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Offline-Capable Mobile Application: A Systematic Literature Review of Research Trends, Synchronization Mechanisms, UI/UX Patterns, and Usability Evaluation

Nenden Citra Softwatul Ningrum¹, Baginda Anggun Nan Cenka², Harry Budi Santoso³

¹University of Indonesia, Depok, Indonesia, nenden.citra@ui.ac.id

²University of Indonesia, Depok, Indonesia, nancenka@cs.ui.ac.id

³University of Indonesia, Depok, Indonesia, harrybs@cs.ui.ac.id

Corresponding Author: nenden.citra@ui.ac.id¹

Abstract: Limited internet connectivity in developing regions creates a significant digital divide and hinders the adoption of essential digital services in sectors such as health, agriculture, finance, education, and sustainability. This study presents a *Systematic Literature Review* (SLR) that is sought in the range of 2018-2025, with nine selected studies to synthesize research trends, technical approaches, UI/UX patterns, and evaluation methods on mobile applications that support offline mode. The results of the analysis show that there is an increase in research attention in the 2021–2025 period and show that mobile applications with *offline* capabilities are relevant in various domains. From a technical point of view, *offline* support is generally achieved through local storage mechanisms, delayed synchronization, and data integrity controls such as hashing and validation. From a UI/UX perspective, explicit connection status labels, local save confirmations, and sync summaries play an important role in increasing system transparency and maintaining user trust. In addition, recent studies have begun to adopt a broader evaluation approach, including PACMAD-based assessments and scenario-based simulations to test the resilience of systems under conditions of limited or unavailable connectivity. These findings provide practical insights for designers and developers in building mobile applications that are resilient, inclusive, and capable of supporting users in environments with limited network infrastructure.

Keyword: Offline Mode, Aplikasi Mobile, Systematic Literature Review, User Experience (UX), Mekanisme Sinkronisasi, Evaluasi Usability.

INTRODUCTION

From public services and productivity systems to communication and transactions, mobile apps are quickly becoming the primary medium for digital service interactions. By 2024, nearly 5.5 billion people will be online, while around 2.6 billion people still do not have internet access, despite increasing internet usage around the world (International Telecommunication Union, 2024). The difficulty persists even when users are "covered" by

the network in terms of infrastructure access. The utilization gap, or the percentage of the population that has access to mobile broadband but does not utilize it, is highlighted in a study on global connectivity. Affordability, digital literacy, and relevance of services are substantial determinants of these numbers (GSMA Association, 2024). This explains why the assumption of always-online design doesn't always correspond to actual user behavior.

The practical effect of an unreliable connection (intermittent connectivity) on the usability of mobile apps is obvious. When the network is unstable, it can cause problems with login, form filling, data upload, service booking, payment processing, and even data synchronization. User trust in the app is eroded by this influence, which lowers efficiency and increases the likelihood of data loss, repetition of activities, and data disputes. So, it's not just for a few more domains; A design that is adaptive to network interference is essential for all mobile application domains.

Here, *offline* mode is more than just this feature is a method to keep the user's tasks running even when the network is disconnected. In summary, an *offline-first* strategy requires the following: (1) a local storage mechanism for temporary data storage (such as a cache or local database); (2) mechanisms to keep changes logged even when the server connection is lost; (3) a way to retry and reconcile when the connection is back on; and (4) clear user interface feedback to let users know if their actions are successful, failing, or pending synchronization. Research on mobile app synchronization also emphasizes the need to design local data mechanisms, updates, and synchronization to remain useful even as network conditions change (Wang & Wang, 2024).

However, technology considerations aren't the only thing that matters when it comes to offline mode performance. Gaining the trust of others and understanding the position is another big hurdle. When there are no obvious signs of progress, users tend to do the same thing over and over again, which can lead to issues such as data duplication or disputes. This is especially true for systems that function in very critical environments and enterprise-level. For example, the ability to function offline and synchronize when connected is critical to the implementation of mobile EHR systems to ensure continuity of service records (Were et al., 2021). The need for a robust design to eliminate ambiguity about the state of the process was also demonstrated in other investigations of transaction systems intended to function under a limited connection arrangement (Deshmukh et al., 2025). These results show that offline design is more than just "storing data." It's also about how the app informs users about the status and dangers through the interface and user experience.

On the other hand, research on mobile app usability shows a wide range of characteristics and ways of rating, and there is a tendency for ideas related to usability and UX to overlap; This can result in contradictory design suggestions if not combined carefully (Weichbroth, 2020). The use of user-viewable UI/UX patterns (such as offline indicators, sync progress, error/failure messages, and manual retry) and how they contribute to greater openness, fewer errors, and avoidance of data conflicts requires additional targeted research.

In response to this knowledge gap, the study used a Systematic Literature Review (SLR) approach to collect and analyze research on mobile app data synchronization and *offline* modes, with a focus on user interface patterns and user experiences that clarify these concepts for end users. For the sake of openness and replication, the SLR process adheres to the PRISMA 2020 reporting standards across the research selection, extraction, and identification phases (Page et al., 2021).

METHOD

The purpose of this study was to use the SLR methodology to collect and analyze previous research on user interface patterns and user experience (UI/UX) in offline mobile applications. The research focuses on topics such as *offline mode*, data synchronization, queue handling, and feedback seen by users in situations with limited connectivity. The

researcher chose the SLR method because it facilitates the synthesis of accountable and well-structured findings through a transparent, methodical, and repeatable literature search procedure. The systematic review reporting standards support the concept of this guidance by emphasizing the need for transparency throughout the process of selection, identification, extraction, and synthesis of research. (Moher et al., 2009).

This study follows the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) methodology, which assists in the discovery, screening, eligibility, and inclusion of studies using reporting checklists and flowcharts. Readers can understand the total number of publications screened, the reasons for their exclusion, and the research that goes into the synthesis using this approach (Moher et al., 2009). Starting with the development of the research question and continuing through the determination of inclusion and exclusion criteria, the selection of search sources, the compilation of search strings, and the synthesis of results, the study follows the principle that the implementation of SLR requires explicit methodological decisions at each stage (Sauer & Seuring, 2023).

Research Questions and Review Process

To determine the scope of the study systematically, this study uses the PICOC framework, namely *Population, Intervention, Comparison, Outcome, and Context*. The PICOC elements used in this study are presented in Table 1.

Table 1. PICOC Framework

Elemen	Explanation
Population	Mobile apps and mobile app users on Android and/or iOS platforms
Intervention	UI/UX patterns for offline mode as well as synchronization/queue mechanism visible to users
Comparison	N/A
Outcome	<i>Usability, user experience, perceived reliability dan control, task success, serta pengurangan error</i>
Context	Intermittent connectivity, unstable network, low bandwidth, and offline usage scenarios

Based on the PICOC framework, the research questions were formulated as shown in Table 2.

Table 2. Research Questions

Research Questions	Reason
RQ1: What research trends can be identified in studies on UI/UX patterns for mobile apps that support <i>offline mode</i> ?	To understand topic developments by year of publication, platform, and application domain.
RQ2: What <i>offline</i> features and queue handling mechanisms are most commonly applied to mobile applications?	To identify technical approaches used in supporting data interaction and continuity when offline.
RQ3: What UI/UX patterns are used to communicate <i>offline</i> status, sync progress, process queues, and errors to users?	To classify design patterns that are visible to users in maintaining usability and user trust.
RQ4: What kind of UX or usability evidence has been reported in studies on mobile apps that support <i>offline mode</i> ?	To see how the selected studies evaluated <i>usability</i> , UX, or user performance in offline scenarios.

Overall, the review process is carried out in four stages. The first stage is the identification of the study from the selected database. The second stage is the selection of titles and abstracts to eliminate irrelevant articles. The third stage is full-text selection to ensure the appropriateness of the topic and completeness of the data. The fourth stage is

quality assessment to assess the methodological quality and relevance of the article to the research objectives.

Study Search and Identification Criteria

A multi-step process is used to design a search strategy. The research questions provide basic ideas, which include offline mode, mobile apps, usability, and queue syncing/management. Second, after reviewing the literature, researchers found similar words and synonyms. Boolean operators are used to combine terms in the final search phrase. This study uses the following search strings:

("offline mode") AND ("mobile application") AND ("user experience" OR HCI OR usability) AND (synchronization OR queue)

Scopus, ScienceDirect, IEEE Xplore, Taylor & Francis, and the ACM Digital Library are the five major academic databases queried for the literature review. The researchers chose these five databases because of the breadth of the scientific literature they cover in the fields of software engineering, information systems, mobile computing, and human-computer interaction.

Articles published in 2018–2025 are the main focus of this study. The first round of database searches yielded 7,915 items. The total number of articles decreased to 4,661 after applying the year of publication filter. Then, 322 articles were left when the open access filter was applied. The remaining 263 papers were selected from leading journals or proceedings. Researchers have not found a similar article.

Scopus produced 4 original articles, ScienceDirect 31, Taylor & Francis 6, IEEE Xplore 7,795 articles, and ACM Digital Library 79 articles, according to the distribution of search results by database. The selection of titles and abstracts is done after the identification stage to filter the results.

Eligibility Criteria

A total of four steps were included in the research selection procedure. The careful application of inclusion and exclusion criteria at every step guarantees that only high-quality and relevant research is maintained.

1. Initiation

Articles are selected from the first search at the initiation stage based on publication type, year of publication, and full access status. The implementation of the publication year filter from 2018 to 2025 resulted in 4,661 articles out of a total of 7,915 entries. After that, 322 articles were left after applying the open access filter, and 263 papers were left after limiting the number to leading journals or conferences. Researchers have not found duplicate articles.

2. Title and Abstract Selection

Reviewing the abstracts and titles of the 263 articles that passed the initiation stage is the second step. In this step, the researcher examined whether the papers were relevant to our research topic, i.e. user interface patterns and user experience in offline mobile apps. This includes things like queue management, visual feedback for users, and sync capabilities. So far, 251 papers have been ruled out as irrelevant to the research. Finally, the full-text selection step can be continued to the remaining 12 articles.

3. Full-Text Selection

For the full-text selection stage, the researcher carefully examined each of the 12 articles to ensure that they discussed the mobile application, *offline* features, queue handling mechanisms, user-visible design elements, and relevant evaluation evidence. Researchers also ensure that the studies address accurate synchronization and evaluation. Researchers are allowed to proceed to the quality evaluation step as all twelve articles are fully accessible in full text according to the selection findings.

4. Quality Assessment

Twelve articles made it through the full-text selection process, and the final step was quality evaluation. In this step, the researcher looks for studies that are methodologically good and relevant to the problem at hand; If they pass, the researchers will include them in the final synthesis. Table 3 shows the five checklist questions used for quality evaluation.

Table 3. Quality Assessment Checklist

Code	Checklist Statement
QC1	Does the study describe in detail the offline operation mechanism and data synchronization techniques used?
QC2	Does the study describe interface elements or visual feedback that help users understand the state of the system while <i>offline</i> ?
QC3	Are there empirical evaluations (such as user testing, surveys, or field observations) that have a clear methodology to support claims of system usability?
QC4	Does the study specifically address how apps keep users' workflows unhindered when switching from online to offline?
QC5	Are the platforms (such as Android/iOS) and the object of study (the app name and its domain) specifically described?

Each criterion was assessed using a three-point scale, namely 1.0 = Yes, 0.5 = Partial, and 0.0 = No. The total score of each study was obtained by summing the scores of the five criteria. In this study, the study is included in the final synthesis if a score above 3.0 is obtained, because it is considered to have met the minimum quality required. Based on the results of the *Quality Assessment*, there were three articles that did not meet the threshold so they were removed while nine articles were retained and used at the final analysis stage.

Figure 1. (Moher et al., 2009) shows the research selection flow based on the PRISMA 2020 flow chart, which helps clarify the procedure for identifying, filtering, selection, and inclusion of articles.

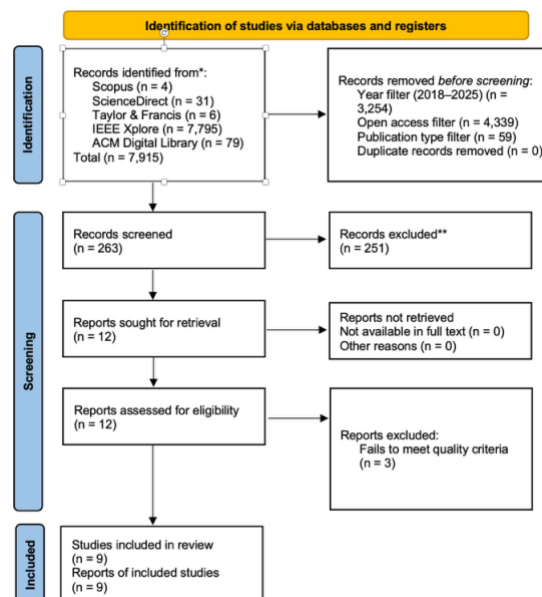


Figure 1. PRISMA 2020 Study Selection Process Diagram

The first search in five databases yielded 7,915 items, as shown in Figure 1. The number of papers was reduced to 263 after applying filters based on the year of publication, open access, and type of publication. After selecting titles and abstracts, 251 publications

were deemed unsuitable for inclusion in the study, leaving only 12 for further evaluation. After passing the quality evaluation, all articles are now accessible in full text. Finally, nine papers went into synthesis after three papers were thrown out for failing to meet quality standards.

RESULTS AND DISCUSSION

Research Trends on Mobile Applications that Support Offline Mode

According to data extracted from the nine studies considered, there has been a significant increase in studies examining mobile apps with offline functionality. Figure 2 shows the publication dates for each year: 2019 had one study, 2021 two, 2022 one, 2024 one, and 2025 three. Based on this distribution, it is clear that there is an increased interest in discussing and designing mobile applications for situations with limited connections in the current literature.

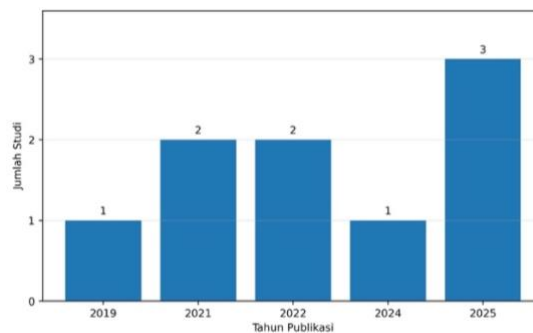


Figure 2. Distribution Of Selected Studies By Year Of Publication

In addition to the year of publication, the selected study shows a diverse range of areas of application. Agriculture, healthcare, education, payments and finance, service provision, and sustainability are the six main areas covered by domain distribution (Figure 3). There are three studies in agriculture, two in health, and one in each of the other fields. These findings suggest that there is a demand for *offline* mode in mobile apps in many different scenarios, rather than just one industry.

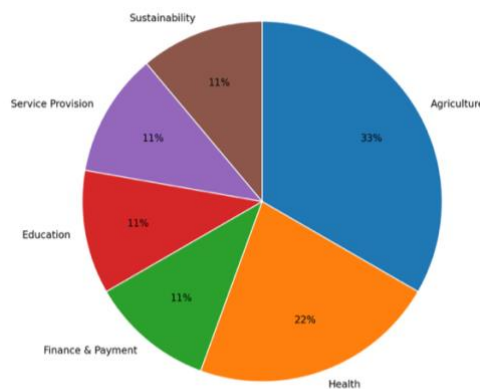


Figure 3. Distribution of selected studies by application domain

Substantively, *offline* mode is especially important in situations that require the continuation of tasks in places with limited network connectivity or in areas where agriculture and health are mostly practiced. At the same time, *offline support* is important in the field of sustainability and payments because it helps to keep transactions smooth, make the system more resilient, and ensure that the service remains reliable even when the connection is lost. Therefore, the researchers' findings show that the topic of mobile applications with *offline capabilities* is becoming increasingly important for various operational demands of users and covers a wide range of domains.

Technical Approach to Offline Mode and Data Synchronization

The synthesis results show that the fundamental technical approach to mobile applications that support *offline mode* focuses on the operational independence of the device through local data storage and efficient synchronization protocols (Were et al., 2021), (Deshmukh et al., 2025), (Guntha et al., 2025), (Ali et al., 2022), (Eitzinger et al., 2019), (John & Renumol, 2022), (Tonle et al., 2024), (Cortijo Mendoza & Ahmed, 2025), (Pham et al., 2021). Key strategies found include:

1. Local Storage Mechanism

All studies used local storage as a temporary data container before the connection was restored (Were et al., 2021), (Deshmukh et al., 2025), (Guntha et al., 2025), (Ali et al., 2022), (Eitzinger et al., 2019), (John & Renumol, 2022), (Tonle et al., 2024), (Cortijo Mendoza & Ahmed, 2025), (Pham et al., 2021). Specific technologies used include IndexedDB for transaction metadata (John & Renumol, 2022), Lucene library for indexing encrypted medical record data in device memory (Guntha et al., 2025), NoSQL database for pest recommendation system (Eitzinger et al., 2019), and Firebase *Real-time* Database to store user performance scores locally.

2. Data Synchronization Strategy

Once internet connectivity is restored, synchronization is often done with a delay (Eitzinger et al., 2019). To conserve bandwidth, the mUzima app uses a delta update approach, which involves uploading and downloading only a small portion of the updated data. Experts and farmers can communicate information bi-way using the GeoFarmer platform's two-way data flow concept. When dealing with thousands of data points acquired during offline periods, the save-and-forward paradigm is also often used. (Were et al., 2021). Offline Integrity and Security.

To guarantee the validity of data when synchronization is delayed, some studies apply SHA-256 hashing algorithms and QR code authentication to prevent replay or data manipulation attacks (John & Renumol, 2022), (Tonle et al., 2024). In addition, a probabilistic matching mechanism is used to prevent duplication of patient identities during offline enrollment (Guntha et al., 2025).

3. Supporting Infrastructure

The use of on-premises microservers (such as the Raspberry Pi) is proposed as an intermediary for distributing applications in packaged form in an environment completely isolated from the central cloud (Deshmukh et al., 2025), (Cortijo Mendoza & Ahmed, 2025).

Table 4. Summary of the Technical Approach

Technical Approach	Related Studies
Local storage / cache	(Were et al., 2021), (Deshmukh et al., 2025), (Guntha et al., 2025), (Ali et al., 2022), (Eitzinger et al., 2019), (John & Renumol, 2022), (Tonle et al., 2024), (Cortijo Mendoza & Ahmed, 2025), (Pham et al., 2021).
Delayed Synchronization	(Were et al., 2021), (Deshmukh et al., 2025), (Guntha et al., 2025), (Ali et al., 2022), (Eitzinger et al., 2019), (John & Renumol, 2022), (Tonle et al., 2024), (Cortijo Mendoza & Ahmed, 2025), (Pham et al., 2021).
Data Integrity (Hashing/QR/Match)	(Guntha et al., 2025), (John & Renumol, 2022), (Tonle et al., 2024).

Technical Approach	Related Studies
	2024)
Queue / Pending status	(Were et al., 2021), (Guntha et al., 2025), (John & Renumol, 2022)
Edge / Local Server	(Deshmukh et al., 2025), (Guntha et al., 2025), (Cortijo Mendoza & Ahmed, 2025)
Delta Updates	(Guntha et al., 2025)

According to Table 4, the most prevalent technical approach is the use of local storage combined with delayed synchronization. This indicates that the maturity of offline-capable applications depends heavily on the application’s ability to manage draft data independently on the user’s device before it is transmitted to the central system.

UI/UX patterns for Offline Mode and Sync

The results of the analysis of selected studies show that the interface design of *offline-capable* applications aims to provide operational transparency as well as maintain user trust when connectivity is not available (Ali et al., 2022), (John & Renumol, 2022), (Pham et al., 2021). The UI/UX patterns found can be categorized into several main aspects.

In terms of communication of connection and operational status, the application is designed to help users understand the mode that is currently active through clear visual and textual indicators. This is achieved through *real-time* status labels such as "Status: Online" or "Status: Offline" at the top of the interface, allowing users to gain certainty about the ongoing processing mechanism (Deshmukh et al., 2025). In addition, there is a confirmation message in the form of a *popup* that appears when a transaction is made without an internet connection, such as a notification that the data has been saved and will be processed when the device comes *back online* (Deshmukh et al., 2025). Some applications also implement automatic interface adaptations, such as the *packaged form pattern* on the vSmartEdu platform, where the interface will switch to a standalone version with limited features when there is no signal (Pham et al., 2021).

In the aspect of visualizing the progress of synchronization and queues, the application provides indicators to indicate the existence of data that is still stored on the device. This can be a *summary dashboard* that displays the status of the data sync, such as the amount of data that has been synced and that is still pending (Were et al., 2021). In addition, there is a grouping of data by status, for example in the "Pending Surveys" and "Completed Surveys" categories which are displayed in the form of tabs or lists (Were et al., 2021), (Eitzinger et al., 2019). In some cases, the app also displays a waiting screen during the validation process or data delivery in the background to prevent duplicate interactions that could compromise data integrity (Deshmukh et al., 2025).

In terms of feedback mechanism and error resolution, the application provides a fast response to minimize input errors in *offline* conditions. Feedback can be both visual and audio signals, such as the use of color or voice alerts to provide immediate corrections (John & Renumol, 2022). In addition, there is *real-time capture guidance that helps users generate high-quality inputs without relying on* cloud synchronization (Cortijo Mendoza & Ahmed, 2025). Some applications also provide dedicated modules for server-side error resolution, which allows non-technical users to handle duplicate data or synchronization conflicts through a simple visual interface (Were et al., 2021).

In terms of instruction and navigation for novice users, the interface design is designed to reduce cognitive load, especially for users with low digital literacy. Apps typically provide an initial instruction page before the task begins so that users understand the steps to take (John & Renumol, 2022). In addition, the navigation is designed in a minimalist

manner with consistent and strategically placed main buttons to maximize the main working area and ease of use (John & Renumol, 2022).

Table 5. Summary of UI/UX Patterns in Offline-Capable Apps

Category	UI/UX elements	Related Studies
Connection Status	"Online/Offline" text label, Save confirmation popup	(Deshmukh et al., 2025), (Pham et al., 2021)
Progress & Queue	Sync (dashboard), "Pending/Completed" tab	(Were et al., 2021), (Deshmukh et al., 2025), (Eitzinger et al., 2019)
Feedback & Error	Audio alerts, visual cues (color), image framing guides	(John & Renumol, 2022), (Cortijo Mendoza & Ahmed, 2025)
User Guidance	Pre-task instructions, minimalist menus, graphical representation of performance	(Ali et al., 2022), (John & Renumol, 2022)

These findings indicate that the UI/UX pattern of mobile applications with offline capabilities does not only focus on aesthetics, but rather on proactive system communication functions to ensure the continuity of user tasks in unstable infrastructure conditions (Were et al., 2021), (Guntha et al., 2025), (Eitzinger et al., 2019).

UX and Usability Evaluation on Mobile Applications That Support Offline Mode

The selected studies report a wide range of evidence of User Experience (UX) and usability through the use of standard frameworks, empirical evaluation methods, and technical performance metrics (Were et al., 2021), (Ali et al., 2022), (John & Renumol, 2022). This evaluation aims to ensure that the application is not only easy to use, but also has resilience when operating without an internet connection (Cortijo Mendoza & Ahmed, 2025), (Pham et al., 2021).

Frameworks and *usability* models in some studies show the use of formal theoretical models to guide the process of interface quality assessment. One of the models used is PACMAD (*People At The Center Of Mobile Application Development*) which measures seven main attributes, namely *effectiveness*, *efficiency*, *satisfaction*, *learnability*, *memorability*, *errors*, and *cognitive load*. *Cognitive load measurement* is an important metric for understanding the user's mental effort when interacting with complex *offline* features (Ali et al., 2022). In addition, in the health domain, *the mHealth Evidence Reporting and Assessment* (mERA) checklist and digital development principles from WHO are used to ensure the scalability and sustainability of interventions in resource-constrained environments (Were et al., 2021). The ISO 9241-11 standard is also used as a basic reference in assessing the effectiveness and satisfaction of users globally (Ali et al., 2022).

The method of collecting empirical evidence is carried out through various technical approaches and field observations. Laboratory *user testing* was carried out in a controlled room with the help of a high-definition camera to record user interactions in detail (Ali et al., 2022). The *single-subject pretest-posttest* method was used in health case studies to measure the impact of app use on physical performance, such as handwriting skills, through the rubric of assessing motor parameters (John & Renumol, 2022). In addition, evaluations were also carried out through *longitudinal field studies* and *pilot projects* as well as *transect walks* methods in various countries such as Tanzania, Uganda, Colombia, and Ghana to capture the

reality of application use in areas without a signal (Eitzinger et al., 2019). To test the resilience of the system, a *scenario-based simulation* approach was also used by involving up to 1,000 virtual users in various scenarios such as *offline resilience* and *fraud stress* (Cortijo Mendoza & Ahmed, 2025).

Performance metrics and reported qualitative evidence include statistical data as well as narrative insights from users. From a technical perspective, it is reported that the application launch time is less than 5 seconds, the form upload time is less than 1 second, and the percentage of crash-free sessions is 92.88% (*crash-free sessions*) monitored using tools such as Firebase Crashlytics (Were et al., 2021). In terms of effectiveness, *the task completion rate* reached an average of 79%, with the group of more educated users recording scores of up to 85.6% (Guntha et al., 2025). In addition, the survey results showed that 76% of participants gave an equivalent rating between pure *online* mode and *hybrid* mode that automatically switches to *offline*, proving that the system is able to maintain seamless workflow continuity when the internet connection is interrupted (Pham et al., 2021). Community feedback is also collected through *community calls*, daily discussion forums, and direct user reviews on platforms such as the Google Play Store (Were et al., 2021).

Table 6. Summary of UX and Usability Evaluation Findings

Types of Usability Proof	Evaluation Methodology	Related Studies
PACMAD Attribute	Lab Testing, NASA-TLX Questionnaire, Likert Scale	(Ali et al., 2022)
Offline Performance	Simulation Scenarios (1000 virtual users)	(Cortijo Mendoza & Ahmed, 2025)
System Stability	Firestore Crashlytics & Paradata Logs	(Were et al., 2021)
Clinical Effectiveness	Pretest-Posttest Case Studies, Rubrik Performa	(Eitzinger et al., 2019), (John & Renumol, 2022)
User Satisfaction	Pilot Lapangan, Transect Walks, Play Store Reviews	(Were et al., 2021), (Eitzinger et al., 2019)

Evidence of usability reported in the literature suggests that the success of offline mode applications is determined not only by the ease of the interface, but also by the technical stability during synchronization and the ability of the application to reduce the cognitive load on users when moving between network conditions (Were et al., 2021), (Ali et al., 2022), (Pham et al., 2021).

Discussion

Here, it will discuss the findings of the literature synthesis in detail, discussing topics such as how well technology techniques work, how important UI/UX patterns are to maintaining user trust, and how relevant assessment models are to offline mobile apps.

Device Independence Effectiveness in Limited Connectivity Conditions

To address the limitations of infrastructure in remote places, studies have shown that the operational independence of client devices is essential (Were et al., 2021), (Tonle et al., 2024), (Pham et al., 2021). To keep sensitive data accessible without always relying on a

central server, on-premises storage solutions such as IndexedDB and Lucene have been successful (Were et al., 2021), (Deshmukh et al., 2025). Users in regions with high data prices or poor signals will greatly benefit from mUzima's delta update method, which demonstrates impressive bandwidth efficiency (Were et al., 2021). In addition, the store-and-forward approach of the GeoFarmer project proves that applications can process large amounts of data (up to 60,000 entries) even when there are long periods of time without network connectivity (Eitzinger et al., 2019). This proves that the "last digital mile" can be achieved with the help of modern mobile technology, while maintaining data integrity (Were et al., 2021).

UI/UX as a Bridge of Transparency and Trust

Because it does not get confirmation directly from the server, offline applications have a harder time maintaining user trust (Deshmukh et al., 2025), (Pham et al., 2021). The use of clear "Online/Offline" status labels and confirmation messages for local storage, among other existing UI/UX patterns, is essential as a "transparency bridge" (Deshmukh et al., 2025). To avoid fatal operational errors in the event of a connection loss, it is useful to use audio and visual feedback in real-time, as is done in HanDex (John & Renumol, 2022). In addition, to avoid user interruption caused by signal loss, interface modifications using bundled form models or standalone containers (such as vSmartEdu) are used (Pham et al., 2021).

Relevance of Usability and Cognitive Load Metrics

The significance of the Cognitive Load characteristics is demonstrated by the use of the PACMAD model in assessing applications such as Houzcalls (Ali et al., 2022). Complex offline procedures often require more mental effort from the user, according to the study. This is especially true for elderly users and populations with lower levels of digital literacy. Therefore, the stated proof of usefulness centers on the capacity of interfaces to simplify complex synchronization procedures in addition to task speed (Ali et al., 2022), (Tonle et al., 2024). To further guarantee security against possible data fraud prior to synchronization, SmartBottle+ research rigorously evaluated the resilience of the system in offline settings using simulated scenarios (Cortijo Mendoza & Ahmed, 2025).

Implications for Future Application Development

It is clear from this synthesis that developers should think about data security using methods such as cryptographic hashing and decentralized validation, in addition to offline functional elements. (Deshmukh et al., 2025), (Cortijo Mendoza & Ahmed, 2025). Mobile apps now have greater flexibility to move between modes of operation thanks to the shift towards a service-based architecture (Pham et al., 2021). When it comes to developing countries, the number of technology adoption in vital industries such as healthcare, agriculture, and finance is determined by the combination of powerful technological processes with communicative interface design (Guntha et al., 2025).

CONCLUSION

The study summarizes previous research on offline mobile app review techniques, research trends, technology approaches, user interface patterns and user experience, and more. The focus on apps that can be used offline has increased in recent years and covers many different areas, including sustainability, agriculture, healthcare, education, payments, and services, according to a review of nine studies. According to these results, there is a growing and cross-sectoral demand for applications that can continue to function even when network speeds are low. These apps will help users in their daily operations.

From a technical point of view, the success of software capable of operating offline depends on data integrity validation procedures, delayed synchronization, and local storage. From an interface design and user experience standpoint, it is critical to maintain system transparency and user trust through the use of patterns such as connection status indicators, local storage confirmations, sync summaries, and prompt feedback. The shift from focusing solely on interfaces to more comprehensive evaluations, including cognitive load, technology stability, and system resilience, is seen in the way offline mode applications are evaluated.

Adaptive technology techniques and communicative interface design should be integrated throughout mobile app creation for environments with limited connections, according to the study's main conclusions. The app's functionality, continuity of tasks, and user experience are all maintained in this way, even when the internet is not available. More comprehensive research on the effectiveness of specific UI/UX patterns, consistent assessment criteria, and hands-on testing in different user settings and network situations are all needed for future studies.

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