	199.933	6.8943		

Table 5.19: **Interface B - Time Performance Summary**

		Df	Sum Sq	Mean Sq	F-value	P
Mental	Tech-Savviness	1	4.1	4.116	0.0197	0.8892
	Residuals	29	6044.3	208.423		
Physical	Tech-Savviness	1	24.28	24.278	0.4218	0.5212
	Residuals	29	766.04	26.4151		
Temporal	Tech-Savviness	1	155.3	155.33	0.4197	0.5222
	Residuals	29	185.733	6.4046		
Performance	Tech-Savviness	1	4102.9	4102.9	4.8354	**0.036**
	Residuals	29	24606.8	848.5		
Effort	Tech-Savviness	1	435.5	435.5	1.9429	0.1739
	Residuals	29	6500	224.14		
Frustration	Tech-Savviness	1	245	244.96	1.0014	0.3252
	Residuals	29	7093.8	244.61		

Table 5.20: **Interface A - Cognitive Load Summary**

		Df	Sum Sq	Mean Sq	F-value	P
Mental	Tech-Savviness	1	108.9	108.87	0.4766	0.4955
	Residuals	29	6625	228.45		
Physical	Tech-Savviness	1	0.08	0.08	0.021	0.9639
	Residuals	29	1169.27	40.32		
Temporal	Tech-Savviness	1	14.2	14.197	0.1579	0.694
	Residuals	29	2606.8	89.889		
Performance	Tech-Savviness	1	8117.4	8117.4	10.424	**0.0031**
	Residuals	29	22750	784.5		
Effort	Tech-Savviness	1	148.2	148.19	0.6774	0.4172
	Residuals	29	6343.8	218.75		
Frustration	Tech-Savviness	1	30.3	30.326	0.262	0.6126
	Residuals	29	3356.8	115.751		

Table 5.21: **Interface B - Cognitive Load Summary**

		Df	Sum Sq	Mean Sq	F-value	P
Ease	Tech-Savviness	1	0.7969	0.79691	0.3943	0.535
	Residuals	29	22.1708	0.76451		
Clarity	Tech-Savviness	1	0.0909	0.09086	0.1196	0.732
	Residuals	29	6.6833	0.2304		
Intuitive	Tech-Savviness	1	0.0302	0.03024	0.0326	0.8581
	Residuals	29	26.9375	0.9288		

Table 5.22: **Interface A - User Satisfaction Summary**

		Df	Sum Sq	Mean Sq	F-value	P
Ease	Tech-Savviness	1	0.0593	0.05927	0.0817	0.5744
	Residuals	29	21.0375	0.72543		
Clarity	Tech-Savviness	1	0.2151	0.21505	0.3226	0.732
	Residuals	29	1021.34	35.219		
Intuitive	Tech-Savviness	1	0.5679	0.56788	0.6785	0.4168
	Residuals	29	24.2708	0.83693		

Table 5.23: **Interface B - User Satisfaction Summary**

5.2 Discussion

The primary focus of this research was to explore the impact of interface design on users with varying technological proficiencies, with a particular emphasis on the non-tech-savvy group (classified as beginners). While the study did investigate differences between beginner and expert users, the discussion will primarily focus on the findings about the beginner user group and the implications for designing interfaces that cater to their needs and preferences.

The experimental tasks measured task performance, cognitive load, and user satisfaction. Through a detailed analysis of interactions with two distinct interfaces, significant insights were gained into how users navigate and are influenced by design nuances (Figure 5.7).

5.2.1 H1a - There will be a significant difference in task completion time between participants with different levels of tech-savviness.

The results support Hypothesis 1a, demonstrating that tech-savviness significantly affects task completion times, mainly with Interface B. Specifically, beginners experienced a significant 46.8% reduction in task completion time on Interface B compared to Interface A (Figure 5.1). This finding supports the hypothesis that technological proficiency impacts interaction efficiency and highlights the crucial role of design in enhancing user experience (Figure 5.2,5.3 and 5.4). The reduction in completion time for beginners using Interface B can be attributed to the interface's design improvements, which were informed by Nielsen's usability heuristics. Based on our observations of the participants, the effective use of app icon colors in Interface B likely helped facilitate easier app identification and interaction, underscoring the importance of intuitive design elements in improving usability for less tech-savvy users.

5.2.2 H1b - Task completion time will increase for beginners as the complexity and demands of the interface increase.

The study's findings on Task 2 challenge the hypothesis (H1b) that increased complexity and demands of the interface invariably elevate task completion time. The absence of significant time differences between Interfaces A and B for this task suggests that user familiarity and pre-existing interface paradigms are crucial in mitigating the negative impacts of increased complexity. This observation highlights an empathetic interaction between user experience and interface design, suggesting that familiarity may buffer users against the potential inefficiencies introduced by complex design elements facilitating recognition rather than recall heuristics. These findings

Descriptives

	N	Mean	SD	SE	Coefficient of variation
Time A (T1)	15	3.867	1.807	0.467	0.467
Time B (T1)	15	2.400	2.444	0.631	1.018

Bar Plots

Time A (T1) - Time B (T1)

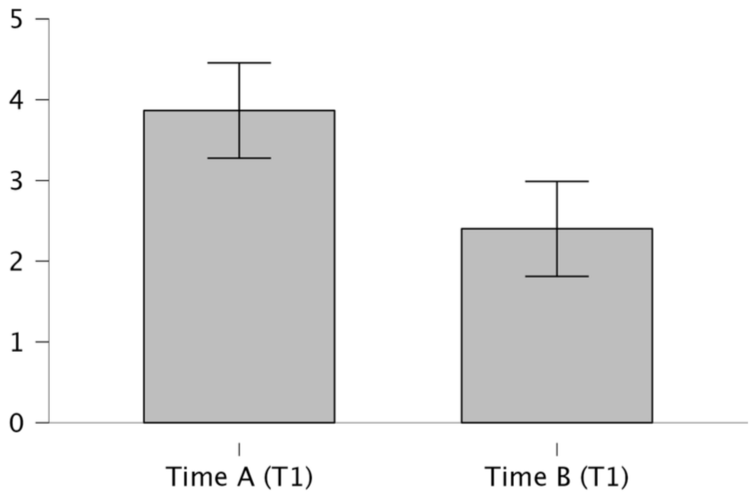

Figure 5.1: **Task Completion Time for Beginners (Task 1)-** Shapiro-Wilk test on the task completion time on task 1 by beginners on interfaces A and B reported it as non-parametric (<0.05). A WSR test showed that beginners took significantly less time to complete task 1 on interface B (proposed design) as compared to the existing interfaces (Z = 2.656, p = 0.008) by 46.8% with the average time for interface A and interface B being 3.867 seconds (SD-A: 1.807) and 2.4 seconds (SD-B: 2.444) respectively.

have profound implications for the design of user interfaces, particularly in emphasizing the need for designs that are accessible and efficient for users of all tech-savviness levels. The marked improvement in task performance among beginners using Interface B underscores the potential for design optimizations or modifications to enhance usability significantly (Figure 5.2,5.3 and 5.4). Future research should further investigate

Descriptives

	N	Mean	SD	SE	Coefficient of variation
Time A (T3)	15	13.467	5.276	1.362	0.392
Time B (T3)	15	9.133	1.807	0.467	0.198

Bar Plots

Time A (T3) - Time B (T3)

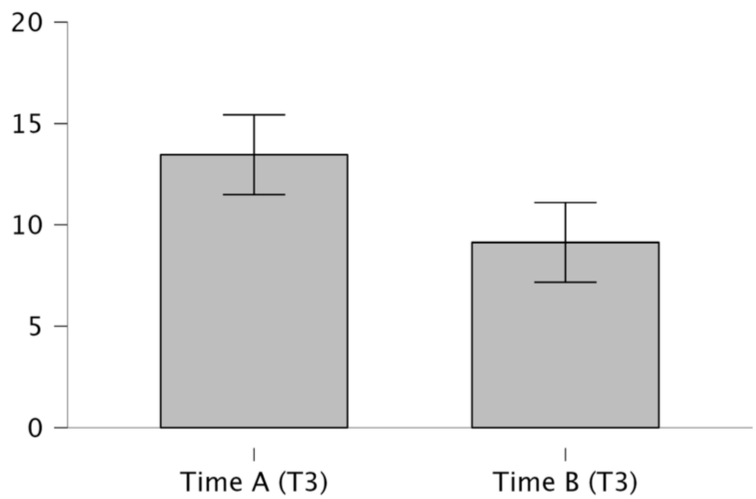

Figure 5.2: **Task Completion Time for Beginners (Task 3)-** An examination with a Wilcoxon signed-rank test unveiled a noteworthy decrease in completion time for beginners on interface B compared to interface A (Z = 2.668, p = 0.008). On average, users completed task 3 38.3% faster on interface B than on interface A

the specific design features that contribute to these improvements, exploring how various elements of human-centered interface design impact user satisfaction and efficiency across a broader range of tasks and technologies.

Descriptives

	N	Mean	SD	SE	Coefficient of variation
Time A (T4)	15	16.400	11.993	3.097	0.731
Time B (T4)	15	8.533	2.326	0.601	0.273

Bar Plots

Time A (T4) - Time B (T4)

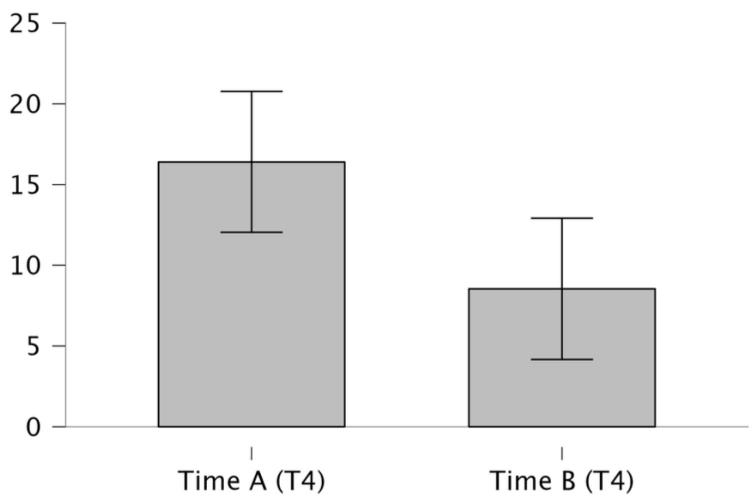

Figure 5.3: **Task Completion Time for Beginners (Task 4)-** The Shapiro-Wilk test conducted on beginners' task completion times for task 4 on both interfaces A and B indicated non-parametric distribution ($p < 0.05$). Subsequent analysis using the Wilcoxon signed-rank test demonstrated a significant decrease in completion time for beginners on interface B compared to interface A ($Z = 2.794$, $p = 0.006$).

Descriptives

	N	Mean	SD	SE	Coefficient of variation
Time A (T5)	15	6.333	2.637	0.681	0.416
Time B (T5)	15	5.267	2.344	0.605	0.445

Bar Plots

Time A (T5) – Time B (T5)

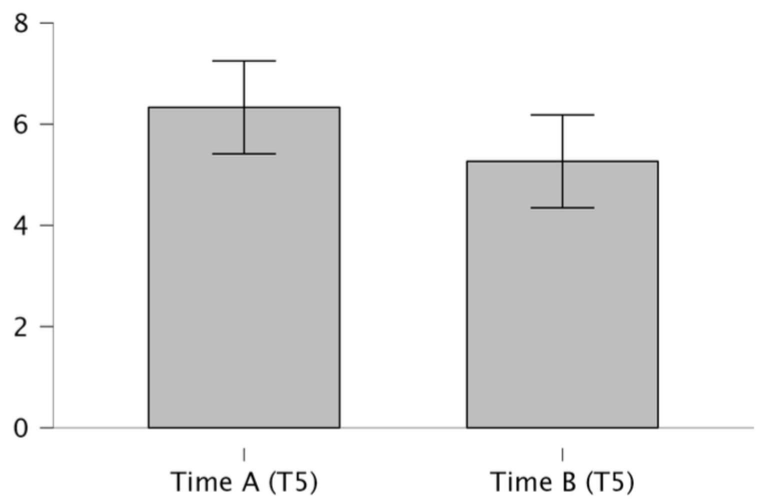

Figure 5.4: **Task Completion Time for Beginners (Task 5)-** An analysis using the Wilcoxon signed-rank test indicated a significant reduction in task completion time for beginners on interface B compared to interface A ($Z = 1.726$, $p = 0.088$). On average, users completed task 5 18.3% faster on interface B than on interface A, with mean completion times of 5.267 seconds (SD-B 2.344) and 6.333 seconds (SD-A 2.637), respectively.

5.2.3 H2a - Cognitive load will vary significantly based on tech-savviness, with either Beginners or Experts experiencing lower cognitive load when interacting with Interface B in comparison with Interface A.

The investigation into the cognitive load, mainly through the lens of tech-savviness, provided mixed results using the NASA TLX method's six components. While significant reductions in temporal demands were observed for beginners using Interface B (Figure 5.5), pointing to the beneficial effects of data-driven human-centered design interventions, other dimensions of cognitive load did not exhibit significant changes. This finding partially supports H2a.

Descriptives

	N	Mean	SD	SE	Coefficient of variation
TLX_Temporal A	15	21.667	20.845	5.382	0.962
TLX_Temporal B	15	3.333	8.797	2.271	2.639

Bar Plots

TLX_Temporal A - TLX_Temporal B

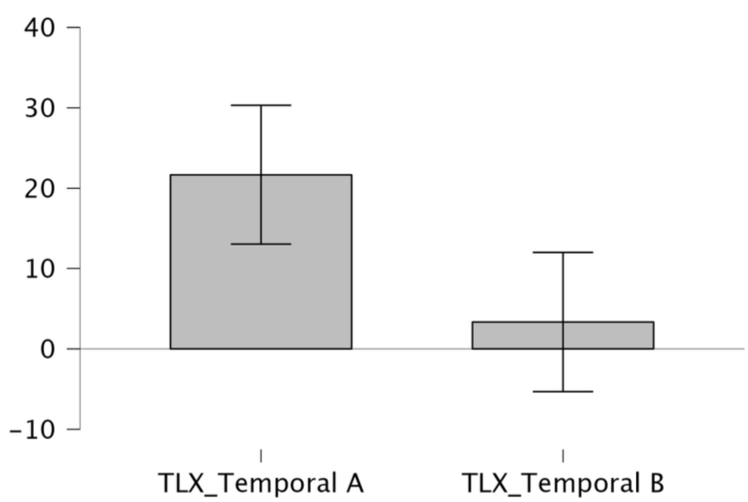

Figure 5.5: **Temporal Demands for Beginners -** Significant reductions in temporal demands were observed for beginners using Interface B (Z = 2.366, p = 0.015), pointing to the beneficial effects of human-centered design interventions.

The results of the one-way MANOVA [79] test revealed a notable significance in performance measures pertaining to cognitive load across both interfaces as depicted in Figure 5.6, as assessed using the NASA TLX method. Specifically, when examining

Interface A, the analysis yielded an approximate F-statistic of 4.8354, with 1 and 29 degrees of freedom, indicating a highly significant result ($p = 0.036$). Similarly, for Interface B, the approximate F-statistic was 10.424, with 1 and 29 degrees of freedom, also indicating a highly significant result ($p = 0.0031$). This finding underscores the impact of interface design on cognitive load performance, suggesting that certain design elements may influence users' cognitive processing differently.

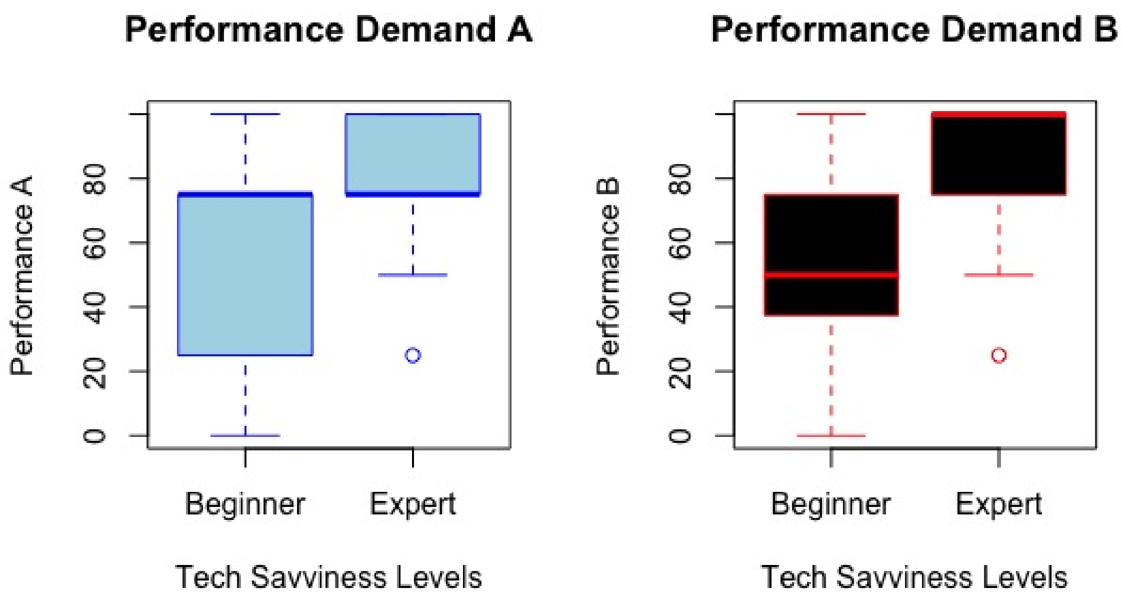

Figure 5.6: **Performance Measures for Beginners and Experts -** The Box plot illustrating the distribution of performance measures across Interface A ($p = 0.036$) and Interface B ($p = 0.0031$), as assessed using the NASA TLX method for cognitive load. The analysis, conducted through a one-way MANOVA, indicates a significant difference in performance between the two interfaces.

5.2.4 H2b - Cognitive load will increase for beginners as the complexity and demands of the interface increase.

The results do not support H2b, but show that the relationship between tech-savviness, cognitive load, and interface complexity is more complex than initially hypothesized.

The specificity of cognitive load reductions to temporal demands underscores the need for a more granular understanding of how different aspects of cognitive load are influenced by interface design. The study's methodology, while nuanced, inherently focuses on a subset of tasks and interface designs, potentially limiting the breadth of the findings. Additionally, the cognitive load analysis, reliant on self-reported NASA TLX scores, may not capture all dimensions of user experience, highlighting the importance of multimodal assessment methods in future studies. These insights into the interplay between interface complexity, cognitive load, and user familiarity offer valuable guidance for interface designers. Specifically, the findings advocate for a design approach that balances human-centered design innovation with user familiarity, ensuring that new interfaces do not unnecessarily exacerbate cognitive load. Future research should aim to dissect the components of cognitive load further, exploring innovative methods to reduce user burden without compromising the richness of the interface functionality.

5.2.5 H3a - User satisfaction will significantly differ based on tech-savviness, with either Beginners or Experts reporting higher satisfaction levels when interacting with Interface B in comparison with Interface A.

Contrary to the expectations set forth by H3a, our findings reveal no significant differences in user satisfaction levels between beginners and experts across both Interface A and Interface B. This suggests that user satisfaction may not be as directly correlated with tech-savviness as hypothesized. Instead, satisfaction appears to be a multifaceted outcome influenced by a variety of factors beyond the simplicity or complexity of the interface. This insight challenges the notion that interface design when tailored exclusively to proficiency levels, will yield universally higher satisfaction rates.

5.2.6 H3b - User satisfaction will decrease as the complexity and demands of the interface increase for beginners.

Similarly, H3b, which assumed a decrease in satisfaction with increasing interface complexity, did not find consistent support across the collated data. The lack of significant changes in satisfaction as a function of interface design suggests a more complex relationship between user experience and satisfaction than previously assumed. Users' adaptability or familiarity with certain interface elements, regardless of their complexity, might play a significant role in mediating satisfaction.

5.2.7 H4a - Task success will significantly differ based on tech-savviness, with either Beginners or Experts demonstrating higher success rates when interacting with Interface B in comparison with Interface A.

The investigation into task success rates, particularly between beginners and experts, did not demonstrate the expected significant differences across Interface A and B. This outcome indicates that both groups could effectively complete tasks, suggesting that well-designed interfaces, even those with varying levels of complexity, can be navigable and usable for users across the tech-savviness spectrum. This finding contradicts H4a, which anticipated distinct success rates based on user proficiency.

5.2.8 H4b - Task success will be significantly higher in Interface B compared to Interface A.

Despite an attempt at intuitive design improvements in Interface B, our study did not find a universal enhancement in task success compared to Interface A, challenging H4b.

This suggests that task success may be less about the interface and the user's ability to adapt to different designs. It highlights the potential for users of all tech-savvy levels to achieve their goals when provided with clear and coherent interface options.

While our participant pool was diverse regarding age and tech-savviness, further research could benefit from exploring a broader demographic spectrum and real-world application scenarios with a larger sample size. This could provide deeper insights into how various user groups interact with technology daily, potentially affecting satisfaction and task success rates. These findings invite future research to delve deeper into the psychological and emotional factors influencing user satisfaction and success. Understanding the nuances of user experience could inform more holistic design strategies that cater to functional efficiency and emotional and cognitive well-being. The nuanced relationship between interface design, user satisfaction, and task success underscores the importance of a human-centered design approach.

Hypothesis	**Results**
H1a - There will be a significant difference in task completion time between participants with different levels of tech-savviness.	Partially Supported
H1a - Task completion time will increase for beginners as the complexity and demands of the interface increase.	Not Supported
H2a - Cognitive load will vary significantly with either Beginners or Experts experiencing lower cognitive load when interacting with Interface B in comparison with Interface A.	Partially Supported
H2b - Cognitive load will increase for beginners as the complexity and demands of the interface increase.	Not Supported
H3a - User satisfaction will significantly differ with either Beginners or Experts reporting higher satisfaction levels when interacting with Interface B in comparison with Interface A.	Not Supported
H3b - User satisfaction will decrease as the complexity and demands of the interface increase for beginners.	Not Supported
H4a - Task success will significantly differ based on tech-savviness, with either Beginners or Experts demonstrating higher success rates when interacting with Interface B in comparison with Interface A.	Not Supported
H4b - Task success will be significantly higher in Interface B compared to Interface A.	Not Supported

Figure 5.7: The study's results challenge initial assumptions, indicating a nuanced relationship between interface complexity and user performance. Users demonstrate adaptability to new design elements irrespective of complexity, underscoring the importance of incorporating users' familiarity and existing mental models into interface design considerations.

Chapter 6

Conclusion

In conclusion, this thesis has employed a mixed-method approach, combining a survey questionnaire and a user study, to provide valuable insights into the complex relationship between interface design, user tech-savviness, and the user experience, with a primary focus on the beginner user group based on tech-savviness. The findings challenge several existing assumptions and offer specific observations that have important implications for the field of human-computer interaction and provide key insights into the field of human-centered design.

The key takeaway from this study is the significant impact that thoughtful design can have on enhancing the efficiency and usability of mobile device interfaces for less tech-savvy individuals. The marked improvement in task completion times for beginner users when interacting with the optimized Interface B, as observed in the user study, underscores the crucial role of design in bridging the gap between beginner and expert users. This supports the notion that tech-savviness is a crucial factor in determining interaction outcomes and highlights the importance of designing with the needs and goals of the target audience in mind.

Contrary to the initial hypotheses, the study's findings reveal that the relationship between interface complexity and user performance is more intricate than previously thought. The observed ability of users to adapt to new design elements, regardless of their complexity, emphasizes the significance of considering users' familiarity and pre-existing mental models when designing interfaces. This challenges the assumption that reducing complexity is the sole path to optimizing the user experience and underscores the value of leveraging users' cognitive flexibility.

The investigation into cognitive load provided mixed results, indicating the need for a more granular understanding of how different aspects of cognitive load are influenced by various interface design features and functionalities. This, in turn, highlights the importance of employing multimodal assessment methods to capture the nuances of user experience, moving beyond self-reported measures.

The findings regarding user satisfaction and task success rates further challenge common assumptions, suggesting that these outcomes are influenced by a multitude of factors beyond just the simplicity or complexity of the interface. This underscores the importance of adopting a holistic, human-centered design approach that considers emotional, cognitive, and functional aspects of the user experience.

Apart from highlighting the intricacies of interface design and user experience, this research recognizes a number of constraints. The broad age range of the participants makes it difficult to generalize the results to certain age groups, requiring more research into age-specific design factors. Moreover, issues with real-world application are brought up by the ecological validity of lab-based testing, indicating the necessity for field research to confirm results in real-world use settings. However, it was made more valid by using the respondent's own mobile devices in the control group. A field study observing users engaging with mobile interfaces in real-world scenarios could be carried out to improve the ecological validity of testing outside of the controlled lab environment. To do this, participants would need to be recruited to use the interfaces in their natural environments, such as places they frequently visit, including their homes and offices. Researchers can capture the intricacies of real-world interactions, such as time limits, distractions from the surroundings, and situational elements that may affect user behavior, by performing the study in real-world situations.

These insights underscore the importance of human-centered mobile device interfaces that cater to the diverse needs and preferences of users, particularly those with varying levels of tech-savviness. Designers are encouraged to engage in an iterative process of user testing, feedback gathering, and design refinement to ensure that interfaces are not only functionally efficient but also emotionally and cognitively supportive for all users.

Several design guidelines have emerged to assist the development of more inclusive and human-centered mobile device interfaces based on the insights gained from this study:

- Prioritizing simplicity and intuitiveness, above all else, can help interface designers reduce cognitive burden and expedite user interactions.
- Icons and buttons are examples of clear, recognizable visual features that should be positioned strategically to make navigation easier and lower the chance of user error - especially for those who are less tech-savvy.
- Interfaces should also accommodate a variety of user preferences and usage patterns by providing numerous entry points to features and functionalities.
- In order to ensure that interfaces are compatible with a variety of devices and can accommodate users with varying requirements and abilities, accessibility should also be considered.

By addressing the limitations of the current study, such as the limited sample size, and exploring additional research directions, future investigations can further contribute to a deeper understanding of the complex interplay between interface design, user experience, and tech-savviness. This knowledge can inform the development of more inclusive and empathetic data-driven user interfaces. This study has provided data based on participant behavior that can guide the design of more inclusive interfaces catering to users' needs and preferences. The end goal is to develop design guidelines that are universally applicable and would alleviate usability challenges for beginners face but still be useful for other user segments catering to the diverse needs of mobile device users, ultimately enhancing their overall satisfaction and productivity.

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Appendix A

Survey

A.1 Survey Questions

A.1.1 Demographic Snapshot

1. What is your age?
2. What is your gender? Male, Female, Other, Prefer not to say
3. What is your level of education? School, Undergraduate, Graduate, Doctorate (Please select the highest level of education completed)
4. Which region or country are you located in? Sate, Country
5. What is your occupation or profession?

A.1.2 Mobile Device Usage Profile

1. What type of mobile device(s) do you use regularly? Smartphone, Tablet, Both, NOTA
2. Which mobile operating system(s) do you primarily use? Android, iOS, Other
3. How often do you use your mobile device(s) in a typical day?

4. What are the top three apps you use when using your mobile device(s)?
5. What are the primary activities you engage in with your mobile device(s)?

A.1.3 Challenges and Contexts

1. Do you face any specific challenges or difficulties when using your mobile device(s)?
2. Are there any particular situations or contexts in which you encounter these challenges? Travel, Work, Leisure, Other (Please specify)
3. Are you part of any specific user groups you believe might share similar mobile device usage patterns or challenges? Frequent Travelers, Students, Professionals

A.1.4 Device Issues and Pain Points

1. What are the top three issues or problems you encounter when using your mobile device(s)?
2. What is the biggest pain point while you use mobile devices?
3. Can you describe, in more detail, how these issues impact your mobile device usage and overall experience?

A.1.5 User Preferences and Suggestions

1. Do you have any preferences or suggestions for improving the design or features of mobile devices and their interfaces to address the challenges you've mentioned?
2. Is there anything else you would like to share about your mobile device usage or experiences that we haven't covered in this survey?

A.1.6 Common Usage Challenges Rating

Rate each of these problems, indicating how often you encounter them.

(Never, Sometimes, About half the time, Most of the time, Always)

1. Finding the menu icon in different apps (Difficulties understanding the meaning of the hamburger icon)
2. Scrolling the menus
3. Switching between tabs or apps to perform functions
4. Navigating between different icons in close proximity (Small icons)
5. Small font sizes
6. Scrolling and swiping to see options (Instead of glancing through the options at once)
7. Looking for old options after app updates
8. Horizontal Scrolling
9. Icons placed too close to the edge of the screen
10. Distinguishing between the touchable and non-touchable screens
11. Understanding and distinguishing icons
12. Buttons without texts

A.1.7 Technological Know-How Assessment

1. Have you ever used augmented reality (AR) features on your mobile device?
2. Have you ever customized the settings of app notifications on your mobile device?
3. Have you used voice commands or virtual assistants (e.g., Siri or Google Assistant) on your mobile device?
4. Do you know how to check for and install software updates on your mobile device?
5. Have you ever used a mobile payment service (e.g., Apple Pay, Google Pay)?

6. Do you know how to check the battery life cycle on your mobile device, including understanding factors like charge cycles and overall health?
7. Have you ever enabled biometric authentication (fingerprint or face recognition) on your mobile device for security?
8. Do you regularly update your mobile apps to ensure you have the latest features and security patches?
9. Have you ever used the “Find My Device” feature to locate your lost or stolen mobile device?
10. Do you know how to check the storage space available on your mobile device?
11. Have you ever set up and used a mobile hotspot on your device to share internet connectivity?
12. Do you know how to clear the browsing history on your mobile web browser?
13. Have you ever connected your mobile device to a smart home device or IoT (Internet of Things) device?
14. Do you regularly review and manage the permissions granted to apps on your mobile device?
15. Have you ever initiated a factory reset on your mobile device, and do you know when it might be necessary?

Appendix B

Treatment Measurements

B.1 Rating Scale for Cognitive Load

Using the NASA Task Load Index (TLX) method.

B.1.1 Mental Demands

1. 0: Very Low
2. 25: Low
3. 50: Moderate
4. 75: High
5. 100: Very High

B.1.2 Physical Demands

1. 0: Very Low
2. 25: Low
3. 50: Moderate

4. 75: High
5. 100: Very High

B.1.3 Temporal Demands

1. 0: Very Low
2. 25: Low
3. 50: Moderate
4. 75: High
5. 100: Very High

B.1.4 Own Performance

1. 0: Very Low
2. 25: Low
3. 50: Moderate
4. 75: High
5. 100: Very High

B.1.5 Effort

1. 0: Very Low
2. 25: Low
3. 50: Moderate
4. 75: High
5. 100: Very High

B.1.6 Frustration

1. 0: Very Low
2. 25: Low
3. 50: Moderate
4. 75: High
5. 100: Very High

B.2 Rating Scale for User Satisfaction

Participants rate their satisfaction using a Likert scale (0 - Not satisfied at all to 4 - Completely satisfied)

B.2.1 Ease of Task Completion

1. 0: Not satisfied at all
2. 1: Slightly satisfied
3. 2: Moderately satisfied
4. 3: Very satisfied
5. 4: Completely satisfied

B.2.2 Clarity of Instructions

1. 0: Not satisfied at all
2. 1: Slightly satisfied
3. 2: Moderately satisfied
4. 3: Very satisfied
5. 4: Completely satisfied

B.2.3 Interface Intuitiveness

1. 0: Not satisfied at all
2. 1: Slightly satisfied
3. 2: Moderately satisfied
4. 3: Very satisfied
5. 4: Completely satisfied