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Technical and Cost Barriers in Accessing Smart Educational Technologies in Rural Areas

Nusrat Jahan

Department of Economics, Begum Badrunnessa Govt. Girls College, Dhaka, Bangladesh
Corresponding Author: nusratnitu2002@gmail.com

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Abstract

This research study explores how data costs and technical issues affect the use of LowDataMode, based on insights from 100 people living in a resource-limited setting. Using chi-square tests and logistic regression, I analyzed how device types, network access, barriers, and platform usability influence LowDataMode use. Results show high data consumption (41%) as the primary barrier, significantly linked to LowDataMode use ($p = 0.023$), with marginal significance in regression ($p = 0.086$). Technical barriers, including lack of affordable devices (28%) and offline learning options (19%), hinder adoption, particularly for shared family device and laptop/desktop users ($p = 0.052$). 3G users (55%) face greater data cost challenges, while Wi-Fi users (15%) rarely need LowDataMode. Higher platform usability was associated with a greater likelihood of skipping LowDataMode ($\beta = 1.48$, $p = 0.008$), suggesting that intuitive, feature-rich apps may encourage more data-intensive activity and thus raise users' data costs. And, non-significant was technical barriers include network stability ($p = 0.315$) and technical problems ($p = 0.545$).

Keywords: Smart Education, Smart Educational Technology, Technical and Cost Barriers

1 Introduction

The integration of smart educational technologies, such as mobile learning platforms, e-reading applications, and virtual classrooms, has revolutionized access to education globally, offering opportunities to bridge educational disparities in underserved regions [1]. In developing countries like Bangladesh, where in 2024 is about 59% of the population resides in rural areas [2], these technologies hold immense potential to enhance educational equity, aligning with Sustainable Development Goal 4 (SDG-4) for inclusive education [3]. However, the adoption of smart educational

technologies in rural contexts is impeded by significant technical and cost-related barriers, including unreliable devices, poor network connectivity, high data costs, and limited digital literacy [4] [5]. These challenges exacerbate the digital divide, limiting the ability of rural populations to leverage digital tools for learning [6] [7]. In Bangladesh, studies have consistently highlighted infrastructural constraints as a primary barrier.

For instance, researchers [5] noted that, inadequate internet connectivity and outdated devices hinder ICT integration in rural classrooms. These researchers [8] emphasized the lack of community-based ICT facilities, such as digital hubs, which limits access to devices and technical support. These findings align with international research, where this researcher [9] reported that students' lack of technical skills and inadequate infrastructure are significant barriers to ICT use in rural schools across developing nations. Another researcher [10] further noted that rural areas globally face challenges like geographic isolation and out-migration of youth, reducing the diffusion of digital technologies. Cost-related barriers are equally critical.

In Bangladesh, Researcher - Hernandez [11] identified high data costs as a major impediment, with rural households spending a significant portion of their income on internet access. Internationally, researchers [12] highlighted that the cost of devices and data plans in rural India creates a financial burden, limiting technology adoption [13].

This study addresses these challenges by investigating the technical and cost barriers impacting the access and use of smart educational technologies in rural Bangladesh.

The research question is, what technical and cost barriers impact the access and use of smart educational technologies in rural areas in Bangladesh? Then I test the null hypothesis (H0): There is no significant impact of technical or cost barriers on the use of smart educational technologies in rural areas, against the alternative hypothesis (H1): Technical and cost barriers significantly affect the use of smart educational technologies in rural areas. Using a structured, closed-ended questionnaire, I was collect primary quantitative data on device reliability, network stability, data cost burden, and platform usability. Descriptive statistics, chi-square tests, and ordinal

logistic regression are employed to analyze relationships and predict the impact of these barriers on technology use.

By providing empirical evidence, this study aims to inform targeted interventions, such as affordable data plans, offline learning modules, and teacher training programs, to enhance digital inclusion. The findings contribute to the discourse on achieving SDG 4 and support Bangladesh's vision of a Smart Bangladesh by 2041 [14]. The paper is structured as follows: Section 2 reviews the literature, Section 3 details the methodology, Section 4 presents results, and Section 5 discusses implications and conclusions.

2 Material and Methods

This study employed a quantitative research approach to investigate the impact of data cost and technical barriers on LowDataMode adoption among users in Darial Union, Bakerganj Upazila, Barishal District, Bangladesh. Participants were surveyed about their demographics, device usage, and network access, barriers to smart educational technology use, platform usability, and perceptions of LowDataMode's role in managing data costs. The survey collected data on age, gender, education, device type, network type, network stability, data cost barriers, content type preferences, technical problems, LowDataMode usage frequency, and suggested improvements for technology access in rural areas.

2.1 Instruments

The primary instrument was a structured survey designed for quantitative analysis of LowDataMode adoption. The survey consisted of closed-ended questions, including yes/no options, Likert scales, and multiple-choice answers to ensure clarity and facilitate statistical analysis. Questions covered: age group (example: 18–24, 25–34), gender (male, female), education level (example: secondary, higher secondary), primary device (smartphone, tablet), device reliability, network type (example: 3G, 4G, Wi-Fi), network stability, impact of poor network quality, data cost as a barrier, content type consuming the most data (example: video-based, interactive apps), LowDataMode usage (regular, occasional, desired but not used, or not needed), platform usability (rated 0–5), frequency of technical problems, biggest technical or

cost-related barrier (example: high data consumption, lack of affordable devices), and key improvements needed for smart educational technology access. A pilot test was conducted with 10 participants to verify the survey's clarity and effectiveness, with no changes made. The survey was administered via Google Forms for accessibility and ease of data collection.

2.2 Data Collection

To Data collection targeted residents of Darial Union, Bakerganj Upazila, Barishal District, Bangladesh, to capture a diverse sample of technology users across ages and educational backgrounds. The Google Form was disseminated online through social media platforms, primarily Messenger, to reach participants. Additionally, I was physically visited the region, engaging with residents to explain the study and provide the Google Form link for participation. For individuals without access to social media or email, I facilitated participation by discussing the survey and ensuring they could respond via the online form. A total of 100 participants provided informed consent through an online Google Form, which mentioned: "Participation in this study is voluntary. No participants are identifiable here. By proceeding with this survey, you consent to participate in this study. Your responses will be kept confidential and will be used solely for research purposes."

2.3 Survey Design

The survey was designed to gather comprehensive data on LowDataMode adoption and its relationship to data cost and technical barriers in rural Bangladesh. Demographic questions (age, gender, education) provided context, as these factors influence technology use. Questions on device type, device reliability, and network type assessed technological infrastructure, while queries on network stability, poor network quality, data-cost barriers, and technical problems identified obstacles to adoption. Participants rated platform usability and LowDataMode usage frequency, using Likert scales and categorical options to quantify perceptions. Additional questions explored the biggest technical or cost-related barrier and the most critical improvement needed to enhance smart educational technology access, offering insights into potential solutions for rural settings. The survey's structure ensured a

broad range of responses to understand how data costs and technical barriers affect LowDataMode adoption.

2.4 Data Analysis

At first, here data was entered into Microsoft Excel using coded values for efficiency and exported as a .CSV file. The dataset was then loaded into JASP (version 0.18.2) for analysis, with coded values converted to string values for analytical clarity. Descriptive statistics summarized central tendencies and variability in demographics, device usage, network access, barriers, platform usability, and LowDataMode usage, providing an overview of usage patterns and perceptions. Chi-square tests examined relationships between categorical variables, such as LowDataMode usage with network type, biggest barriers, or device type, to identify significant associations. A logistic regression model predicted non-adoption of LowDataMode, incorporating predictors like platform usability, high data consumption, network stability, and data cost barriers, technical problems, and device reliability. All analyses were conducted to explore the influence of data costs and technical barriers on LowDataMode adoption. And, the manuscript was prepared using Microsoft Word software.

3 Results and Discussions

Here 100 participants were mostly young: 43% were 25–34, 33% were 18–24, 22% were under 18, and just 2% were 35–44. The group was 68% male and 32% female. Education-wise, 38% had higher secondary schooling, 33% were undergraduates, 16% had secondary education, and 13% were graduates or postgraduates. Smartphones ruled the device scene at 54%, followed by tablets (16%), laptops/desktops (15%), shared family devices (13%), and button-phones (2%). For network access, 55% used 3G, 30% used 4G, and 15% used Wi-Fi. The biggest barrier was high data consumption (41%), followed by lack of affordable devices (28%), lack of offline learning options (19%), and poor network coverage (12%). Most people used video-based content (60%) or interactive apps (39%), with only 1% on text-based content, which makes that data a bit shaky. LowDataMode usage broke down as 19% using it regularly, 37% occasionally, 40% wanting to but not using it, and 4% saying they neither use nor need it.

Fig. 1 shows how people use devices and networks. Smartphones lead with 54 users, followed by tablets (16), laptops/desktops (15), shared family devices (13), and button-phones (2). For networks, 3G is most common (55), then 4G (30), and Wi-Fi (15). This highlights the dominance of mobile devices and 3G in our sample.

Then here Fig. 2 shows that, how LowDataMode usage varies by network type (chi-square = 25.189, df = 6, $p < 0.001$, Cramer's V = 0.355). All 4 people who don't use or need LowDataMode are on Wi-Fi. Meanwhile, 3G users make up most of the other groups: 62.5% (25) of those who want to use it, 54.1% (20) of occasional users, and 52.6% (10) of regular users. 4G is used some, like 36.8% (7) for regular users, but not by the "don't need it" group.

Now, Fig. 3 shows how barriers affect LowDataMode use (chi-square = 19.282, df = 9, p = 0.023, Cramer's V = 0.254). High data consumption, a key data cost issue, dominates for occasional users (62.2%, 23). Potential adopters cite technical barriers: lack of affordable devices (42.5%, 17) and lack of offline learning options (27.5%, 11). The 4 who don't need it split evenly (1 each).

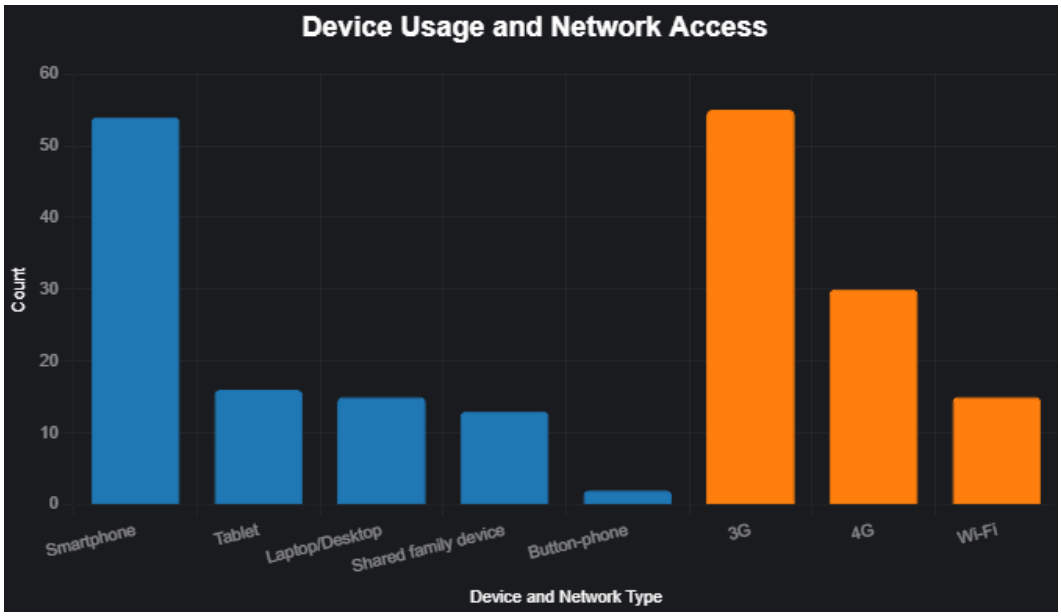

Figure 1. Device Usage and Network Access.

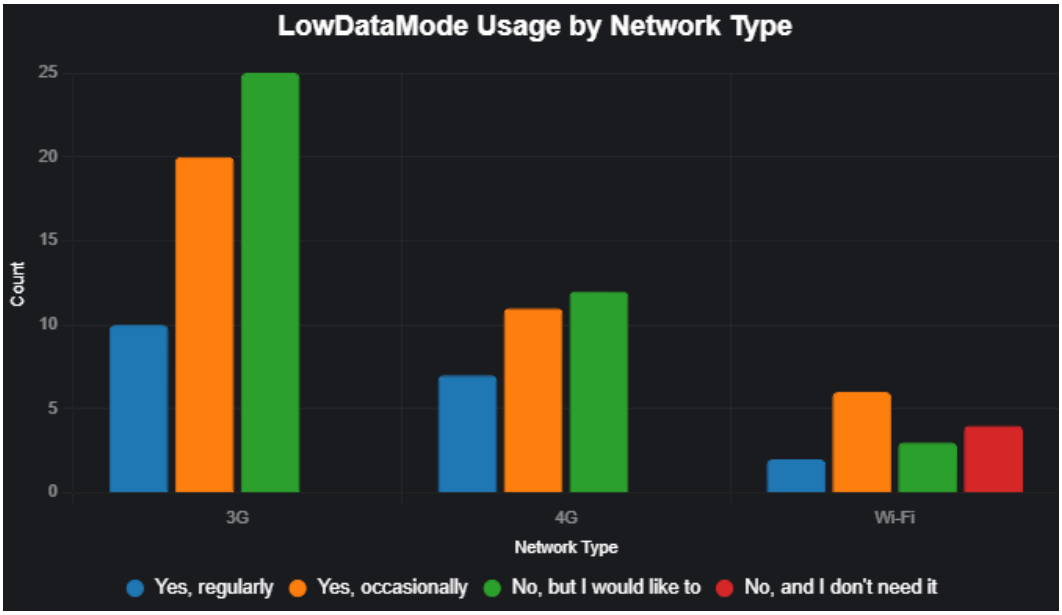

Figure 2. LowDataMode Usage by Network Type.

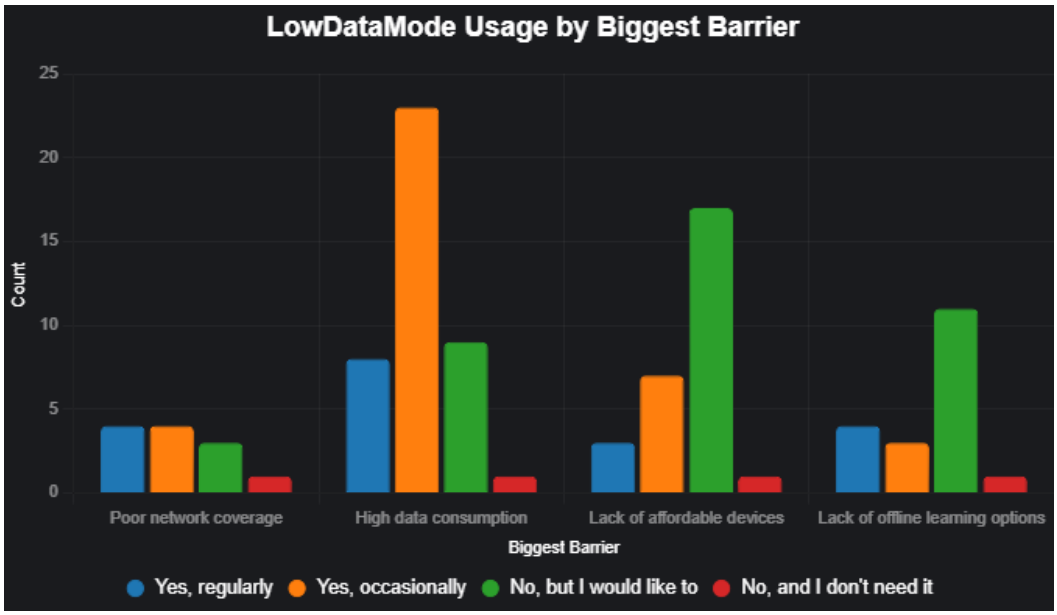

Figure 3. LowDataMode Usage by Biggest Barrier.

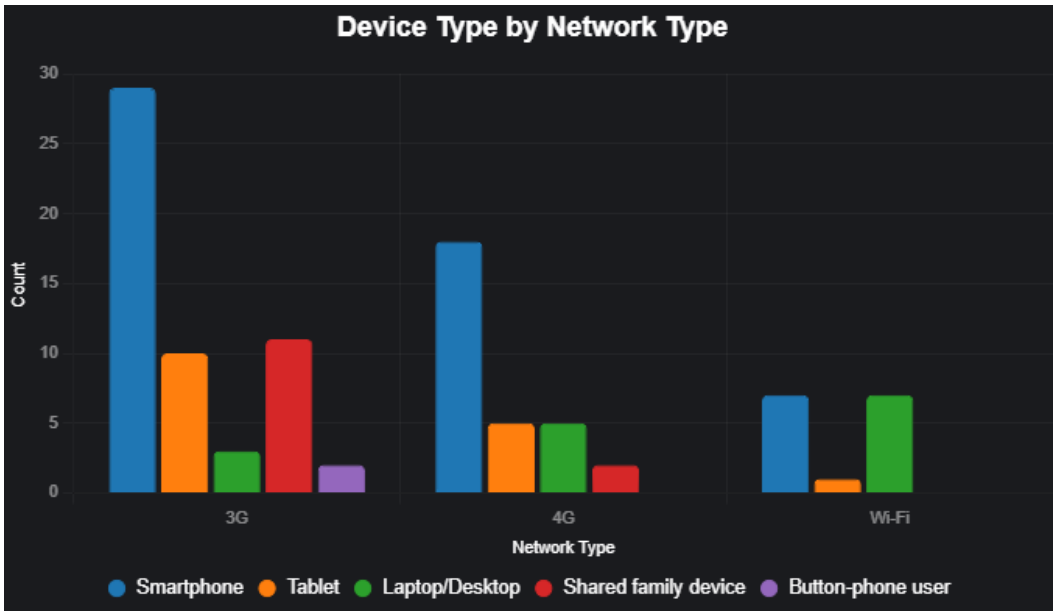

Figure 4. Device Type by Network Type.

Fig. 4 shows device types across network types (chi-square = 21.364, df = 8, p = 0.006, Cramer's V = 0.327). Laptop/desktop users lean toward Wi-Fi (46.7%, 7). Shared family devices (84.6%, 11) and button-phones (100%, 2) stick to 3G. Smartphones (53.7%, 29) and tablets (62.5%, 10) mostly use 3G, with some 4G (33.3%, 31.3%).

Fig. 5 shows how platform usability affects not using LowDataMode ($\beta = 1.477$, SE = 0.556, p = 0.008, 95% CI [0.387, 2.567]). The chance of skipping LowDataMode jumps from 2.47% at usability score 0 to 95.67% at score 5.

Fig. 6 shows p-values for tests and predictors. Blue bars ($p < 0.05$) are significant: LowDataMode vs. NetworkType ($p < 0.001$), BiggestBarrier ($p = 0.023$, includes data cost), User-friendly platform ($p = 0.016$), DeviceType vs. NetworkType ($p = 0.006$), and PlatformUsability ($p = 0.008$). Orange bars ($p < 0.10$) are marginally significant: DeviceType vs. BiggestBarrier ($p = 0.052$, technical barriers), High Data Consumption ($p = 0.086$), Intercept ($p = 0.052$). Red bars (e.g., DataCostBarrier, $p = 0.966$; NetworkBarrier, $p = 0.216$; TechProblems, $p = 0.545$; DeviceReliability, $p = 0.350$) aren't significant.

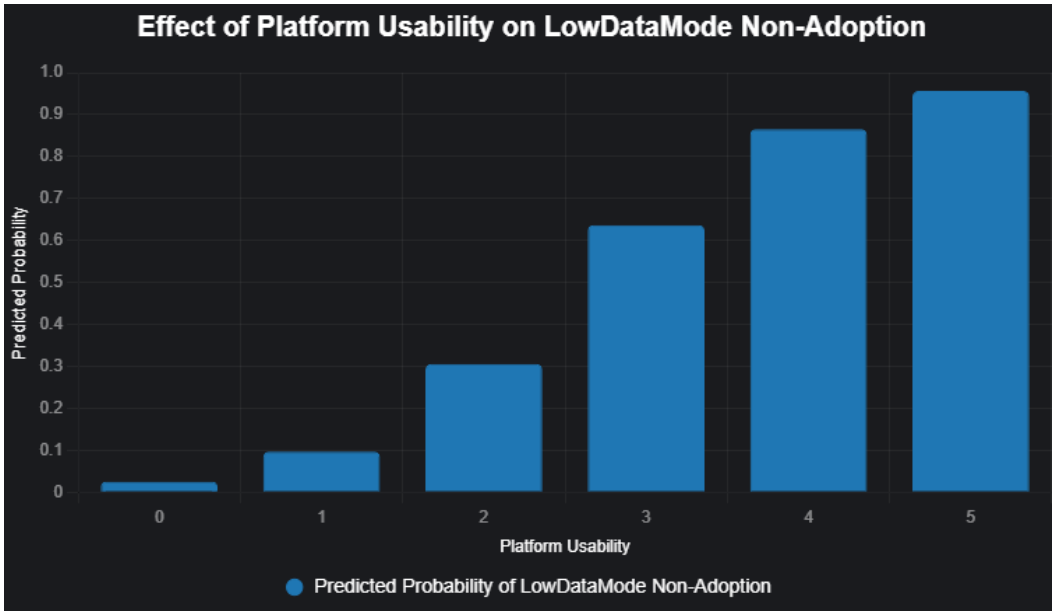

Figure 5. Effect of PlatformUsability on LowDataMode Non-Adoption.

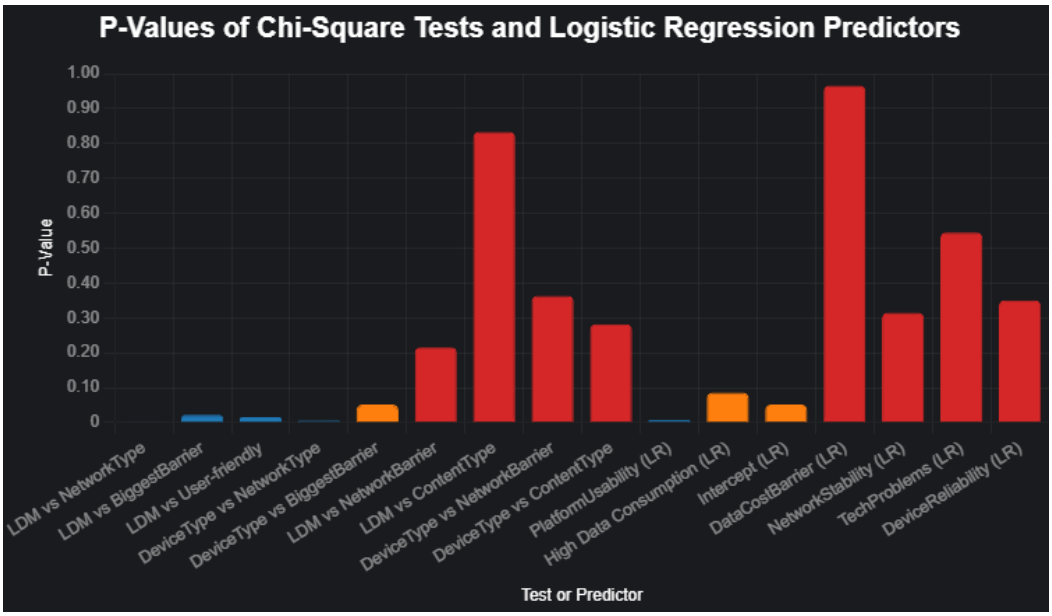

Figure 6. P-Values of Key Tests and Predictors.

Figure 7 shows device types by barriers (chi-square = 20.884, df = 12, p = 0.052, Cramer's V = 0.264). Shared family device users often cite lack of affordable devices (53.8%, 7), a technical barrier. Laptop/desktop users frequently mention lack of offline learning options (46.7%, 7). Smartphones (40.7%, 22) and tablets (37.5%, 6) point to high data consumption, a data cost issue.

Fig. 6 and 7 cover additional findings. LowDataMode showed no significant links with NetworkBarrier (p = 0.216) or ContentType (p = 0.833), nor did DeviceType with NetworkBarrier (p = 0.363) or ContentType (p = 0.282), as shown in Fig. 6's high p-values. Text-based content (1%) made results unreliable. User-friendly platform was likely significant (p = 0.016, Fig. 6), but I lack its data for a detailed figure.

My model (M1) predicted who skips LowDataMode, outperforming the baseline (delta chi-square = 32.873, df = 14, p = 0.003). Fit measures were solid (McFadden = 0.240, Nagelkerke = 0.375, Tjur = 0.292, Cox & Snell = 0.280). Fig. 5 shows PlatformUsability's strong effect (β = 1.477, p = 0.008). Fig. 6 shows High Data Consumption (β = -1.582, p = 0.086) and Intercept (β = -3.681, p = 0.052) as marginally significant, with DataCostBarrier (p = 0.966), NetworkStability (p = 0.315), TechProblems (p = 0.545), and DeviceReliability (p = 0.350) not significant.

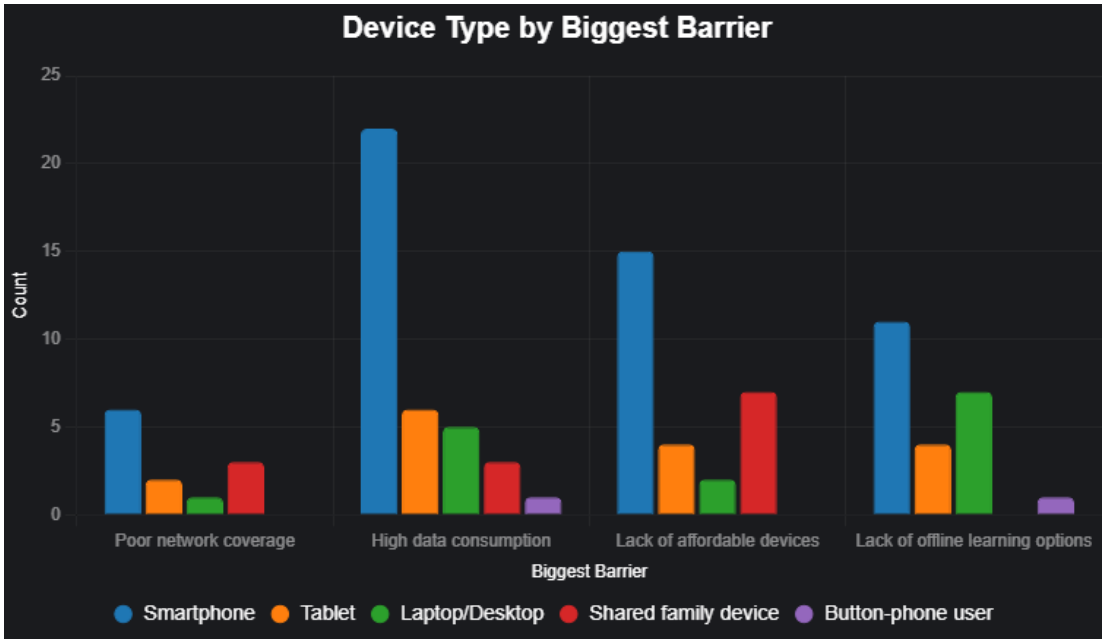

Figure 7. Device Type by Biggest Barrier.

Fig. 3 shows high data consumption (41%) as the top issue, especially for occasional users (62.2%), and Fig. 6 confirms its marginal significance ($p = 0.086$), pushing users toward LowDataMode. Technical barriers, like lack of affordable devices (28%) and offline learning options (19%), affect potential adopters (42.5%, 27.5%, Fig. 3) and vary by device type (Fig. 7, $p = 0.052$), with shared family devices (53.8%) and laptops/desktops (46.7%) highlighting these issues. 3G users (55%, Fig.s 1, 2) face significant data cost challenges, while Wi-Fi users (Fig. 2) don't need LowDataMode due to lower costs. User-friendly platforms (Fig. 5) increase data-heavy content use (60% videos), exacerbating data costs. Fig. 6 confirms significant ($p < 0.05$) and marginally significant ($p < 0.10$) factors. Other technical barriers like NetworkBarrier ($p = 0.216$) and TechProblems ($p = 0.545$) were not significant (Fig. 6). The small sample (100) and sparse text-based content data (1%) limit some findings, and lack user-friendly platform data for a full picture.

4 Conclusion

This research study confirms that high data costs and technical barriers, particularly lack of affordable devices and offline learning options, are major obstacles to LowDataMode adoption. High data consumption drives many to use LowDataMode, especially among 3G users (55%), who face significant cost constraints, while Wi-Fi users rarely need it. Technical barriers disproportionately affect users of shared family devices and laptops/desktops, limiting access to data-efficient platforms. User-friendly platforms, while beneficial, increase data usage, worsening cost issues. These findings shows that many people, about 40% who want to use LowDataMode but simply can't. This really highlights the need for more data-friendly platforms, affordable devices, and offline features to support them.

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