Usability and User Experience of Mobile Applications

A Case of Functional Illiterates in Nigeria

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ABSTRACT

Despite the challenges faced by functional illiterates (FXI) when using smartphones, usability studies of mobile applications for FXI in Nigeria are still lacking in Human-Computer Interaction (HCI) research. To address this gap, we conducted a mixed (quantitative and qualitative) user study with FXI users to explore their experiences using current mobile applications for banking and shopping. Our study uses a digital skills framework (DLGF) with usability and user experience (UX) metrics to investigate user interaction, providing a novel approach to understanding users' capabilities in HCI research. Triangulating interview data with both applications' user interface (UI) data, we found that FXI users encountered challenges in certain tasks but not all. Our findings revealed below-average UX ratings of the current mobile applications compared to established benchmarks. These findings contribute to an emerging discussion about designing more inclusive and accessible UIs. We propose that using the DLGF in usability studies can provide a more comprehensive view to all stakeholders in accessibility research.

CCS CONCEPTS

• ; • **Human-centered computing** → Human computer interaction (HCI); HCI design and evaluation methods; Usability testing; Human computer interaction (HCI); Empirical studies in HCI; Accessibility; Accessibility design and evaluation methods;

KEYWORDS

Functional illiterates, Low-literates, Mobile applications, HCI4D

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1 INTRODUCTION

Functional illiteracy is a condition where adults have limited literacy skills that make it difficult to understand written information and low skills in the context in which literacy is required [1]. This condition presents challenges when using mobile applications, particularly in developing countries such as Nigeria, where smartphones have become widely adopted for accessing digital services [2, 3]. Researchers in the field of Human-Computer Interaction (HCI) are focusing on improving user interfaces (UIs) for individuals with functional illiteracy, as poorly designed UIs often contribute to the challenges experienced [4–7]. To address this issue, recommendations have been made for developing text-free, graphical, and voice UIs [5].

However, limited research exists on the digital skills of functionally illiterate (FXI) users when interacting with mobile banking and shopping applications in developing countries such as Nigeria. Additionally, the fact that 64% of the most popular app content is design elements other than text [8], presents a complex issue beyond text-free solutions, especially considering Nigeria's low digital skills ranking compared to regional peers [9]. This study aims to bridge this gap by examining FXI users' difficulties when using mobile banking and shopping applications in Nigeria.

This research is significant because the inability of FXI to use mobile applications can lead to exclusion from online transactions and services, limiting their access to the benefits of the digital economy. Also, inclusive design is essential because UIs designed for users with lower levels of digital skills tend to be more accessible to all users, regardless of their skill level [10]. We conducted descriptive user studies with 20 FXI and provided them with a list of tasks to perform on current mobile banking and shopping applications in Nigeria. We also recruited 5 literate (LIT) adults for comparison. We mapped out the tasks to the Digital Literacy Global Framework (DLGF) by Law et al. [11] to research the digital skills of these users. We recorded the UI's screen (including keystrokes) and interviewed participants to gather background and user experience (UX) data using Schrepp et al.'s survey [12] post-study. The research questions are:

1. What are the difficulties in using mobile banking and shopping applications for FXI users?
2. What is the quality of mobile banking and shopping applications' user experience (UX) for FXI users in Nigeria?

The objectives of this study are (1) to explore the experiences and challenges of FXI and to assess the effectiveness of the current mobile applications' UI design in meeting the needs of FXI users, (2) to show the digital skills required for completing the essential tasks on mobile shopping and banking applications, (3) to assess the UX of mobile banking and shopping applications for FXI users. To answer the research questions and achieve these objectives, we triangulated the interview data with the UI data of both applications. We analysed the UI data and measured user performance based on difficulty metrics (e.g., error rate) in the preassigned tasks. Then we compared these results with LIT users using statistical methods to establish whether only FXI experienced difficulties. Finally, we used rank analysis to determine the most challenging tasks for FXI.

We find that FXI faced significantly more challenges than LIT users on some tasks but not others. The most challenging tasks for the mobile banking application were transferring money between accounts, while filtering search results and checkout were the most difficult tasks in the shopping app. This may be influenced by their lack of experience in using similar applications for banking and shopping, as well as lower literacy skills compared to LIT users. We also introduce the use of the DLGF with usability evaluation as a novel approach in HCI research that provides an excellent opportunity to provide structure and a holistic view of investigating and designing UIs for users.

2 RELATED WORK

2.1 Usability of Mobile Applications

The impact of literacy challenges on usability is a well-studied area in HCI research [13]. However, comparing results is challenging because of the inconsistent terminologies used. As such, we reviewed works of researchers who have used different terms to describe these users, such as 'low literates' and 'semi-literates', as the common thread among these terms is they refer to individuals who face challenges in areas where literacy is necessary for adequate participation in society.

2.1.1 Mobile Applications for Financial Management. Medhi et al. in [14] compared illiterate and semi-literate users' performance with banking and health mobile applications following an ethnographic and quantitative method. The study revealed several barriers to using existing text-based UIs, including difficulties understanding or utilising hierarchical structures, soft keys, scroll bars, non-numeric inputs, and specialised terminology. The study also found that text-free designs enabled faster task performance and required less assistance with spoken dialogue UIs, while task completion rates were higher for rich graphical UIs. Parikh et al. [15] conducted field studies involving semi-literate women in India to investigate UIs for managing financial institutions in rural India. The study resulted in three iterations of prototyping, where techniques such as contextual studies, informal association tests, participatory design, and rapid iterative prototyping were employed to reach the final UI. The authors recommended a linear navigation structure and highlighted several key points while designing for low-literate users.

Mehra et al. [16] designed Prayana, a mobile application for financial management in a resource-constrained setting in India. They used a methodological approach involving ethnographic, iterative and user tests in designing and evaluating the mobile application with limited text and scrolling requirements. They found their users were confident using the app and could complete all the evaluation tasks. Tandon et al. [17] followed up on Prayana with SalaPrayana, a financial management app for users with varying literacy levels in India, with an iterative and human-centred approach. The app was evaluated with user testing and interviews with prospective users. They found that checking loan status was challenging, while identifying payment history was easy for all users.

2.1.2 Mobile Applications for Shopping. Following a user-centred design approach, Emmanuel and Muyingi [18] designed and evaluated a mobile shopping application for low-literate users in South Africa. Participants performed specified tasks while observations, post-test questionnaires based on the technology acceptance model (TAM), and interviews were recorded. Results showed a success rate of over 50% for low literates. Notably, the usability was assessed based on task completion rate only. In Islam et al.'s study [19], different UIs of a Sales Force Automation (SFA) mobile application were tested by observing semi-literate sales agents in Bangladesh. Users preferred using each UI screen for a single task, but black and white UI components were like regular texts, making them reluctant to tap. Rahman [20] researched online shopping UIs for illiterate and semi-literate users in Pakistan. Using an ethnographic approach, they developed two similar UIs with and without audio support. The System Usability Scale (SUS) questionnaire was adopted for evaluation. Semi-literate users completed their tasks faster than illiterates and were less interested in using the audio UI. The study found that experience with modern technologies only affected task completion duration but not the accuracy of a complete task.

2.2 Limitations and Gaps in Previous Research

The reviewed research has clear objectives of exploring the usability of mobile UIs for novice and low-literacy users. However, none of the studies except for [18], who adopted the TAM, provided a theoretical model or framework to structure their research. Furthermore, many studies failed to provide quantitative data or metrics to assess the success of the design artefact [14–17, 19]. It is also worth noting that even though FXI qualify as users with special needs, there is no mention of the ethical considerations taken to conduct research with them in any of the reviewed studies. Finally, none of the studies provided information on the recruitment criteria for FXI. To ensure that research is replicable and that results can be compared, consistency in defining/recruiting FXI and detailing the theoretical and methodological approach to design is crucial.

Despite these limitations, the studies have contributed to developing mobile applications that FXI users can use. Nevertheless, there is a need for more research to understand better the challenges faced by FXI and to improve the design of mobile applications for them. As noted by Srivastava et al. [13] in their review of FXI and HCI research, studies have focused on designing technologies for literacy interventions in agriculture (e.g.,[21]), information portals (e.g., [22]), telecommunication (e.g., [23]), and redesigning UI elements (e.g., [24]). However, there is limited attention in investigating mobile applications for users with limited literacy in commerce and

finance, particularly in Nigeria. Since e-commerce is becoming the norm, FXI users should not be left behind [25].

3 METHOD

We used a descriptive study design to investigate the skilfulness of FXI users with mobile banking and shopping applications [26]. This approach allowed us to accurately describe the difficulties of interacting with smartphones, providing implications for UI design for FXI users. We conducted mixed (quantitative and qualitative) user studies with locally available mobile banking and shopping applications. The mobile banking application was chosen because of its importance in promoting financial inclusion in Nigeria [2]. The shopping application allowed us to test digital skills in a different sector understudied by FXI researchers.

To provide contextual background for our study, we specifically targeted smartphone users in Nigeria—a West African country with an estimated population of 230 million people in 2023 [27]. Like most developing countries, Nigeria has achieved 61.4% Internet penetration, mainly through mobile devices [2]. English is the official language used daily in Nigeria [28]. We selected Kaduna State, a city in the Northern region, for our study because we had access to a literacy centre for its students. Therefore, this research's findings will not represent other parts of Nigeria.

3.1 Data Collection

The first author collected data with FXI at the adult literacy centre from June to July 2022. Participants were recruited by sharing a poster with the centre's leaders. A pool of volunteers who expressed interest in the study was evaluated using the DIBELS8 Maze Assessment [29]. In DIBELS8 Maze, a passage is presented to the participants where every seventh word is left blank, and three options are provided to fill in the blank [29]. Research has shown that Maze measures are valid assessment methods for low-level comprehension [30]. Although the DIBELS was developed to assess students, it has been adopted and validated by researchers in studying adults e.g [31]. Volunteers who scored below the 50th percentile on Grade VII of the assessment [32] and stated they required assistance with using mobile applications were selected as FXI participants, provided they were over 18 years old and confident in completing the study in English. Participants who lacked sufficient English to use the UI were excluded from the study. Of the 24 volunteers, 4 were removed due to inexperience with mobile touch UIs or insufficient English proficiency. An additional 5 LIT were recruited from the adult literacy centre's staff as a comparison group after scoring above the 50th percentile on Grade VII of the DIBELS8 Maze test. All participants were shown a pre-recorded video of a person performing similar tasks to explain the study procedure.

3.1.1 User Interviews. We structured our interviews in three sections, which took an average of 5 minutes each. The first interview section consisted of structured background questions about the participant's age, gender, and experience with smartphones/mobile applications. The study included twenty (20) functional illiterate (FXI) participants aged 20-49 years (mean=31), with 55% male and 45% female. The majority had completed senior secondary education (80%) and enrolled in the literacy centre for self-learning (55%), job-related (25%), or personal interest (20%) purposes. Participants spent considerable time on their smartphones daily (22% >10 hours, 28% 6-9 hours, and 39% 3-9 hours). All participants owned a smartphone and had at least six months of mobile application usage experience. However, 75% had never used mobile banking, and 70% had never used shopping applications because of issues relating to preconceptions on its usability (65%), trust issues (43%) and unawareness (22%). All participants used social networking applications, phone calls, and messages, while 55% used their phones for watching videos and 46% for studying/learning. Of the literate (LIT) participants, 3 were females (60%) and 2 males (40%), with 60% aged 40-49 and 40% aged 30-39, all having at least a bachelor's degree. Most participants (80%) had used smartphones for over 7 years, spending 3-5 hours (40%), 6-9 hours (40%), or 10+ hours (20%) daily. Of those, 60% used mobile banking applications, with 80% frequent users and 20% rare users, and 80% had used mobile shopping applications, with 40% frequent users and 60% occasional users.

Interviews two and three were conducted with FXI and LIT after their interaction with each mobile app. We employed Schrepp et al.'s User Experience Questionnaire (UEQ-S) [12], which utilises a short version UX scale to alleviate potential fatigue from reading for FXI. The UEQ-S measures six aspects of UX: Enjoyability, Understandability, Efficiency, Predictability, Excitement, and Novelty on a semantic scale. The UEQ-S provides a benchmark for comparing products based on data from 246 product evaluations of various mobile applications [33].

3.1.2 Tasks. A set of tasks were chosen and assigned to participants from mobile banking and shopping applications based on the essential skills that apply to other applications (e.g., searching and filling forms). The chosen tasks were mapped out to the Digital Literacy Global Framework (DLGF) [11], as shown in the following link https://doi.org/10.17036/researchdata.aston.ac.uk.00000608. Following the pathway-mapping methodology and guidelines for adapting the framework to specific contexts, the functions available in mobile shopping and banking contexts were mapped out to the chosen tasks. Due to time and resource limitations, not all competencies were tested. The participants' interview responses and UIs' keystrokes were recorded using the Samsung Fold 2's built-in features (HxWxD, mm of 159.2 x 68 x 13.6-16.8) running Android v12 and a touch UI.

3.2 Data Analysis

Our data analysis process was done in 4 stages. 1) analysis of background data 2) analysis of screen data for recording (discussed below in 3.3.1) 3) statistical and descriptive analysis to compare FXI vs LIT user performance based on data in stage 2. 4) analysis of post-study UX data. It is important to note that we analysed each of the applications separately.

3.2.1 Data Recording. The screen recording, keystrokes and audio transcriptions for each task and participant were reviewed in detail whilst taking account of the challenges encountered by everyone. The following four (4) categories characterised difficulties.

1. Error rate – recorded as dichotomous data [34]. These include (i) several attempts to complete a task, (ii) delaying

mid-task and being unable to proceed without help, (iii) doing a wrong action, and (iv) requesting verbal confirmation. It was noticed that some participants falsely stated they were successful in completing some tasks, which was taken as an indication of an error. Hence, an additional category was created, (v) a false perception of success.
2. Task completion rate - recorded as dichotomous data (ISO 9241-11, 1998).
3. Number of taps – recorded as count data (ISO 9241-11, 1998), and
4. Time taken – recorded in seconds [35].

Data from each UI was evaluated separately, and the lead author computed the average for each difficulty category across all tasks. Descriptive rank analysis was used to assign ranks to each task for each difficulty category based on the highest average recording of participants who experienced challenges. Next, the average of the ranks assigned to each difficulty category for each task was calculated. This served as the average difficulty per task, with tasks having the highest scores classified as the most challenging and tasks with the lowest average scores considered more manageable. The study assumed that all difficulty measures carried the same weight (more details on this can be found in this link https://doi.org/10.17036/researchdata.aston.ac.uk.00000608).

3.2.2 Exploring User Performance (FXI vs LIT).. We analysed task performance differences between FXI and LIT users using descriptive frequencies and statistical analysis, including Fisher's Exact Test and Independent Samples T-test [36]. Fisher's Exact Test determined an association between error rate and literacy group, as well as task completion and literacy group. The Independent Samples T-test measured differences between FXI and LIT users' mean time elapsed scores. We excluded the tap difficulty measure from statistical analysis due to the small sample size of the LIT group, making statistical methods for count data inappropriate. We considered a tapping count ratio of 1:2 or higher as significant.

3.2.3 Post-Study User Experience (UX) Interview. We analysed participants' responses to the UEQ-S using Schrepp et al.'s guidelines [12], where values above/below 0 indicate positive/negative evaluations. The UEQ-S provides feedback on five UX categories based on a benchmark. Further details on the analysis of UX metrics using the UEQ-S can be found in [12]. Participants received 3,000 NGN ($6) for transport and subsistence.

3.3 Ethical Consideration

This study received ethical approval from Aston University College of Business and Social Sciences' Ethics Committee. To minimise potential anxiety and nervousness in participants, we recruited FXI individuals already part of adult literacy programs and asked them to sign an informed consent form. We read a condensed version of the form to prevent exhaustion among FXI participants whose attention span tends to wane early [37]. Additionally, a neutral party read it to minimise coercion risk.

4 RESULTS

The rank analysis of the 4 banking and 11 shopping tasks indicated that some were easy, some were difficult, and some were moderate for FXI. Because our first research question centres on assessing difficulties, we focus the rest of the results on discussing the challenging tasks. However, it is worth noting the easy tasks for FXI. These include purchasing airtime for a phone number [B2, banking UI], searching for products [S3, shopping UI], and adding products to the shopping cart [S4, shopping UI]. In these easy tasks, we found that FXI tapped at least 3x more in all three tasks than LIT users and took significantly longer on two tasks. Despite this, comparing the FXI users' performance with that of the LIT users in three tasks considered easy for the FXI did not reveal any statistically significant differences concerning error rates and task completion. These results suggest that both user groups completed the tasks with high accuracy and low error rates.

Conversely, the most challenging tasks were transferring funds between accounts [B1, banking UI], filtering search results [S4, shopping UI], and checking out [S11, shopping UI] (full details of the results can be accessed here https://doi.org/10.17036/researchdata.aston.ac.uk.00000608). In section 4.1, we investigated whether these tasks' difficulties were exclusive to FXI users, while section 4.2 presents the results of the UEQ-S for FXI users only.

4.1 Exploring User Performance (FXI vs LIT)

The study compared the difficulty parameters of two user groups (FXI and LIT) based on their performance on the mobile banking and shopping applications for the most challenging tasks. The study found significant differences between FXI and LIT users regarding all difficulty categories for the three (3) tasks classified as challenging for FXI users as discussed below.

Transferring funds between accounts [B1, banking UI]: Specifically, FXI users differed significantly in the rate of errors from LIT users (Fishers Exact Test, $p = .016$), with 95% of FXI users experiencing errors compared to 40% of LIT users (see Figure 1). Regarding task completion, 25% of FXI users completed the task compared to LIT users, who had a 100% completion rate, a significant difference (Fisher's Exact Test, $p = .005$). FXI users spent three times longer (187 seconds) compared to LIT (60 seconds), a significant difference (independent samples t-test; t (38) = 3.678, $p = .001$). Also, FXI had about twice the number of taps (36) completing this task compared to the LIT users (19).

Filtering search results [S4, shopping UI]: Results showed that the FXI users experienced significantly more errors than the LIT (Fisher's Exact Test, $p = .002$), with a 95% error rate for FXI vs 40% for LIT (Figure 1). A significant difference is also observed in task completion rate, with 25% of FXI completing the task compared to 100% of LIT (Fisher's Exact Test, $p = .005$). A Welch test showed a significant difference in mean time between the two user groups (FXI 69 seconds vs LIT 15 seconds, $p = <.001$). FXI had an average tap count of 18 compared to LIT (5).

Completing a purchase [S11, shopping UI]: Figure 1 shows that FXI had a 90% error rate, while LIT had a 0% error rate, indicating significant differences between the two groups (Fisher's Exact Test, $p < .001$). FXI had a 25% completion rate for task completion, while LIT completed all tasks ($p = .005$). A statistically significant difference was observed in the mean time to complete this task (Welch Test $p = <.001$), with FXI users spending 168 seconds compared to

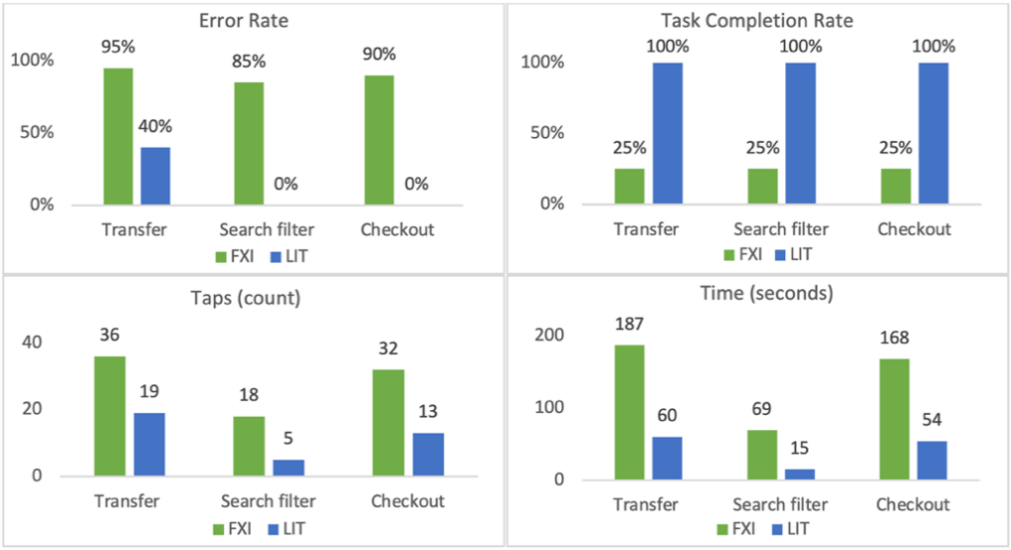

Figure 1: Frequency distribution of four difficulty measures for the three most challenging tasks.

LIT 54 seconds. In tapping behaviour, FXI users tapped 19 times more than LIT.

4.2 Post-Study User Experience (UX)

FXI rated the banking and shopping UIs based on the UEQ-S, as shown below in Figure 2. The ratings for the banking UI are as follows Enjoyability: above average (mean 1.21), Understandability: below average (mean 0.79), Efficiency: below average (mean 0.79), Predictability: bad (mean 0.63), Exciting: good (mean 1.31), and Novelty: bad (mean 0.05). For the shopping UI, FXI ratings are Enjoyability: excellent (mean 2.0), Understandability: above average (mean 1.2), Efficiency: bad (mean 0.4), Predictability: bad (mean 0.7), Exciting: excellent (mean 1.85) and Novelty: bad (mean -0.55).

FXI were also asked to rank their success in completing all tasks. In the mobile banking application, FXI participants ranked their success rate as relatively high (64.7%) compared to their average total task completion rate (27.5%) for all tasks measured. Similarly, in the shopping app, FXI ranked their success rate at 75% compared to their average total task completion rate of 42%.

5 DISCUSSION

The present study aimed to investigate the mobile banking and shopping applications usage and perceived user experience (UX) of functional illiterates (FXI). Our findings indicate that while some tasks were easy, others were hard. Specifically, FXI took longer and tapped more than literate users, regardless of task difficulty. Regarding the hard tasks, FXI had significantly lower skill levels than LIT participants. The difficult tasks required all the digital competencies areas we tested, except for communication and collaboration. In terms of UX, FXI rated both applications below average.

5.1 Experience with Mobile Applications

Our findings suggest that the FXI lacked experience with mobile banking and shopping applications. This could explain why they generally took longer and tapped more than the LIT users, regardless of task difficulty. However, FXIs had considerable experience using smartphones for social networking. Notably, 65% avoided shopping and mobile applications due to perceived difficulties with their usability. This aligns with prior research showing that users'

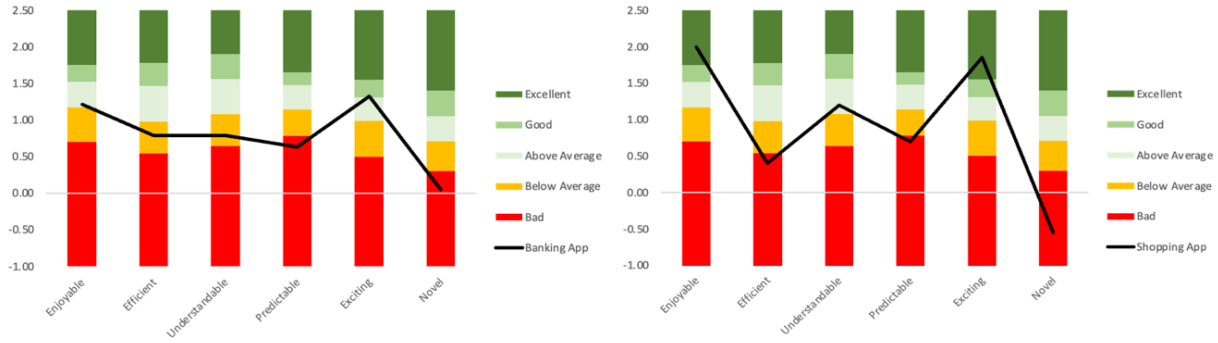

Figure 2: User Experience (UX) Rating based on (UEQ-S) [12].

attitudes and intentions towards using applications can be influenced by how they perceive UI design attributes [38]. This indicates that perceived usability is important when designing mobile applications for FXI users.

Moreover, research has shown that most social networking applications prioritise personal videos and images over text in their UI design, with text comprising only 26% of social media UIs compared to 40.7% and 41% for retail and personal finance UIs, respectively [8]. Thus, the text-heavy UIs of the tested applications may have seemed daunting to FXI users because of their lower reading comprehension skills. This aligns with Rao and Ramey's finding [39] that low-literate users avoided text-intensive UIs.

5.2 Difficult Tasks

Our study was not meant to be a rigorous comparison but rather a preliminary investigation that identified if some tasks were more challenging for FXI than LIT users. We found three such tasks: transferring funds between accounts (B1), filtering search results (S4), and checking out (S11). FXI users made significantly more errors and taps, took much longer, and completed the tasks at much lower rates than LIT users. Specifically, FXI users took three times longer than LIT users and had four times lower task completion rates. They were also seven times more error-prone and tapped twice as much.

This finding aligns with previous research showing FXI have significantly lower digital skills than LIT users; for example, Kodagoda and Wong's study [40] found FXI users performed significantly worse than high literacy users in information search tasks. Olivers et al. [41] noted that users with literacy challenges often have difficulties with visual searches due to cognitive shortcomings. As such, they spend much time reading instead of scanning, usually terminating their search before finding the correct information [37]. They also tend to reread text and revisit UI elements frequently to find the correct information [37]

Medhi's study found a similar finding in that transferring between accounts was challenging for FXI users [42]. The author noted that unfamiliarity with banking vocabulary was a contributing factor. Notably, in our study, this task involved filling out a form, and FXI users have been known to do as little reading as possible or even skip instructions on a form [37]. These factors may explain why FXI made significantly more errors and taps, took much longer, and completed the tasks at much lower rates than LIT users.

5.3 Digital Literacy Competences

HCI researchers commonly rely on usability models to guide investigations in studying user performance. However, we used the DLGF for our design to combine usability and digital skills perspectives. Our second research objective was to show the digital skills required to complete essential mobile banking and shopping applications tasks. We discovered that the Communication and Collaboration digital competence area was the only one where tasks were not difficult for FXI users, likely because of their familiarity with social networking, which relies heavily on that area. Interestingly, a Google Scholar search of HCI and usability studies referencing the DLGF [11] revealed that it had not been adopted in these fields, making our research a novel contribution.

Mapping out various usability tasks given to users across the DLGF can inform us more about users' capacities and needs, which presents an excellent opportunity for HCI research. The framework also provides structure by serving as design themes where specific digital competence areas can be researched and evaluated through usability tasks. However, there are challenges in using the DLGF for usability research because some tasks may require multiple digital competency areas (as shown here https://doi.org/10.17036/researchdata.aston.ac.uk.00000608), and some UIs may have varying levels of complexity and cognitive demand. This poses difficulties in pinpointing specific difficulty areas [11]. Complexity has serious implications for FXI participants as tasks requiring higher cognitive processing and working memory are challenging [5, 31]. Furthermore, some complex tasks may be easy for FXI users (e.g., B2 -purchasing airtime). This could indicate that some UI patterns are easier for FXI users, and familiarity with certain processes may make some tasks easy.

To address these challenges, we suggest combining the analysis of task models with users' familiar knowledge (e.g., through the think-aloud protocol) to narrow down specific challenging digital skills and identify whether certain UI patterns contribute to or aggravate the challenges for users. This approach presents a holistic view of HCI research beyond usability, encompassing users and artefacts from all angles.

5.4 User Experience (UX).

Our study evaluated the quality of UX provided by mobile banking and shopping applications for Nigerian FXI users. We found that both applications were rated as bad in predictability and novelty and were among the worst 25% of results based on the benchmark. However, UX aspects critical to an app's nature and goal vary [35]. For instance, efficiency and understandability are relatively more critical for banking applications, whereas enjoyability and exciting elements are equally crucial for shopping applications.

Based on considering critical UX aspects, the banking app was rated below average in terms of understandability and efficiency. In contrast, the shopping app was rated above average in understandability but bad in efficiency. Therefore, our findings suggest that mobile banking and shopping applications do not meet the quality expectations of FXI users in terms of predictability, novelty, understandability, and efficiency, which may contribute to the frustration, dissatisfaction, and abandonment of the applications.

Interestingly, FXIs perceived themselves as more successful in completing tasks than they were, possibly due to difficulties in recognising the correctness of their actions or anxiety about admitting difficulties [37]. This finding was added as a novel error measure (see section 3.3.1).

6 CONCLUSION

This work contributes to an emerging discussion about designing UIs that are inclusive and accessible to all users, which can be helpful for policymakers, designers and developers looking to improve the user experience of their products and create more inclusive and accessible digital products. By evaluating the UX and challenges of FXI users in mobile banking and shopping applications, the research provides insights into the strengths and weaknesses

of current products. Overall, our findings suggest that usability difficulties among FXI users may be influenced by their literacy and cognitive challenges, task complexity, limited experience with applications and differences in UI design attributes. Our findings also show that the current mobile banking and shopping applications provide a below-average UX compared to currently established benchmarks.

Our study has some limitations that need to be acknowledged. It was conducted in a single location with a relatively small sample size of the comparison group of literates. We note that our aim was not to conduct a direct comparison, but to show whether the mobile applications were usable to other users. In future studies, we will (a) explore the reasons for challenges in FXI users' performance, focusing on users' familiar knowledge, UI design patterns and task complexity, (b) investigate what specific aspects of the DLGF and tasks assigned are challenging for FXI, (c) design and evaluate a custom UI that aims to improve the challenges faced in this study, (d) develop guidelines for designing for FXI.

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