

The Digital Democracy Paradox: When Usability and Literacy Barriers Undermine Inclusive E-Government

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Abstract

Bangladesh's expansion of online public services has improved access on paper, yet literacy barriers, fragile infrastructure, and inconsistent design continue to exclude many citizens. Through a convergent mixed-methods study, 293 survey responses, 28 administrator and mediator interviews, and heuristic evaluation, we show how digital literacy strongly predicts task success and autonomy, while qualitative accounts reveal how irreversibility, payment failures, and mistrust drive users toward informal mediators. These dynamics produce a *Digital Democracy Paradox*: systems justified as efficient and publicly framed as accessible can, in practice, deepen exclusion. We contribute: (1) the Literacy-Adaptive Usability Framework (LAUF), which treats literacy as a dynamic design parameter and integrates adaptation, mediation, and infrastructural resilience; (2) Civix UI, a lightweight illustrative prototype demonstrating bilingual, low-bandwidth, literacy-sensitive components; and (3) a mediator-inclusive design model that formalizes assisted use through accountable, gender-inclusive support. Together, these offer a pathway toward more equitable and trustworthy digital public services.

*These authors contributed equally to this research.

CCS Concepts

• **Human-centered computing** → Empirical studies in HCI;
• **Applied computing** → E-government; • **Social and professional topics** → Digital divide.

Keywords

E-Government Usability, Accessibility, Digital Literacy, User-Centered Design, Digital Inclusion, Heuristic Evaluation

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1 Introduction

Over the past decade, governments worldwide have increasingly adopted digital platforms to deliver essential services, promising efficiency, transparency, and convenience [44]. In the Global South, these initiatives are often justified in policy documents as instruments of modernization and administrative efficiency, speeding up transactions, reducing queues, and cutting costs, while public rhetoric also frames them as pathways to more transparent and accessible services. Bangladesh's "Digital Bangladesh" initiative represents one of the most ambitious pushes toward e-governance in South Asia [58], offering services such as the e-Passport application system [22], the Bangladesh Road Transport Authority (BRTA) portal [6], the National Identity (NID) platform [43], and the Bangladesh Railway eSheba [5].



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Yet the success of these systems hinges on their usability for all citizens, regardless of digital literacy. For users with limited ability to navigate interfaces, interpret system feedback, or understand security requirements, the promise of e-government often remains out of reach [44]. Prior research underscores recurring challenges: marginalized groups with low literacy face amplified errors and anxiety; inclusive design strategies like text-free or adaptive interfaces remain unevenly applied; and access is frequently mediated through helpers or telecenters, creating both support and risks of dependency. Bangladesh-specific studies further reveal systemic shortcomings, language mixing, fragile servers, and inconsistent standards that compound these barriers. Together, this body of work highlights both the universality of literacy-related usability challenges and the urgency of context-sensitive solutions.

We use the term *Digital Democracy Paradox* to describe how, from the citizen's perspective, systems that are publicly promoted as expanding access and transparency can end up excluding those with the least digital resources. In practice, many e-governance initiatives are primarily driven by goals of bureaucratic efficiency and cost reduction, but their rollout is often accompanied by promises of inclusion and empowerment. When usability and trust are not treated as core design concerns, digitalization can reproduce or even amplify existing divides instead of reducing them. This problem is particularly acute in Bangladesh, where over 30% of the population has low or emerging digital literacy, and infrastructural fragility compounds the difficulties of interacting with government portals [67].

Existing HCI research on e-government in low and middle-income countries (LMICs) has predominantly focused on diagnosing usability issues like slow server performance, unclear navigation, poor mobile optimization, and inadequate error handling [26, 38, 58]. While this diagnostic work is crucial, there remains a gap in *literacy-aware evaluation*: systematically linking concrete usability breakdowns to measured digital literacy profiles, and then to context-aware, technically feasible design and policy responses.

Motivated by this gap, our study is guided by two research questions:

RQ1: How do usability breakdowns on key Bangladeshi e-government platforms differentially affect users with varying levels of digital literacy?

RQ2: How can these literacy-linked breakdowns inform the design of interfaces, workflows, and intermediary support that are realistically implementable within existing institutional and infrastructural constraints?

Our work responds directly to this gap. Drawing on a convergent mixed-method study involving 293 user surveys, 28 interviews with administrators and mediators, and heuristic evaluation of four major Bangladeshi e-government portals, E-Passport, BRTA, NID, and Railway eSheba, we go beyond problem description by integrating insights across these streams during analysis [13]. We link each identified barrier to a digital literacy profile and use this linkage to design and prioritize deployable solutions: literacy-adaptive user interfaces, progressive form disclosure, mediator-integrated workflows, and low-bandwidth, offline-capable booking systems.

For low-literacy users, usability challenges are often multiplicative: a poorly labeled navigation link is not just an inconvenience; it

may halt the task entirely [27]. Conversely, for advanced users, the same interface flaw may only cause minor delays. Understanding these divergent impacts is critical for designing equitable systems. By explicitly mapping usability issues to digital literacy tiers, beginner, intermediate, and advanced, we identify which interventions offer the highest inclusion impact for the most disadvantaged groups. This paper makes three key contributions to the HCI and e-government literature:

1. A Literacy-Adaptive Usability Framework (LAUF) that connects digital literacy assessment with interface adaptation and service workflow redesign, extending prior literacy-aware design frameworks by explicitly linking measured competency levels to concrete breakdowns in e-government tasks.
2. A set of context-specific, technically implementable design interventions for e-government portals in LMIC settings, embodied in CiviX UI, a prototyped government component library, that demonstrate the feasibility of literacy-adaptive principles through localized, bilingual, and low-bandwidth-ready interface components.
3. A mediator-inclusive design model that formalizes the role of informal service intermediaries while reducing dependency through guided, secure, and auditable co-use features, building on but going beyond existing telecenter and Union Digital Center models.

By centering solutions that are both technically realistic and socio-culturally grounded, this research offers actionable guidance for governments, designers, and policymakers seeking to close the usability gap for low-literacy populations, not only in Bangladesh but also in other regions where e-government initiatives are shaped by similar tensions between efficiency, rhetoric, and inclusion.

2 Related Work

Digital inclusion, literacy, and mediated use have long been central concerns in HCI and HCI4D research. Prior work spans four major strands: usability barriers for marginalized users, inclusive interface design, mediator-supported interaction models, and literacy-aware evaluation frameworks, all of which inform our investigation of e-government accessibility in Bangladesh. This section synthesizes these bodies of work to situate our study within broader debates on capability, infrastructure, and equitable service access.

2.1 Digital Literacy and Usability Challenges for Marginalized Users

Marginalized groups, including older adults, rural residents, and citizens with limited education, face persistent digital literacy barriers that constrain their ability to use digital services effectively [8, 20, 68]. Digital literacy here refers to practical competence and confidence in performing everyday digital tasks. Older adults frequently report anxiety, limited control, and low confidence, which, combined with ergonomic and comprehension issues, reduce adoption and increase error risk in high-stakes domains like finance and e-government. In such cases, perceived usefulness and self-efficacy shape willingness to adopt as much as access or device availability.

In the Global South, literacy challenges intersect with structural inequalities. In India, for instance, roughly 43% of adults were classified as illiterate as of 2000 [54]. HCI4D research shows that low-literate users can struggle even with text-free interfaces because conventional UIs assume abstract problem-solving and hierarchical navigation skills that are typically taught through formal education [37]. These skill assumptions are embedded in many menu-driven designs.

Recent work situates these barriers in contemporary service ecosystems. Rayed et al. designed mobile financial services for low-literate, marginalized communities in Bangladesh, demonstrating how simplified flows and multimodal cues (icons, stepwise guidance) are crucial in practice [61]. Barbareschi et al. showed how inclusive “making” practices build confidence and digital literacy among older adults, emphasizing hands-on learning and low-barrier entry points [8]. Complementarily, work on self-efficacy among formerly incarcerated people shows that structured, scaffolded digital-skills interventions can measurably increase confidence and task success for marginalized learners [48]. Together, these studies argue that usability barriers co-evolve with social context, and effective interventions must target both interface and learner confidence.

Bangladesh mirrors these global patterns while adding distinct stressors. Rural and low-income households, especially women, report lower digital literacy; affordability, bilingual text (Bangla–English), and infrastructure fragility (e.g., OTP delays, server errors, payment reconciliation) compound the difficulty of completing multi-step tasks [26, 28, 67]. From the perspective of Digital Design Marginalization (DDM), such breakdowns are not incidental: non-inclusive designs can reinforce inequality and dependency beyond the screen [9, 57, 70]. This framing motivates literacy-aware, workflow-aware, and infrastructure-aware design for public services in Bangladesh.

2.2 Inclusive and Adaptive Interface Design for Novice and Low-Literacy Users

A large body of HCI and HCI4D scholarship proposes design strategies that reduce textual dependence and adapt to user capability. Early interventions demonstrated the value of numeric representations and icons where users understood numbers better than text [54]; controlled studies showed that illiterate participants failed with text-heavy UIs yet succeeded when tasks were re-expressed using pictorial/voice cues and linear flows [19, 38, 39]. Subsequent work validated that “text-free” and multimodal interfaces outperform text-centric ones across low-literacy contexts [25, 72]. Voice-based and IVR designs have repeatedly proven effective in agriculture and health when reading is a barrier [1, 12, 14, 17, 40].

Designing for novices also benefits from adaptive scaffolding: progressive disclosure, training-wheels modes, and tightly constrained choices that gradually reveal complexity as users gain competence [29]. These patterns are found in civic and public-service contexts. “Civic Quality of Life” design research details service-interaction patterns that help residents navigate complex socio-technical systems [16]. Studies of accessible web design in the Global South highlight how cultural design preferences, localization, and accessibility standards need to be reconciled to actually reduce cognitive load [49]. More broadly, reviews of sustainability

and development in HCI show recurring gaps between formal accessibility compliance and lived usability for marginalized users, calling for situated, context-sensitive adaptation rather than checklist conformance [69].

Despite this evidence, Bangladeshi e-government portals frequently exhibit WCAG (Web Content Accessibility Guidelines) violations, inconsistent labels, and low mobile readiness, each amplifying cognitive burden for novice users [4, 7, 18, 28, 30, 57]. Our implications, therefore, draw on proven global strategies (multimodality, linear task scaffolds, clear feedback) but tailor them to Bangladesh’s bilingual semantics, bureaucratic vocabulary, and network/payment fragility.

2.3 Mediator-Supported Interaction Models

Beyond direct use, intermediated interaction, where a more skilled person helps a less skilled user, pervades low-resource settings. Classic HCI4D work enumerates patterns like proximate enabling, proximate translation, and surrogate usage, showing how mediators bridge gaps in literacy, language, and device access [65]. Recent work in Bangladesh further shows that intermediaries shape not only access but also the infrastructuring of digital services themselves, as Prottoy et al. document how account-sharing and informal practices emerge as essential access strategies within constrained subscription ecosystems [56].

Further studies continue to identify multi-user dynamics across domains. For example, research on contraceptive decision-making in low-resource health settings explicitly theorizes intermediated interaction as coordinated, cooperative work between intermediaries and clients [52]. Community-based digital-skills programs in public housing demonstrate that training local “peer-helpers” can improve uptake and confidence at scale, institutionalizing mediation as a resource rather than a workaround [33]. In agriculture, “KishiPustak” documented how farmers and mediators co-produced content and assistance through an audio-visual social system, formalizing shared use and learning [40]. Complementing these findings, Rohanifar et al. show that intermediaries in Bangladesh’s mobile-financial ecosystem navigate re-skilling, informal expertise, and socio-political pressures, highlighting how mediation work is shaped by broader institutional and security concerns [63].

In e-government, many Global South contexts have long relied on telecenters or kiosk operators as human gateways to digital services [21, 60]. Bangladesh institutionalizes this via Union Digital Centers and widespread informal service shops. Beyond formal centers, Rahman et al.’s *Dakter Bari* project demonstrates how hyper-local intermediaries such as grocery shops and pharmacies can act as trusted access points for life-critical services, reinforcing the centrality of mediated interaction in Bangladeshi service ecosystems [59]. Yet current portals rarely include features that acknowledge multi-user realities; e.g., co-browsing, shared task views, or auditable “assistance” actions that protect privacy while enabling help [24, 57, 74]. Paying attention to mediation is not merely descriptive; it is a design requirement for inclusive public services. Related work on global HCI cautions that user appropriation and shared practices reshape technologies in ways that designers must anticipate, especially in resource-constrained settings [42]. Moreover, infrastructural fragility (e.g., disconnection) can

systematically force mediated, supervised, or shared use, further underscoring why “assisted modes” should be first-class features rather than ad hoc fixes [50, 65, 71].

2.4 Literacy-Aware Design Frameworks and Evaluation Methods

Design frameworks increasingly treat literacy as a primary usability dimension. Nielsen’s guidance for lower-literacy users emphasizes plain language, linear layouts, and reduced distractions to accommodate narrower visual focus and word-by-word reading patterns [46]. Usability protocols have been adapted for non-literate participants through story-based (“Bollywood”) tasks and explicit measurement of literacy/cognitive skills; such measurements predict success with hierarchical UIs and clarify which breakdowns are literacy-driven versus infrastructural [37, 39].

Contemporary work extends these methodological insights to civic technologies. Parnaby et al. argue that digital inclusion practice must move “beyond bridging divides,” scrutinizing institutional goals and accountability in post-digital societies, an important lens for e-government portals that externalize learning costs to users or mediators [55]. Studies in digital civics operationalize user-centred service design patterns and evaluation approaches that prioritize legibility, reversibility, and trust for non-expert publics [16]. Work on AI and data-intensive public services in the Global South highlights how procedural opacity and institutional constraints interact with usability, complicating equitable access even when interfaces are “compliant” [31]. Relatedly, literacy-building initiatives increasingly target older adults’ AI literacy and ethics awareness, aligning pedagogical scaffolds with accessible interaction [75].

In Bangladesh, evaluations often remain compliance-centric: studies report WCAG violations or heuristic mismatches without stratifying outcomes by literacy level or incorporating low-literacy protocols in testing [7, 18, 28, 30]. Our study, therefore, complements prior audits by explicitly linking literacy levels to task success, error recovery, and mediator dependence. This literacy-aware evaluation clarifies which issues stem from content/interaction complexity, which from infrastructural fragility (e.g., payment reconciliation, OTP delays), and which from institutional rules (e.g., irreversible submissions, limited rescheduling).

Across HCI and HCI4D, the literature converges on four leverage points for inclusive e-government: (1) multimodal, low-text interfaces with linear task scaffolds; (2) adaptive pathways that sequence complexity; (3) explicit support for mediated and shared use; and (4) literacy-aware evaluation and institutional accountability. Bangladesh’s bilingual semantics, infrastructural instability, and mediator-driven usage make these points especially salient. Our work grounds this global evidence in the Bangladeshi context, quantifying literacy-segmented outcomes and translating findings into implementable, literacy-adaptive patterns for public service portals.

3 Methodology

This study adopted a **convergent mixed-methods design** that combined large-scale surveys, task-based digital literacy assessments, heuristic evaluations of four government service portals, and qualitative interviews with mediators and administrators

[2, 47, 53, 64]. Survey data, interviews, and heuristic evaluations were collected in parallel rather than sequentially. This design was appropriate because usability breakdowns, literacy-linked task failures, and infrastructural issues manifest differently across users, mediators, administrators, and expert evaluations, making parallel data streams suitable for triangulation.

This multi-layered approach enriched the study, as combining quantitative and qualitative methods provided a more comprehensive understanding of e-government usability in Bangladesh. The survey data captured measurable patterns of literacy and usage, while open-ended responses highlighted the everyday frustrations experienced by citizens. Interviews with key stakeholders further revealed structural and organizational perspectives. Each method contributed differently to our research questions (RQ1 and RQ2): surveys surfaced literacy-linked usability breakdowns (RQ1), while interviews and heuristic evaluations informed design and workflow implications (RQ2). A graphical summary of our workflow is presented in Figure 1.

3.1 Participants and Recruitment

The quantitative component of the study involved 293 survey participants, representing a diverse cross-section of Bangladeshi citizens. Participants were recruited through purposive and snowball sampling, with care taken to include both urban and rural populations. To avoid over-representation of digitally confident youth, recruitment extended beyond university networks to rural community groups. The survey itself was administered through a Google Form, which allowed participants with internet access to complete it independently. For those who could not operate the form independently due to limited digital skills, the researchers personally assisted them in filling it out, ensuring that their perspectives were also included. As a result, the final sample illustrated in Table 1, reflected meaningful variation in age, gender, education, and socioeconomic background, enabling the analysis to capture the range of challenges faced by different demographic groups. Although the recruitment strategy reached beyond university networks, the final sample still contained a higher proportion of digitally confident participants. This reflects the reality that individuals with very low literacy rarely attempt e-government tasks independently and typically rely on mediators. We therefore compensated for this imbalance through mediator interviews, which served as a proxy for the experiences of low-literacy users.

In addition to the survey, we conducted 28 semi-structured interviews with mediators and administrators. Across the 28 interviews, we spoke with a total of 9 administrators and 19 mediators. Their distribution across platforms was as follows: BRTA (5 administrators, 14 mediators), Passport (3 administrators, 4 mediators), and NID (1 administrator, 1 mediator). Consistent with public service practices in Bangladesh, no dedicated administrators or mediators were available for the Railway eSheba system. Unlike the other portals in this study, the Railway ticketing platform is operated by a private vendor rather than directly by a government office, which made it difficult to secure an interview with a relevant system administrator. Furthermore, Railway services do not have an informal mediator ecosystem comparable to BRTA or Passport offices; users typically rely on family members, friends, or neighbors

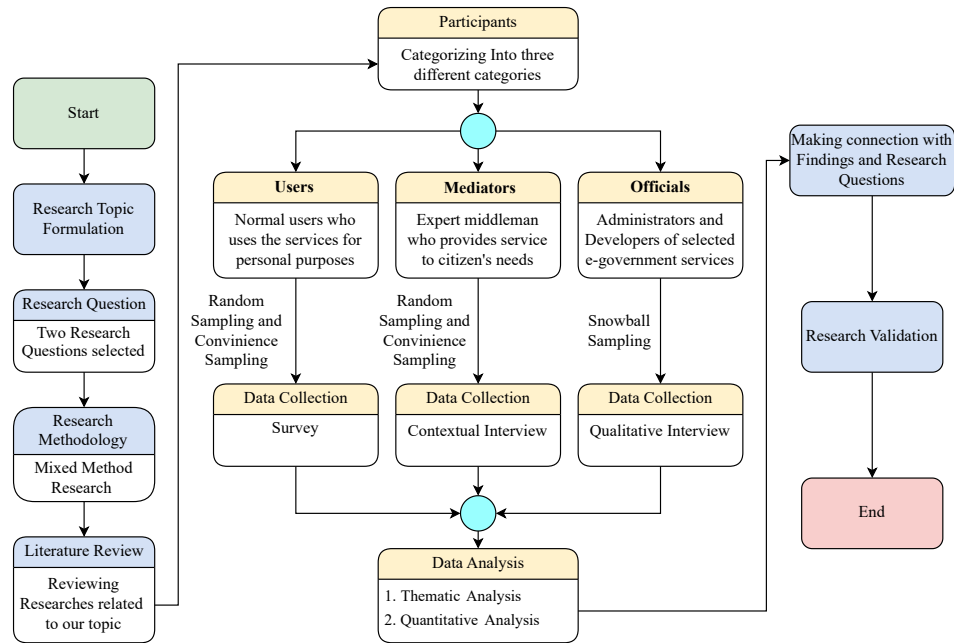


Figure 1: Workflow diagram showing parallel data collection from three participant groups and subsequent integrated analysis

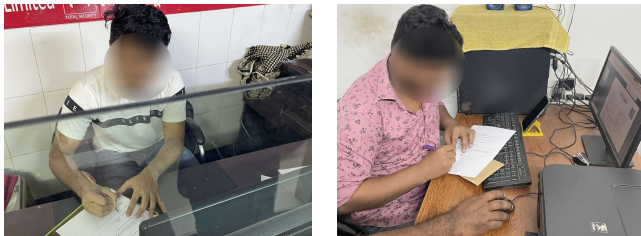


Figure 2: The left picture is of a tech support center beside BRTA in Mirpur-13 while providing service to the users. The right picture features a computer service shop in Agargaon, outside Passport Office.

for assistance rather than commercial service shops. As a result, the Railway eSheba platform is represented in our data through user survey responses and heuristic evaluations, but not through administrator or mediator interviews.

We conducted two types of interviews: contextual interviews with mediators in their work environments (e.g., service shops near BRTA or passport offices), and semi-structured stakeholder interviews with administrators in institutional settings. These formats differed in both setting and purpose, with mediators providing situated accounts of user struggles and administrators offering system-level perspectives. Mediators were selected because they play an indispensable role in assisting citizens, particularly those with limited digital literacy, in navigating government portals. As illustrated in Figure 2, these mediators were typically located near

government offices such as the passport office, BRTA office, and local NID offices, where citizens routinely seek informal assistance.

Administrators were included in the study because their perspectives illuminate how technical design choices and policy constraints shape the usability of these systems. Access to administrators was secured primarily through the researchers' networks. We interviewed officials from the Passport, BRTA, and NID systems; we were unable to include an administrator from the Railway service. All participants gave informed consent, and ethical approval was secured from our institution's review board. Anonymity was maintained throughout the study, with interviewees identified only by their role (e.g., "Mediator 3, e-Passport" or "Administrator, BRTA"). Special care was taken with the task-based literacy assessment. Participants were reminded that the evaluation was of the systems' usability, not their competence, to minimize anxiety and avoid reinforcing feelings of inadequacy. This framing proved crucial in building trust and ensuring authentic performance in the tasks.

3.2 Survey Design, Implementation, and Task-Based Literacy Assessment

The survey was designed to capture both quantitative measures and qualitative experiences, while also embedding a task-based digital literacy assessment. Closed-ended items gathered information on demographics, frequency of platform use, satisfaction levels, mediator dependency, and perceptions of security and trust. Alongside these, carefully crafted open-ended questions invited respondents to describe their difficulties in their own words. For example, respondents were asked: "Describe a recent difficulty you faced while using any government website. What changes would you like the

Table 1: Demographic characteristics of survey respondents (N=293)

Characteristic	Category	Count	PCT. %
Age	18-24	124	42.3
	25-34	77	26.3
	35-44	34	11.6
	45-54	27	9.2
	55+	31	10.6
Gender	Male	194	66.2
	Female	97	33.1
	Prefer not to say	2	0.7
Education Level	Below High School	6	2.0
	High School/SSC	19	6.5
	College/HSC	78	26.6
	Diploma	13	4.4
	Bachelor's Degree	118	40.3
	Master's Degree	58	19.8
Digital Literacy	PhD Degree	1	0.3
	Beginner	68	23.2
	Intermediate	74	25.3
	Advanced	151	51.5
Daily Internet Usage	More than 5 hours	152	51.9
	3-5 hours	66	22.5
	1-3 hours	61	20.8
	Less than 1 hour	14	4.87
Total		293	100.0

government to implement to make this easier?” These responses became an invaluable qualitative dataset, enabling citizens’ perspectives to be integrated without requiring direct interviews. Such accounts enriched the statistical patterns, grounding them in the lived realities of everyday struggles.

A critical component of our quantitative analysis involved converting participants’ self-reported and task-based skill assessments into reliable numerical digital literacy scores. This was necessary because self-assessed literacy levels are often shaped by subjective bias and overconfidence effects, which can distort actual competence. To address this, we implemented a performance-based competency scoring system, aligning with best practices in digital literacy research where demonstrated task performance provides a more robust measure of ability than perception alone. In our survey, this meant mapping participants’ ability to perform representative e-government tasks to weighted scores based on their cognitive complexity, a process summarized in Table 2.

Our scoring methodology was grounded in two internationally recognized academic frameworks: the European Digital Competence Framework (DigComp 2.2) and the OECD’s (Organization for Economic Co-operation and Development) Programme for the International Assessment of Adult Competencies (PIAAC) [51, 77]. These frameworks provide hierarchical skill classifications based on both cognitive complexity and task demand levels, making them

suitable as reference points for mapping survey responses into structured scores.

In the survey, participants were presented with a list of common digital tasks associated with using government websites, such as browsing information, filling out online forms, or making online payments, and were asked to indicate which tasks they were comfortable performing independently. As shown in the Table 2, each task was assigned a weighted score proportional to its cognitive complexity. For instance, browsing websites was weighted as a basic navigation skill, while making secure online payments was classified as an advanced integrative skill involving financial and security literacy. Table 2 presents the scoring rubric; the literacy categories shown in Table 1 reflect these computed scores rather than self-reported ability.

This weighted scoring system is consistent with applications of cognitive load theory in digital literacy assessment, where task complexity corresponds to the number of distinct cognitive elements a user must process simultaneously [11]. By summing the total scores achieved by each participant, we were able to classify respondents into three literacy categories: Beginner, Intermediate, and Advanced. These categories became the foundation for our subsequent quantitative analyses, where we examined how literacy levels correlated with platform satisfaction, mediator dependency, and independent service completion.

3.3 Heuristic Evaluation of Platforms

To complement user-generated data, we carried out a **heuristic evaluation** of the four main e-government portals: e-Passport, BRTA services, National ID, and Bangladesh Railway eSheba. The evaluation framework was based on Nielsen’s usability heuristics [45], adapted to reflect the realities of Bangladeshi users. Four researchers independently performed typical service tasks, such as applying for a passport or renewing a driving license, while documenting issues related to navigation, error prevention and recovery, information clarity, form complexity, server responsiveness, and visible security features. These findings were consolidated into a comparative evaluation matrix.

The heuristic evaluation frequently corroborated survey complaints and mediator testimonies. For instance, our evaluators noted that the e-Passport portal lacked mechanisms to edit or cancel submissions once made, which directly aligned with mediators’ frustration that “once information is submitted, there is no way to correct it except by canceling and starting over”. Although conducted independently, heuristic evaluation findings were later triangulated with survey complaints and interview narratives during integrated analysis.

3.4 Data Analysis

The data collected through interviews, surveys, heuristic evaluations, and expert consultations underwent rigorous analysis to ensure **reliability, validity, and methodological transparency**. Given the mixed-methods design of this study, we employed both qualitative and quantitative analytical strategies, followed by an integration phase where findings were compared, contrasted, and combined.

Table 2: Digital literacy score conversion methodology and demographic distribution of survey participants

Digital Competency	Assigned Weight	Academic Framework Justification	Cognitive Complexity Rationale
Browsing websites and searching for information online	1 point	DigComp Level 1–2 (Foundation) PIAAC Level 1 (241–290 points)	Basic navigation requiring minimal cognitive load and simple recognition tasks
Sending and reading emails	2 points	DigComp Level 2–3 (Foundation/Intermediate) PIAAC Level 1–2 (241–340 points)	Communication competency requires interface understanding and message composition
Filling out online forms	3 points	DigComp Level 3–4 (Intermediate) PIAAC Level 2 (291–340 points)	Multi-step processes requiring data validation and form logic comprehension
Downloading files from the internet	4 points	DigComp Level 3–4 (Intermediate+) PIAAC Level 2–3 (291–400 points)	Technical operations requiring file system knowledge and security awareness
Installing and using mobile or computer applications	4 points	DigComp Level 4–5 (Advanced Intermediate) PIAAC Level 3 (341–500 points)	Advanced technical knowledge requiring system understanding and troubleshooting
Using online payment systems	5 points	DigComp Level 5–6 (Advanced) PIAAC Level 3+ (341–500+ points)	Complex integration requiring security literacy, financial understanding, and multi-platform coordination

3.4.1 Qualitative Analysis. All mediator and administrator interviews were transcribed, translated into English where necessary for manual coding. In parallel, the open-ended survey responses were treated as qualitative mini-interviews and included in the same analysis corpus. We applied a manual thematic analysis approach, following Braun and Clarke’s six-phase model [10]. The first stage involved familiarization, where three researchers independently read through transcripts and responses, noting recurring phrases and contextual patterns. In the coding stage, descriptive codes such as “navigation confusion,” “payment failure,” “server unreliability,” and “fear of mistakes” were assigned. These codes were then clustered into broader themes, including navigation and information architecture, error handling and recovery, server and performance reliability, document and form complexity, and security and trust concerns. While the resulting themes aligned closely with established usability categories (e.g., navigation, error handling, server reliability), they were generated inductively from the data rather than imposed in advance. Illustrative quotes were then selected to exemplify each theme, ensuring that the voices of mediators, administrators, and citizens were represented in the Findings section.

3.4.2 Quantitative Analysis. The quantitative analysis was conducted on survey responses from 293 participants who met the inclusion criteria. The dataset was first cleaned and standardized: text entries in Bangla were translated into English, categorical responses were harmonized, and incomplete entries were removed. Missing values were minimal (<3%) and were handled using case-wise deletion to maintain the integrity of the analysis. All statistical analysis was carried out in Python (using libraries such as pandas, numpy, scipy, and statsmodels) [23, 35, 66, 76]. The first step involved converting survey responses into numeric values. Each participant’s comfort level with a predefined set of digital tasks (e.g., browsing, sending emails, form completion, file handling, installing

apps, online payments) was assigned a weighted score, proportional to the cognitive complexity of the task. This process generated a Digital Literacy Score for each participant, which was then categorized into three levels: Beginner, Intermediate, and Advanced. The primary dependent variables in our quantitative analyses were (1) mediator dependency, (2) satisfaction with platform usability, (3) perceptions of security and trust, and (4) ability to complete services independently. The analysis was not pre-registered; however, the statistical procedures were selected based on data distributions and theoretical alignment with digital literacy research.

Statistical Framework

Before running hypothesis tests, we conducted normality checks using the Shapiro–Wilk test [62], which confirmed that the literacy and dependency variables were non-normally distributed. Consequently, non-parametric tests were applied:

- **Kruskal–Wallis H Test** → compared mediator dependency across literacy groups ($H = 57.855, p < .001$) [34].
- **Mann–Whitney U Test** → conducted as a post-hoc analysis, confirming that lower-literacy participants were significantly more dependent on mediators compared to intermediate and advanced groups [36].
- **Spearman Correlation** → revealed strong positive correlations between literacy and both satisfaction and trust ($\rho > 0.4, p < .01$) [3].
- **Logistic Regression** → demonstrated that higher literacy substantially increased the odds of completing services independently ($OR > 2.5, p < .01$) [15].

Effect sizes were calculated (η^2 for Kruskal–Wallis, r for Mann–Whitney) to assess the magnitude of observed differences, ensuring that results were not only statistically significant but also practically meaningful.

3.4.3 Integrated Analysis. The final stage involved triangulation of quantitative and qualitative findings. For example, statistical analysis revealed that form-filling was disproportionately difficult for beginners, while open-ended responses explained why (“the system asks for documents in PDF, but I only know how to take pictures”). Similarly, logistic regression showed literacy predicted independent usage, while mediator interviews revealed the psychological barriers that reinforced dependency. By systematically weaving together these strands, the analysis moved beyond surface-level description to reveal the structural interplay of literacy, usability, and institutional trust. This mixed-methods integration ensured that quantitative breadth and qualitative depth informed one another, yielding a holistic account of the problem space.

3.5 Prototype Development

To illustrate the feasibility of the proposed interventions, we developed *Civix UI*, a lightweight component library built with React and TailwindCSS [41, 73]. The prototype demonstrated literacy-sensitive design elements (e.g., simplified forms, bilingual toggling, error-prevention defaults) and was validated through heuristic evaluation and expert consultations with senior UI/UX professionals and software engineers. This served as a formative step toward our design recommendations rather than a fully deployed system.

4 Findings

Our findings reveal that usability challenges on Bangladeshi e-government websites are strongly conditioned by citizens’ levels of digital literacy. While quantitative survey results identify systematic disparities in satisfaction, completion, and reliance on mediators, open-ended responses and interviews with mediators and administrators illuminate why these patterns occur. This section presents the findings thematically, organized around five major domains: Navigation and Information Architecture, Error Handling and Feedback Systems, Server and Performance Issues, Document and Form Complexity, and Security and Trust Deficits. A cross-cutting synthesis highlights how literacy operates as the key predictor across all domains.

These domains were not pre-specified checklists but the result of an iterative thematic analysis of interview transcripts and open-ended survey responses. We began with inductive open coding, then grouped recurring patterns (for example, “getting lost in menus,” “not understanding error codes,” or “asking mediators to upload files”) into higher-order themes. In a final step, we mapped these emergent themes onto four cross-cutting usability domains: navigation, feedback, reliability, and form/document complexity plus a fifth domain foregrounding security and trust. In the subsections that follow, we interweave quantitative survey trends, qualitative accounts, and heuristic violations to show how digital literacy shapes citizens’ experiences within each domain.

4.1 Navigation and Information Architecture

Navigation and information architecture emerged as one of the most persistent barriers in e-government platforms. Survey data showed beginners consistently struggled at this first step: nearly two-thirds failed at least once to locate the correct service, compared with just 12% of advanced users. This was most pronounced

in the BRTA and e-Passport portals, which relied on dense menus and bureaucratic labels. In contrast, the Railway eSheba site, with a simpler, task-focused interface, reported far fewer failures. Participants frequently described these struggles. For example:

“The BRTA website should introduce a dedicated help section for editing information and establish an active call center for assistance.” - P79

Mediators confirmed that confusion over service location was the most common reason clients sought help, often after repeated failed attempts:

“The clients do not understand the instructions clearly... those who do understand, they don’t come to us.” - M2

Administrators, however, often framed these failures as user shortcomings, arguing that citizens simply did not read carefully. This revealed a disconnect: what officials viewed as logical appeared hazy to users. The heuristic evaluation reinforced this divide. Simulating a passport application required navigating three menu layers before reaching the form, with no breadcrumbs, progress indicators, or alignment with the language citizens used. These issues reflected a violation of the heuristic principle of “match between system and the real world,” as sites mirrored bureaucratic categories rather than user needs.

Overall, poor navigation design acted as a gatekeeping mechanism. For advanced users, obstacles were frustrating but manageable. For beginners, they were often insurmountable, pushing citizens toward mediators or abandonment. We saw this pattern consistently across methods: survey respondents most frequently reported “finding the right service” as a point of failure, mediators described navigation confusion as the dominant reason clients sought help, and heuristic walkthroughs repeatedly encountered deep, poorly signposted menu hierarchies. Together, user, mediator, and administrator perspectives highlight not only the prevalence of navigation difficulties but also a structural problem: platforms were designed around institutional hierarchies rather than the practical, task-driven pathways citizens required.

4.2 Error Handling and Feedback Systems

If navigation was the first stumbling block, error handling and feedback was the second. Across platforms, users reported that when mistakes occurred, typos, failed uploads, or rejected payments, the sites rarely provided clear recovery guidance. Instead of instructive messages, participants encountered cryptic pop-ups, silent failures, or no feedback at all. For users with limited digital literacy, these lapses reinforced helplessness and dependency on mediators.

Survey data confirmed this pattern: 54% of beginners abandoned a task at least once due to unclear errors, compared with 23% of intermediates and 8% of advanced users. Failures were most common in e-Passport and BRTA services, where form submissions and payments often broke down. Even advanced users rated error handling lowest, showing the issue was systemic. Besides, the survey data showed, as demonstrated in the Figure 3, people with a lower digital literacy level require more assistance than those with a higher one. One participant noted:

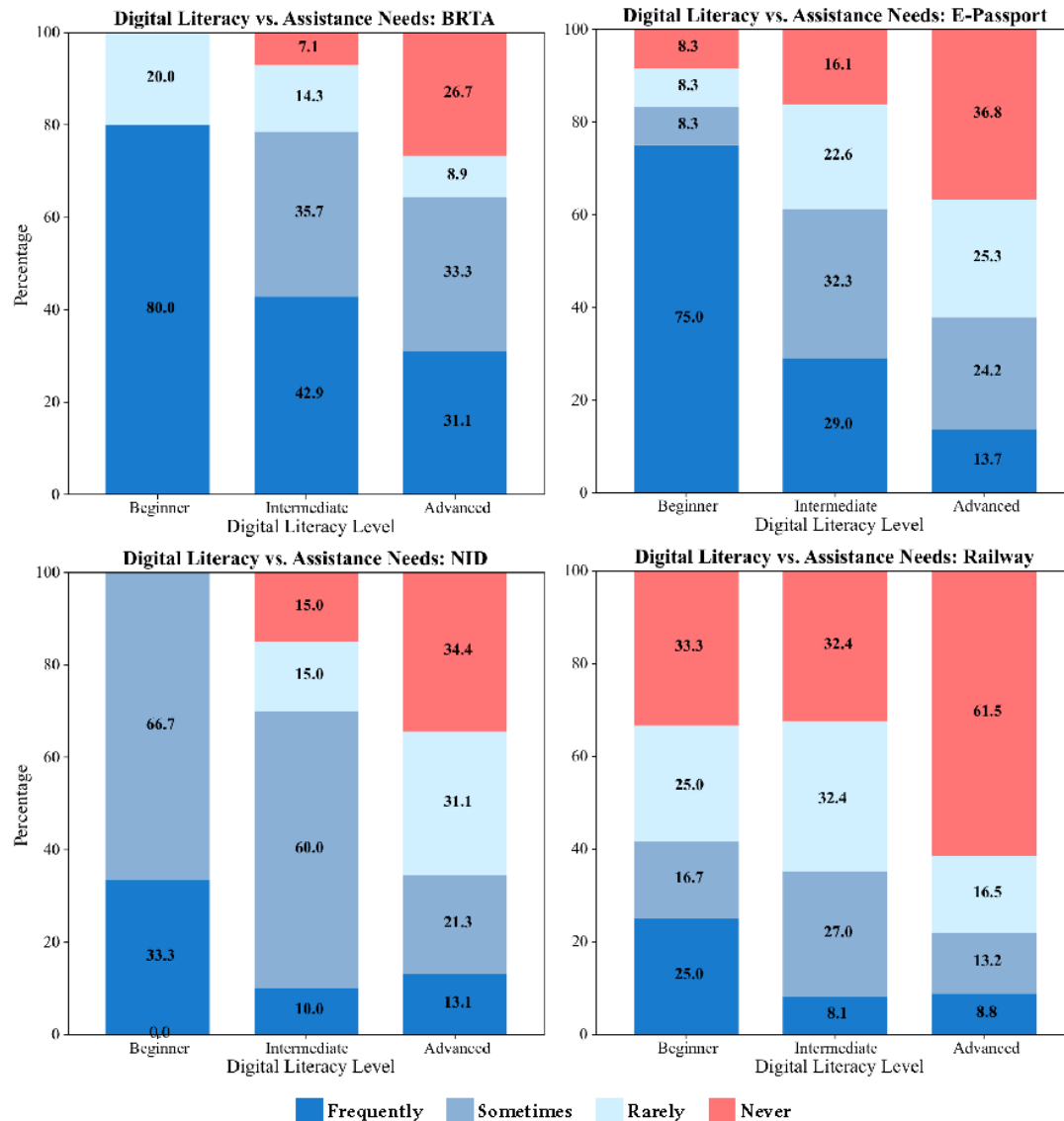


Figure 3: Assistance required by different digital literacy level users

“The passport website does not give clear instructions when something goes wrong. If a file is rejected, it only shows an error code that I don’t understand.” - P125

Another added:

“When the payment failed two times, I thought the money was gone. Later, I had to go to a shop to check.” - P183

Mediators regularly received screenshots of error codes:

“People bring me screenshots of error codes. They think the system is broken, but actually, they just need to fix a small mistake. The site never tells them that.” - M7

Administrators often reframed the problem as user negligence, claiming instructions were available. Yet many were buried in PDFs, written in bureaucratic English, or offered in one language only. Heuristic evaluation highlighted the same flaws that users and mediators described: the BRTA portal showed only “Invalid input” when a file format was wrong; the NID system failed silently if fields were left blank. The Railway eSheba did slightly better with prompts like “Enter 10-digit phone number,” but still lacked feedback during peak failures. Statistical analysis linked clarity of feedback with satisfaction and trust ($p > 0.4, p < .01$). Users who understood errors were more likely to continue independently; confusing systems drove mediator reliance. As one respondent urged:

“The NID website should make error messages clearer and show step-by-step instructions when something goes wrong.” - P158

In sum, poor error handling not only blocks tasks but also erodes trust, increases mediator dependence, and deepens exclusion for low-literate users. For officials, these may seem minor, but for citizens, they are daily reminders that systems are not designed with their needs in mind.

4.3 Server and Performance Issues

If navigation and error handling created cognitive barriers, server instability and performance bottlenecks posed equally disruptive technical obstacles. For many, unreliable systems meant incomplete transactions, wasted time, and renewed reliance on intermediaries. Whereas usability issues confused users, performance failures left them stranded. Survey results showed the scale: 47% reported delays or timeouts, and nearly 60% of low-literate users abandoned tasks after downtime, compared to 27% of advanced users. Passport and BRTA systems drew the most complaints, with one in three respondents facing repeated failures during peak demand. Railway eSheba fared better but still suffered during festival seasons. Participants highlighted the toll:

“The website often does not work at night. I tried three times to submit, but every time it showed a server error” - P77

“When the server is slow, the payment gets stuck. I was scared I lost the money” - P188

Mediators confirmed instability as a key reason clients sought help, often arriving with printed error screenshots. One mediator near Agargaon noted:

“People wait all night and still cannot submit. In the morning they come to us, and we try again until it works” - P189

Administrators tended to treat failures as inevitable, citing surges before deadlines or vendor delays in upgrading servers, shifting responsibility away from institutions, and leaving users to bear the burden. Heuristic evaluation confirmed these flaws. On BRTA and Passport portals, large file uploads caused repeated timeouts and unresponsive buttons with no feedback. Railway eSheba ticket searches lagged in high-traffic periods without progress indicators. These violated principles of “visibility of system status” and “user control and freedom,” leaving users unsure whether to refresh, restart, or abandon tasks. Statistical analysis reinforced this: satisfaction was lowest among those experiencing downtime, with a strong negative correlation between reliability and independent task completion ($\rho < -0.5, p < .01$). As one user suggested:

“The government should increase server capacity and make the website available 24 hours without interruption” - P240

In sum, server and performance failures turned routine transactions into stressful ordeals. For advanced users, they caused frustration and wasted time; for beginners, they entrenched mediator dependency and eroded trust. Reliability, therefore, is not just technical infrastructure but a core requirement of digital inclusion.

4.4 Document and Form Complexity

Beyond navigation and performance, one of the most formidable challenges was the complexity of online forms and document requirements. Filling out e-government forms often meant coping with rigid validation rules, file formats, and incomplete instructions. For users with limited digital literacy, this created heavy cognitive load, frequent task abandonment, and reliance on mediators.

Quantitative analysis further reinforced the centrality of this issue. Logistic regression showed that digital literacy significantly predicted form completion success, with advanced users being more than three times as likely to submit successfully compared with beginners (OR = 3.2, $p < .01$). Moreover, mediator reliance was strongly associated with tasks requiring file uploads or multi-step forms, suggesting that form complexity is one of the strongest drivers of third-party assistance. In Figure 4, we can see this pattern vividly: usage rates of e-government platforms change drastically with digital literacy level, as beginners struggle to engage while advanced users dominate successful adoption.

User testimonies captured the struggle: *“Uploading scanned documents is the hardest part because I don’t know how to change the file format”* (P129); *“The photo size is very confusing. It says 300 kb, but my file is always rejected”* (P183). While advanced users could resize or convert files, beginners often lacked both software and knowledge.

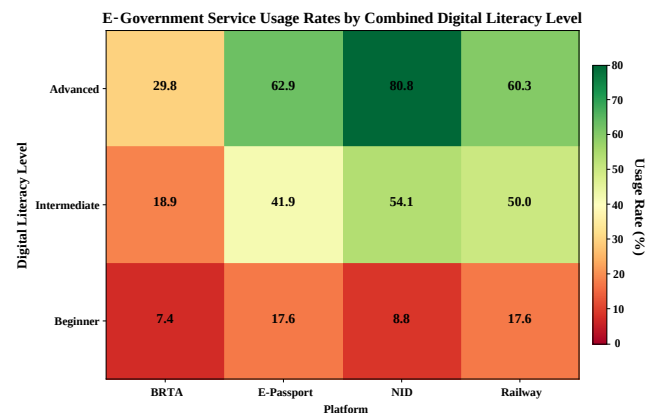


Figure 4: E-Government service usage rate heatmap by combined digital literacy level

Mediators described document handling as a major income source. One in Agargaon noted: *“Most people come here just to upload photos or documents. They don’t know how to scan, resize, or upload correctly”* (M10). Another handling NID services said clients often brought printed documents asking him to *“make them ready for upload.”* For citizens, this turned “self-service” into mediated service. Administrators defended strict requirements as safeguards for fraud prevention and machine readability. Yet, privileging precision over usability excluded large segments of users. Heuristic evaluation confirmed the rigidity: on e-Passport, slightly mis-sized photos returned only *“Invalid File”*; on NID, leaving a field blank reloaded the entire form with *“Submission Failed”*. These violated principles of error prevention and recovery, leaving users disoriented.

The psychological toll was evident. One participant urged: *“There should be a sample form or practice option, so people can learn before submitting the real one”* (P164). Another stressed: *“The form should use easier language and not so many technical terms”* (P203). These quantitative patterns align with the qualitative accounts of both users and mediators: mediator reliance was highest for tasks requiring uploads or multi-step forms, confirming form complexity as a key driver of third-party dependence. In short, document and form requirements are not minor inconveniences but systemic barriers. For advanced users, they slow progress; for beginners, they often prevent participation altogether. By embedding technical demands without adequate guidance, e-government platforms reinforce rather than reduce digital inequality.

4.5 Security and Trust Deficits

Even when users navigated forms and performance issues, one of the deepest barriers remained: fear about security. For many, digital transactions involving personal or financial data felt risky, especially when system reliability was already doubtful. This distrust was strongest among beginners and intermediates, whose literacy gaps amplified anxieties about privacy, fraud, and data misuse.

Quantitative results confirmed the trend. Among beginners, 64% reported low confidence in portal security, compared with 38% of intermediates and 15% of advanced users. Trust was lowest for online payments: 52% preferred cash alternatives. Correlation analysis showed a positive link between literacy and security confidence ($\rho = 0.45, p < .01$), highlighting skill level as central to perceptions of risk. In other words, the same users who could navigate forms and recover from errors were also those most willing to transact online, whereas low-literate users interpreted interface breakdowns as evidence that the system itself was unsafe. User testimonies captured this vividly:

“I was afraid to pay online because if the money is cut and the service fails, who will give it back?” - P198

“The NID website asks for too much personal information, but I don’t know who can see it.” - P56

Mediators confirmed this distrust, often asked to handle payments on clients’ behalf:

“People don’t trust the online payment. They give me money in hand and say, ‘you do it on your card’” - P204

While administrators framed this as a “user awareness problem,” users pointed to real failures such as transaction errors and delays. For many, insecurity was not abstract but a daily calculation of risk. As one participant concluded, *“If I cannot trust the system, then I will just go to the office like before.”*

Regression analysis showed trust in security significantly predicted independent task completion ($OR = 2.7, p < .01$): even literate users abandoned platforms if confidence was low. Heuristic evaluation confirmed the roots of distrust: outdated SSL certificates, inconsistent payment redirects, vague error messages, and missing indicators of encryption. Some safeguards, like OTP or CAPTCHA, were misinterpreted as barriers rather than protections due to poor explanation.

Equally problematic was the lack of visible reassurance. None of the portals provided clear privacy policies or data protection statements. Without transparent communication, even strong technical safeguards failed to inspire confidence. In this sense, security deficits were as much about perception as about technology. Literate users may see omissions as minor, but for beginners they amplified fear, dependence on mediators, and withdrawal from digital services. Ultimately, trust is not a marginal issue but a core determinant of adoption. Addressing it requires not only backend upgrades but also visible guarantees, clearer messaging, and support mechanisms that reassure citizens their data and money are protected.

“BSP portal is updating with time, and about 10 million people are using it for their license, and about 6 million people are using the portal for their vehicle-related information.” - A4

In summary, across all five domains navigation, error recovery, system reliability, form complexity, and security, our findings converge on a single pattern: digital literacy consistently predicts whether citizens can complete tasks independently or must rely on mediators. Qualitative discussion, survey patterns, and heuristic evaluations collectively show that these usability breakdowns are not isolated technical flaws but structurally embedded barriers that shape who can meaningfully access e-government services.

5 Discussion

The findings reveal a nuanced picture of e-government usability in Bangladesh. From the state’s perspective, many initiatives were explicitly justified as modernization and efficiency reforms, speeding up transactions, reducing queues, and cutting costs, while public-facing rhetoric promised more transparent and accessible services. Our data show how, at the level of everyday practice, this mix of efficiency-driven implementation and inclusion-oriented messaging produces what we call the *Digital Democracy Paradox*: platforms that are publicly promoted as expanding access can end up deepening exclusion for citizens with limited digital skills. Seen through a narrow efficiency lens, the under-servicing of low-literacy users is a predictable, if troubling, outcome; seen against democratic commitments to equal access, it is paradoxical for those whose needs are greatest. Connecting these findings back to digital literacy theory, infrastructural trust, and HCI4D scholarship highlights how the promise of inclusion can easily reproduce new forms of exclusion if design and governance are not addressed holistically. Our convergent mixed-methods design was crucial here: survey data quantified literacy-linked breakdowns (RQ1), while interviews, open-ended responses, and heuristic evaluations revealed how infrastructural fragility and mediated use shape design and policy levers (RQ2).

Our findings also align with and concretize the established theory of Digital Design Marginalization (DDM) [70]. DDM emphasizes how non-inclusive interface decisions not only exclude certain users but also create downstream forms of social marginalization. In our study, this was evident in the absence of error recovery, unclear feedback, and reliance on complex bilingual workflows, design gaps that *push away* low-literate citizens from independent use. We extend DDM in three ways. First, we show its operation in a large-scale, high-stakes e-government ecosystem rather than in

isolated interface examples. Second, we quantify how marginalizing design correlates with mediator dependence and task failure across literacy tiers. Third, we connect DDM to a literacy-adaptive usability framework (LAUF) and mediator-inclusive model that specify concrete design and policy interventions. This reinforces that the Digital Democracy Paradox is not an isolated usability issue but part of a broader pattern of design-enabled exclusion and governance choices.

5.1 Digital Literacy, Fear of Mistakes, and Systemic Trust

Together, our quantitative and qualitative findings show that digital literacy, fear of mistakes, and task-based competence are tightly intertwined rather than separable factors. Our quantitative analysis indicates a strong negative correlation between digital literacy and reliance on mediators ($\rho = -0.395, p < .001$) alongside a positive correlation with task completion success ($\rho = .422, p < .001$). While this supports the intuitive claim that higher literacy increases autonomy, qualitative data complicate the story: even users who “can” read instructions or navigate menus often avoid acting alone due to perceived irreversibility (e.g., failed payments, locked accounts). In short, literacy functions as a *gradient* shaped by confidence, trust, and contextual knowledge, not a binary capacity [37]. Systems that treat literacy as a simple skill variable underestimate the chilling effect of risk and irreversibility.

In a high-stakes administrative environment, “knowing how” does not equal “feeling safe.” This extends text-free UI insights [39]. Many citizens outsource tasks to mediators, not because reading is impossible but because error costs feel intolerable. Policy that equates inclusion with access and skills alone misses two co-requisites of digital citizenship: confidence and reversibility. When mistakes threaten legal identity, income, or mobility, users rationally choose mediated help, even when literate. Bangladesh lacks a standardized, *task-based* digital literacy assessment. Reliance on self-report or education levels obscures heterogeneity within “beginners.” We argue for a localized, task-based instrument that mirrors real e-government steps (OTP, document upload, payment, rescheduling). Such measurement would prevent misaligned interventions (e.g., training where infrastructural fixes are needed) and directly support the adaptive mechanisms we propose below.

At the same time, interface improvements cannot compensate for fragile infrastructures. Users repeatedly prioritized server downtime, payment reconciliation failures, and brittle cross-agency integrations as their most frustrating experiences. Notably, overall satisfaction did not differ significantly across literacy strata in our ANOVA ($p = .15$), underscoring that systemic failures degrade experience for everyone, yet low-literate users are least able to recover or seek redress. We differentiate platform-specific flaws (e.g., lack of rescheduling, non-editable submissions) from systemic weaknesses (e.g., inter-agency identity linkages, payment gateways, hotline capacity). Prior audits focused on per-site WCAG issues [7, 18, 30]; our cross-platform results show why siloed fixes underdeliver. Infrastructural reliability must itself be treated as a first-order usability criterion in public-service contexts.

5.2 Mediators, Institutional Misalignments, and Socio-Technical Dynamics

Citizens value mediators for reassurance, time savings, and accountability, classic patterns of intermediated use [65]. In Bangladesh, the scale is striking: even moderately literate users delegate routine tasks to “computer shops,” effectively externalizing risk. Unregulated mediation introduces risk (exploitation, privacy breaches) and interacts with gender norms (scarcity of female mediators), constraining women’s safe access to the state. Rather than treat mediation as a failure of literacy, we propose treating it as a *design condition*. Systems can legitimize assistance while protecting the agency through certified helper accounts, co-browsing with explicit consent, compartmentalized credential sharing, and auditable action trails.

Officials often equated usability with information provision. BRTA administrators pointed to landing pages, bilingual FAQs, and NID/OTP validation as evidence that “anyone” could access services, while passport officers emphasized YouTube tutorials and step-by-step guides as sufficient support. One NID officer even denied the recurring server instability reported by mediators, insisting the system was “very easy to use” for anyone with “basic knowledge”. This reflects a supply-side framing of usability: accessibility as the availability of instructions, not the ease or safety of completing tasks.

In contrast, users and mediators repeatedly emphasized that documentation does little when forms are irreversible, servers time out, or payments vanish without receipts. BRTA mediators described payment rollbacks and missing edit/cancel options as major pain points, while e-Passport mediators highlighted the impossibility of rescheduling once a date is set. Our survey data confirm this mismatch: 65% of respondents ranked server and payment failures as their top barrier, ahead of navigation concerns. For them, “usable” meant the ability to complete a transaction safely, with undo options, confirmations, and reliable receipts.

This divergence illustrates an institutional blind spot. Administrators measure success by documentation and compliance, while citizens measure success by safe completion. This misalignment sustains mediator dependence: literate users hesitate to act due to irreversibility, while low-literate users outsource tasks entirely. Addressing this requires shifting design priorities from information provision to literacy-adaptive workflows with built-in reversibility and infrastructural resilience, as outlined in the Literacy-Adaptive Usability Framework (LAUF).

5.3 The Literacy-Adaptive Usability Framework (LAUF)

To address these intertwined barriers, we introduce the *Literacy-Adaptive Usability Framework (LAUF)*, a conceptual and practical model that links *measurement of literacy-in-use* to *adaptive interfaces and workflows*, while formalizing *mediated use* and prioritizing *infrastructural resilience*. Prior literacy-aware design frameworks typically recommend static simplification (for example, text-light layouts or icon-based alternatives) or parallel “low-literacy” variants of services. In contrast, LAUF treats literacy as a dynamic, gradient parameter that can be inferred from task performance and used to drive tiered interaction, couples this with explicit support

for socio-technical mediation, and elevates infrastructural reliability itself as a usability dimension. LAUF thus does not simply restate existing principles; it integrates adaptation, mediation, and resilience into a single, testable framework grounded in our empirical literacy gradients. By doing so, LAUF moves beyond describing literacy-related barriers to offering a structured way for governments and designers to re-architect e-government systems around literacy as a first-class design parameter. A visual overview of the framework is shown in Figure 5, which illustrates how its components interact dynamically. LAUF comprises three interlocking pillars:

P1. Assessment-Driven Adaptation. Treat literacy as an *interactional variable*. Lightweight, privacy-preserving micro-assessments (e.g., completing a short warm-up step, past completion history) classify users into adaptive tiers (Beginner/Intermediate/Advanced). Interfaces then scale complexity: *Beginners* get linear, step-by-step flows with icon/voice scaffolds, larger hit targets, and aggressive inline validation; *Advanced* users retain power features (batch actions, jump links). Crucially, tier is *fluid*: successful completions gradually unlock complexity (progressive disclosure).

P2. Mediator-Inclusive Design. Acknowledge intermediated realities by design. Provide *verified mediator profiles*, session-based *co-browsing* with explicit consent and redaction of sensitive fields, *dual-signature* submissions (citizen+mediator), and *transparent audit logs*. Unlike existing models such as Union Digital Centers, which primarily formalize physical access points, our OSDSC model specifies fine-grained digital roles and accountability mechanisms for mediators, links licensing and scoped digital permissions to concrete interface mechanisms (co-browsing, credential masking, dual signatures), and foregrounds gender- and safety-aware staffing. This converts informal risk into accountable support while preserving citizen agency.

P3. Infrastructural Resilience for Low-Literacy Contexts. Engineer for fragility. Implement *autosave*, *resumable forms*, *payment redundancy & reconciliation*, *offline-first fallbacks* for known outages, clear *status/receipt* artifacts (downloadable PDFs/SMS), and *multi-channel support* (hotline/IVR, WhatsApp chatbots) with adequate staffing. When the stack is unreliable, the interface must cushion rather than cascade failures.

We distill LAUF into principles and concrete patterns that can be dropped into design systems: designing for tiers, not averages (for example, “training-wheels” beginner modes and “fast lanes” for advanced users); engineering explicit reversibility (graceful undo, sandbox previews, fix-it pathways); legitimizing safe mediation (co-use sessions, dual-consent receipts, role-scoped tokens); and supporting reliability, clarity, and constrained environments (reliability widgets, verifiable receipts, mobile-first, low-bandwidth flows). These patterns translate abstract principles into testable components that ministries or vendors can adopt incrementally and evaluate with literacy-stratified usability testing.

Taken together, our findings and framework foreground three contributions. First, we provide a literacy-aware evaluation that empirically links measured digital literacy gradients to specific usability breakdowns and mediator dependence across four major

e-government portals. Second, we introduce LAUF, which operationalizes literacy as a design parameter by coupling assessment-driven adaptation, mediator-inclusive workflows, and infrastructural resilience. Third, we sketch an institutional and technical model (OSDSCs and Civix UI) that demonstrates how these principles can be instantiated in practice. This structure clarifies how our work builds on, but goes beyond, existing literacy-aware design and mediation-focused initiatives.

5.4 Policy, Governance, and Transferability

Institutionalize Literacy-Aware Standards. Most governments already mandate accessibility through frameworks such as WCAG, but these standards rarely account for literacy as a usability dimension. We argue that digital literacy should be institutionalized as a first-class design criterion for public service portals. This means extending procurement and accessibility policies to require *literacy-adaptive guidelines*, including tiered flows (beginner, intermediate, advanced), reversible actions (edit/undo, rescheduling), and session-level receipts that provide citizens with verifiable evidence of their submissions. Crucially, compliance should not be measured only by technical checklists but by *stratified usability outcomes*: task completion, error recovery, and confidence across literacy tiers. In practice, this requires governments to tie vendor contracts to literacy-segmented success metrics, so that procurement prioritizes solutions that demonstrably work for beginners as much as for experts. Just as ramps and screen-readers became mandatory in physical and digital accessibility, literacy-adaptive mechanisms should become non-negotiable in civic technologies.

Formalize Mediator Ecosystems. Mediators are often portrayed as informal fixes or, worse, sources of corruption. Our findings suggest a more nuanced reality: mediation is a socio-technical adaptation to design and infrastructural failures. Instead of ignoring or suppressing their role, governments should *formalize mediator ecosystems*. This includes licensing community mediators through Union Digital Centers (UDCs) or accredited service shops, requiring privacy and consent training, and offering them *official helper portals* with scoped permissions (e.g., co-browsing with consent, credential masking, dual signatures). Such formalization simultaneously reduces the risks of exploitation and expands the reach of e-government services by scaling human support where automated support remains insufficient. In contexts where hotline staffing is chronically underfunded, certified mediators can act as a trusted, distributed infrastructure bridging both literacy and gender gaps, provided certification schemes intentionally support female and rural mediators.

Fund Reliability as Usability. Usability is often framed narrowly as an interface property, but our results show that infrastructural fragility, server downtime, failed payments, and dropped OTPs remain the most cited barriers for all users. We therefore argue that *reliability is usability*. Governments must allocate recurring budgets for infrastructural resilience, including service-level agreements (SLAs) for payment reconciliation, redundant cross-agency identity linkages (e.g., NID, passport, BRTA), and adequately staffed helplines. Queue transparency, live service status indicators, and verifiable receipts should be treated not as “extras” but as central

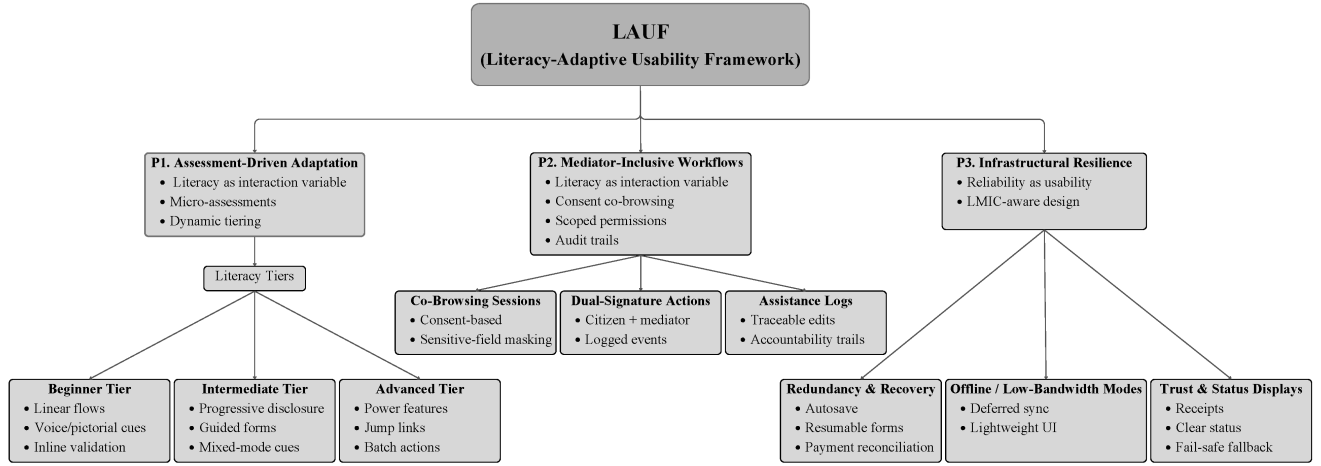


Figure 5: Visual representation of LAUF

components of usability. In the absence of these investments, even the most well-designed interfaces will collapse into frustration and distrust, particularly for low-literate users who cannot troubleshoot failures. By reframing reliability as a usability requirement, policymakers can integrate infrastructural spending into the same mandate as interface design.

Measure What Matters. Finally, inclusive design requires inclusive metrics. Bangladesh currently relies on education level or self-reported digital competence to approximate literacy, which obscures the nuanced gradients revealed in our study. We call for the adoption of *task-based digital literacy assessments* embedded into service ecosystems. These can involve lightweight tests around common tasks (OTP entry, document upload, online payment) and provide not only data for policymaking but also adaptive triggers for interface adjustment. Beyond measurement, governments should commit to publishing *literacy-segmented service analytics*: disaggregating completion rates, retries, error types, hotline escalations, and mediator use by literacy tier. Such reporting would make visible which groups are systematically excluded and incentivize continuous improvement, creating accountability loops that align institutional goals with citizen experience. Because very low-literacy citizens rarely attempt portals independently, they are under-represented in our survey sample; our mediator interviews partially compensate for this by surfacing their experiences indirectly. Future work should complement our approach with observational or kiosk-based studies that directly engage non-users and reluctant users of e-government services.

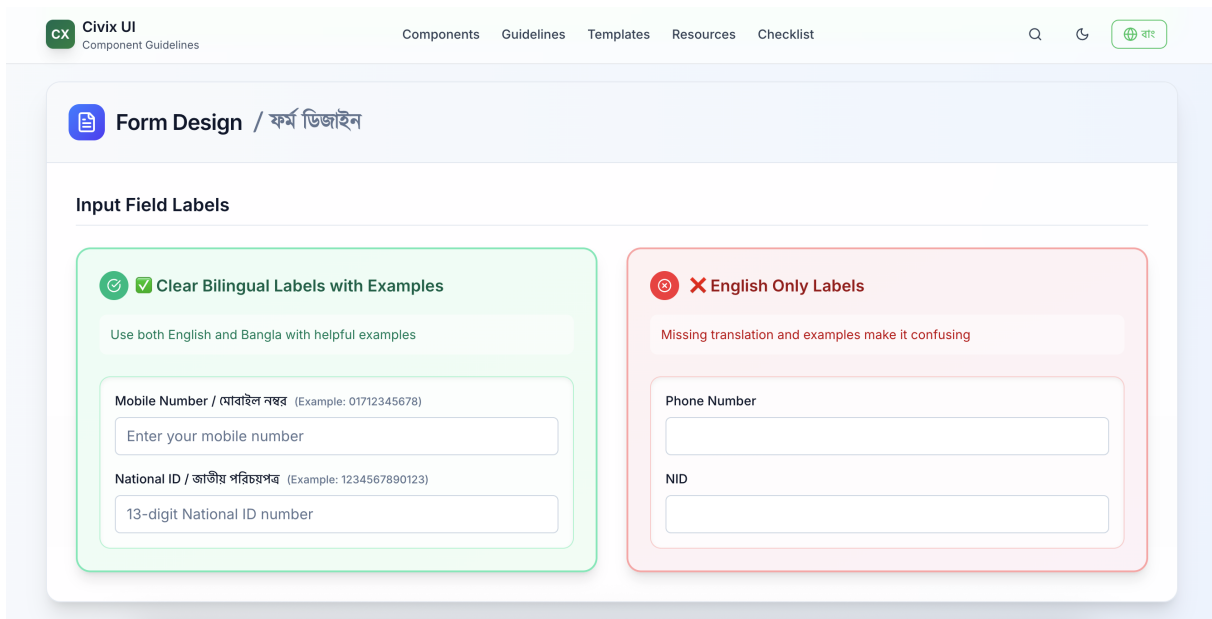
Although our study is grounded in Bangladesh, the mechanisms we document, literacy gradients, infrastructural fragility, and intermediated use, are best understood as *transferable* patterns rather than strictly “generalizable” laws. They resonate strongly with HCI4D and accessibility research in other regions. In India, illiteracy and multilingual complexity have long hindered e-government adoption, even where infrastructure is relatively robust [37, 39].

Across sub-Saharan Africa, intermediated use through kiosk operators and telecenters mirrors the role of Bangladeshi mediators, highlighting how informal actors often substitute for missing institutional support [50, 65]. Even in high-income contexts, similar dynamics appear: older adults in North America and Europe often avoid online tax or health portals out of fear of irreversible mistakes, despite being literate in the formal sense [8].

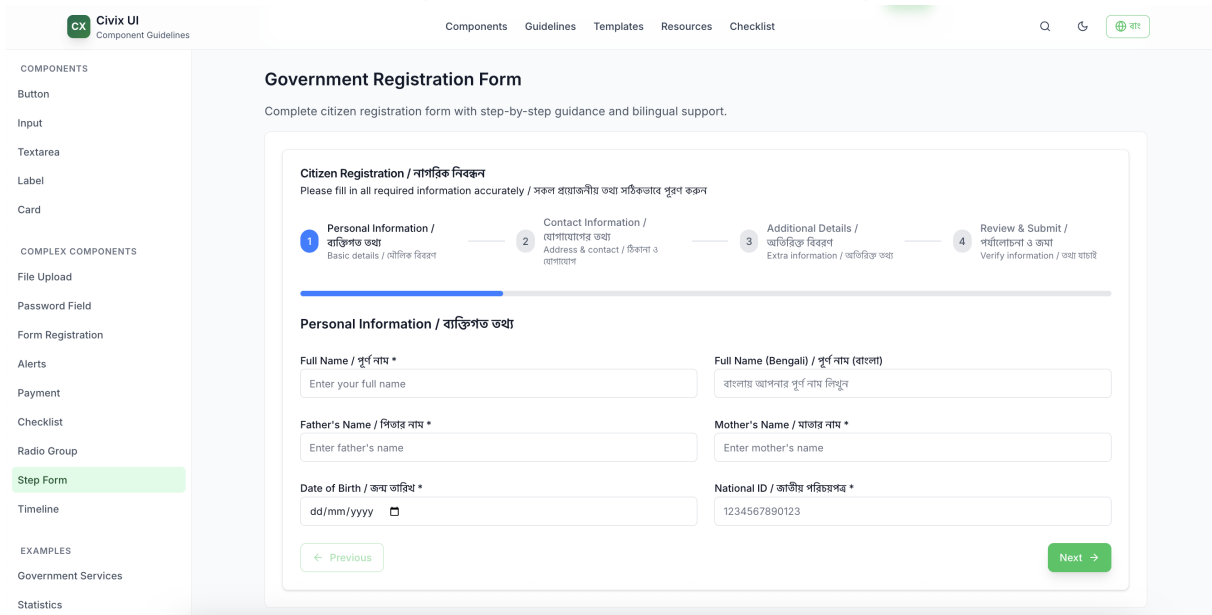
Our framework, LAUF, contributes a transferable stance: *treat literacy as a design parameter, not a background condition*. This has three global implications. First, systems should be *tiered by literacy* everywhere, from African agriculture platforms to Western tax portals. Second, intermediated use should be designed for, not designed around: whether community health workers in Kenya or family helpers in the U.S., mediation is part of digital practice. Third, infrastructural resilience must be treated as a usability criterion: whether in fragile mobile networks or in overburdened Western unemployment systems, downtime and irreversibility disproportionately harm the least confident users. By framing LAUF as a lens that can be adapted to different institutional and infrastructural contexts, rather than a one-size-fits-all solution, we emphasize transferability and local tailoring over universal generalization.

6 Design Implications / Recommendations

The challenges we identified across e-government portals in Bangladesh highlight that improving usability requires interventions at multiple layers of the system-interface consistency, infrastructural stability, and socially embedded human support. Drawing directly from the literacy gradients, infrastructural fragilities, and mediation dynamics surfaced in our study, we outline two complementary directions for implementation: a lightweight government design system (Civix UI) and a formalized, accountable mediation model (One-Stop Digital Service Centers). These should not be read as additional contributions but as concrete instantiations of LAUF’s principles in practice.



(a) Bilingual input field with literacy-aware formatting.



(b) Progressive disclosure for long-form submissions.

Figure 6: Illustrative components from Civix UI. These are not exhaustive recommendations but examples showing how LAUF principles can be instantiated.

6.1 Civix UI: A Lightweight, Example Implementation of LAUF

Our findings revealed substantial fragmentation across government portals: inconsistent layouts, duplicated errors, incompatible form patterns, and divergent interpretations of bilingual requirements. Administrators confirmed that the absence of a shared guideline

forces vendors to independently define interface conventions, resulting in wide variability and recurring usability failures. To illustrate how LAUF’s principles can be operationalized, we developed *Civix UI* [32], a lightweight prototype of literacy-adaptive, bilingual, and infrastructure-aware components. Rather than a full design system,

Civix UI serves as an example scaffold demonstrating how ministries could standardize key patterns. Three LAUF-aligned design priorities shaped the prototype:

- (1) **Assessment-driven adaptation:** simplified flows, larger hit targets, and progressive disclosure for beginners; optional shortcuts for advanced users.
- (2) **Localization and clarity:** plain-language Bangla/English components, dual-encoded icon+text cues, and glossary popovers for bureaucratic terms.
- (3) **Infrastructure-aware robustness:** lightweight rendering, offline-tolerant inputs, and transparent payment/queue status indicators.

Instead of proposing an entirely new platform, As illustrated in Figure 6, Civix UI shows how governments can standardize reusable, literacy-sensitive modules—such as error-resistant form fields, time-limited undo mechanisms, and verifiable receipt components—so that vendors do not reinvent solutions or reproduce known pitfalls. These modules directly address breakdowns identified in our fieldwork (e.g., payment ambiguity, irreversible submissions, complex terminology) and demonstrate how a consistent pattern library can reduce cognitive load, foster trust, and mitigate infrastructural fragility.

Expert consultations with senior UI/UX designers and engineers supported the viability of such a shared pattern library while emphasizing that adoption requires institutional backing—clear guidelines, procurement alignment, and cross-ministry coordination. Civix UI thus operates as a proof-of-concept: a minimal, demonstrative step toward a consistent, literacy-aware design foundation for public services.

6.2 One-Stop Digital Service Centers: Institutionalizing Mediation

LAUF highlights that intermediated use is not a deviation but a central mode of digital interaction, especially for low-confidence users. Our findings confirmed that citizens often rely on mediators due to fear of irreversible errors, infrastructural uncertainty, and the social trust afforded by human assistance. Yet informal mediators are unregulated, predominantly male, and sometimes exploitative, limiting safe access for many—particularly women. We propose *One-Stop Digital Service Centers (OSDSCs)* as a governance-level instantiation of LAUF’s mediator-inclusive principle. Unlike existing Union Digital Centers, which focus on physical access points, OSDSCs formalize digital mediation itself through:

- **Verified mediator roles:** licensed helpers with scoped permissions, field-level masking, and audit trails.
- **Gender-inclusive staffing:** ensuring women citizens have safe and culturally acceptable access to assistance.
- **Tiered support levels:** self-service, guided self-service, and full delegation, matching the literacy gradients we observed.
- **Transparent pricing and accountability:** standardized service fees and digitally logged submissions.

This model elevates mediation from an informal workaround to an equitable component of digital infrastructure. OSDSCs not only increase trust and safety but also distribute support capacity where

automated help remains insufficient in low-literacy, low-bandwidth contexts.

6.3 A Multi-Modal Ecosystem for Inclusive Digital Governance

Civix UI and OSDSCs are complementary enactments of LAUF’s core principles. Civix UI addresses interface-level inconsistency and infrastructure-aware design. OSDSCs address socio-technical realities of fear, trust, and assistance. Together, they reflect a multi-modal ecosystem aligned with our empirical findings: equitable e-government requires both consistent literacy-adaptive interfaces and accountable human support. More broadly, these implications expand HCI4D discussions by demonstrating that in fragile infrastructures, design systems and human mediation cannot be treated as separate spheres. Digital governance demands architectures that integrate technical robustness with social trust, ensuring that citizens across literacy levels can safely and confidently participate in digital public services.

7 Limitations and Future Research Directions

Our study offers a multi-layered view of literacy-aware e-government use, but several limitations shape the scope of our claims. First, our survey relied partly on self-reported measures, which may introduce response and social desirability bias. The convenience and snowball sampling strategies, while practical for reaching active users across services, skewed the sample toward more urban, digitally engaged participants, an important constraint for a study centered on “literacy-aware evaluation.” Although mediator interviews helped surface the perspectives of very low-literacy citizens who rarely interact with portals independently, these accounts remain indirect. Additionally, Bangladesh lacks a validated, context-specific digital literacy assessment framework; our adaptation of international models (DigComp, PIAAC) and task-based scoring therefore serves as an informed proxy rather than a locally standardized instrument. Our mixed-methods workflow was designed to triangulate perspectives across surveys, interviews, and heuristic evaluation, but the convergent design does not allow us to trace causal pathways or temporally evolving usability failures, and the analytic framing around usability dimensions may obscure some nuances of the thematic analysis.

The limits of evaluation also bound the scope of our design contributions. Civix UI was developed as a lightweight prototype to illustrate how LAUF principles might translate into reusable components rather than as a production-grade system; correspondingly, its validation relied on heuristic review and expert feedback rather than large-scale user testing or field deployment. We therefore cannot claim that incorporating these components would directly improve completion rates or reduce mediator dependence without further implementation research. Finally, the geographic concentration of data collection in urban/peri-urban regions, the focus on four high-demand services, and the under-representation of certain groups, particularly rural residents, women, persons with disabilities, and linguistic minorities, constrain generalizability. Future work should therefore incorporate rural ethnographies, validated local literacy scales, gender and disability-inclusive recruitment,

and longitudinal or intervention-based evaluations to robustly assess how literacy-adaptive and mediator-inclusive designs perform in real-world governance infrastructures.

8 Conclusion

Our study of Bangladeshi e-government platforms reveals a central tension in digital transformation efforts: systems justified in the name of efficiency and publicly promoted as expanding access can, in practice, deepen exclusion when literacy, reversibility, and infrastructural reliability are not treated as core design requirements. Through a convergent mixed-methods investigation, we showed how literacy gradients, infrastructural fragility, and reliance on informal mediators jointly shape the lived experience of digital citizenship. By framing this dynamic as the *Digital Democracy Paradox*, we highlight that usability breakdowns are not merely technical defects but structural barriers that undermine equity, trust, and participation.

Our contributions move beyond diagnosis. The Literacy-Adaptive Usability Framework (LAUF) offers a unified perspective that treats literacy as a gradient design parameter, legitimizes safe mediation, and positions infrastructural resilience as a first-order usability criterion. Civix UI, a lightweight illustrative prototype, demonstrates how LAUF's principles can be operationalized into reusable, bilingual, and infrastructure-aware interface patterns. In parallel, the One-Stop Digital Service Center model reframes mediation as an indispensable socio-technical layer that can be formalized, gender-inclusive, and accountable. These two directions are not independent solutions but complementary enactments of LAUF, showing how inclusive digital governance requires the integration of consistent technical design systems with human infrastructures of support.

Although grounded in Bangladesh, the mechanisms we document resonate across contexts where digital ambitions outpace institutional and infrastructural readiness. We call on designers, researchers, and policymakers to recognize that digital inclusion cannot be achieved through digitization alone. It demands systems that support reversibility, confidence, and shared accountability across literacy tiers. Embedding literacy-aware adaptation and structured mediation into the fabric of public services offers a pathway to move from paradox toward genuinely inclusive digital governance.

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