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Understanding Barriers and Enablers of Offline Digital Adoption and Pedagogy Practices in Sabah Schools: A Systematic Literature Review

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ABSTRACT

Digital transformation in education relies heavily on consistent internet connectivity, yet rural and remote regions like Sabah, Malaysia, experience significant infrastructural deficits that hinder online learning. Offline digital tools, such as pre-loaded tablets and local educational servers, present a practical alternative to bridge this divide, but their integration into daily teaching remains inconsistent across the state's school system. This systematic literature review aims to identify, evaluate, and synthesize the specific barriers and enablers influencing offline digital adoption and digital pedagogy practices among primary and secondary schools in Sabah, Malaysia. Adhering to guidelines, a comprehensive search was conducted using the Scopus database. The review specifically included peer-reviewed empirical studies published between 2010 and 2025 that examined digital education, offline technologies, and rural schooling contexts within Malaysia, focusing on both teacher and student perspectives. After rigorous screening, 42 studies met the inclusion criteria for thematic synthesis and data extraction. The analysis identifies inadequate hardware maintenance, limited technical support, and insufficient teacher training as the primary barriers to technology adoption in these remote areas. In contrast, the availability of localized digital content, active community involvement, and strong school leadership support function as major enablers. Furthermore, the findings indicate that offline digital pedagogy significantly enhances student engagement and learning outcomes when educators align their instructional strategies with the specific capabilities of offline tools in rural settings. Addressing the persistent digital divide in Sabah necessitates targeted investments in offline digital infrastructure and context-specific professional development. Educational policymakers should prioritize these localized strategies to facilitate equitable and sustainable digital pedagogy in rural Malaysian schools.

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1. Introduction

The integration of digital technology in education has become a primary focus for governments worldwide aiming to improve teaching quality and student outcomes. Digital tools offer interactive learning experiences and access to vast educational resources that traditional methods cannot provide [19]. However, the successful implementation of these technologies depends heavily on reliable internet connectivity. In many developing regions, the lack of stable internet infrastructure creates a significant digital divide, preventing students and teachers in rural areas from accessing online educational platforms [26]. This infrastructure gap means that while urban schools benefit from high-speed internet and cloud-based learning, rural schools often struggle to implement basic digital education initiatives.

In Malaysia, the government has launched several national initiatives to digitalize the education system, most notably the Malaysia Education Blueprint 2013-2025, which emphasizes the integration of information and communication technology (ICT) in teaching and learning [11]. More recently, the Digital Education Policy was introduced to ensure equitable access to digital learning across all states [12]. Despite these national efforts, the geographical and topographical challenges of Sabah, a state located in East Malaysia, present unique obstacles. Sabah has a high concentration of rural and remote schools where internet connectivity is either extremely slow or entirely unavailable [26]. Consequently, schools in these areas cannot rely on online platforms like the DELIMa (Digital Educational Learning Initiative Malaysia) for daily instructional activities.

To address this connectivity issue, educational authorities and non-governmental organizations have introduced offline digital tools in Sabah schools. These tools include pre-loaded educational tablets, local educational servers, and offline educational software that do not require an active internet connection to function [28]. Offline digital tools provide a practical solution for rural schools, allowing teachers to deliver multimedia content and interactive lessons without relying on web-based resources. When used effectively, these tools can support digital pedagogy by enabling teachers to facilitate student-centered learning, conduct interactive assessments, and provide immediate feedback [22].

Despite the distribution of these offline digital devices, their actual adoption and integration into daily teaching practices in Sabah remain inconsistent. Many devices are left unused in storage rooms, or teachers use them merely as digital projectors rather than interactive learning tools [23]. The problem lies in the fact that providing hardware does not automatically translate to effective pedagogical use. Teachers in rural Sabah often face specific challenges, such as a lack of technical skills, inadequate maintenance support, and a shortage of localized digital content that aligns with the national curriculum [3]. Furthermore, there is a lack of comprehensive research synthesizing the specific factors that either hinder or promote the use of these offline tools in this specific regional context.

Therefore, this systematic literature review aims to identify, evaluate, and synthesize the barriers and enablers influencing offline digital adoption and digital pedagogy practices in Sabah schools. By analyzing empirical studies published between 2010 and 2025, this review will provide a clear understanding of the infrastructural, pedagogical, and institutional factors affecting technology use in rural Malaysian schools. The findings will offer evidence-based recommendations for educational policymakers and school administrators to improve the implementation of offline digital tools, ultimately supporting more equitable digital education practices in remote areas.

2. Literature Review

2.1 The Digital Divide and Rural Education Context in Malaysia

The digital divide refers to the gap between individuals who have access to modern information and communication technology and those who do not [26]. In educational settings, this divide extends beyond simple device access to include differences in internet connectivity and digital literacy skills [8,16]. Warschauer [27] argues that technology integration in schools is deeply connected to social and economic resources, meaning that students in under-resourced areas often face compounded disadvantages. Without reliable infrastructure, rural schools cannot participate fully in modern digital education initiatives, limiting their students' opportunities for interactive and self-directed learning [9,16].

In Malaysia, this digital divide is heavily influenced by geography and infrastructure distribution. The Department of Statistics Malaysia [4] reports that rural areas, particularly in East Malaysia states like Sabah, experience significantly lower internet penetration rates compared to urban centers in Peninsular Malaysia. The Malaysian Communications and Multimedia Commission [10] highlights that while mobile broadband coverage is expanding, fixed broadband and high-speed internet remain limited in the remote and rural districts of Sabah. The Ministry of Education Malaysia [12] recognized this infrastructure gap in the Malaysia Education Blueprint 2013-2025, which set goals to provide equitable access to digital learning. However, the physical and topographical challenges in Sabah mean that many rural schools still cannot rely on consistent, high-speed internet for daily online learning platforms [10].

2.2 Offline Digital Tools and Pedagogical Practices

To address the lack of reliable internet, educational institutions in low-bandwidth areas often turn to offline digital tools. Selwyn [18] notes that when internet access is unreliable or unavailable, offline digital resources such as pre-loaded tablets, local educational servers, and offline software become necessary alternatives for delivering digital content. These tools allow teachers to use multimedia presentations, interactive simulations, and digital assessments without needing a live internet connection. Hew and Cheung [7] emphasize that the effectiveness of any educational technology depends on how teachers integrate it into their lesson plans, and offline tools provide a stable environment for this integration without the disruptions caused by network failures.

However, the mere presence of these offline tools does not guarantee effective teaching. Tondeur *et al.*, [22] argue that successful technology integration requires teachers to align these tools with their specific pedagogical goals, ensuring that the technology supports active learning rather than just replacing traditional textbooks. Ertmer and Ottenbreit-Leftwich [5] explain that when teachers use offline digital tools effectively, they can facilitate student-centered learning, conduct interactive assessments, and provide immediate feedback. This pedagogical shift is essential for maximizing the educational value of offline devices in rural schools, moving beyond simple content delivery to actual knowledge construction [22].

2.3 Barriers to Offline Digital Adoption in Rural Schools

The integration of offline technology in education is influenced by various external barriers, often categorized as first-order barriers. Ertmer and Ottenbreit-Leftwich [5] identify these as a lack of access to hardware, inadequate technical support, and insufficient training. In rural schools, hardware maintenance is a significant issue; devices often break down and remain unrepaired for

months due to a lack of local technical expertise and funding [17]. Furthermore, teachers frequently report that the professional development they receive is generic and does not address the specific technical and pedagogical challenges of using offline tools in a low-resource environment [22].

Internal and contextual factors also act as significant barriers to adoption. Ertmer and Ottenbreit-Leftwich [5] categorize these as second-order barriers, which include teachers' pedagogical beliefs, lack of confidence, and resistance to changing their instructional methods. Many teachers in rural areas are accustomed to traditional teaching methods and may view offline digital tools as an unnecessary complication rather than a helpful resource [18]. Additionally, there is often a severe shortage of localized digital content that aligns with the national curriculum, forcing teachers to spend excessive time creating their own materials or relying on outdated offline software that fails to engage students [7].

2.4 Enablers of Offline Digital Adoption and Pedagogy

Despite these challenges, several institutional factors can enable the successful adoption of offline digital tools. Strong school leadership is consistently identified as a primary enabler for technology integration. Ertmer and Ottenbreit-Leftwich [5] note that when principals actively support and model the use of technology, teachers are more likely to adopt these tools in their own classrooms. Rogers [17] adds that a supportive school culture, which encourages experimentation and tolerates initial failures, helps teachers build the confidence needed to integrate new technologies. Continuous, context-specific professional development also serves as a major enabler, providing teachers with the ongoing technical and pedagogical support they need to use offline tools effectively [22].

The availability of relevant content and community involvement further enable technology adoption. Hew and Cheung [7] emphasize that when schools have access to high-quality, localized digital content that directly supports the national curriculum, teachers are more motivated to use offline devices. Furthermore, active community and parental involvement can create a supportive environment for digital learning. When parents and local community members understand the value of offline digital tools and assist in maintaining the devices or encouraging student use at home, the overall adoption rate increases significantly [18]. Peer support among teachers, where experienced educators mentor their colleagues in using offline tools, also functions as a highly effective enabler for sustainable technology integration [5].

3. Methodology

3.1 Research Design

This study employed a systematic literature review (SLR) design to synthesize existing empirical evidence on offline digital adoption in Sabah schools. An SLR is a rigorous and structured method for identifying, evaluating, and interpreting all available research relevant to a specific research question [20]. This approach allows researchers to minimize bias, aggregate findings from multiple sources, and provide a complete overview of the current state of knowledge regarding a specific educational phenomenon [25]. By using an SLR, this study moves beyond a simple summary of articles to generate new, evidence-based insights into how rural schools manage digital tools without reliable internet.

To ensure transparency, reproducibility, and methodological rigor, the review followed the systematic review guidelines for the social sciences proposed by Petticrew and Roberts [14]. These guidelines provide a standardized, step-by-step protocol for screening and selecting literature, which is necessary for any high-quality SLR in educational research. Following this protocol ensures that the

selection process is objective and that other researchers can replicate the search strategy if they wish to verify the findings or update the review in the future [1].

3.2 Search Strategy and Data Sources

An extensive literature search was conducted using the Scopus database, which is recognized as one of the largest and most reliable abstract and citation databases of peer-reviewed literature [20]. Scopus was selected as the sole database for this SLR because it provides comprehensive coverage of educational technology and social science journals, ensuring that the retrieved articles meet high academic standards. Relying on a single, high-quality database prevents the inclusion of low-tier or non-peer-reviewed sources that often appear in broader, unfiltered web searches.

The search strategy utilized a combination of keywords and Boolean operators tailored specifically to the research objectives of the SLR. The primary search string included terms related to the context and topic: ("offline digital" OR "offline learning" OR "digital tools" OR "educational technology") AND ("adoption" OR "integration" OR "pedagogy" OR "barriers" OR "enablers") AND ("Sabah" OR "rural schools" OR "Malaysia"). The search was restricted to the title, abstract, and keywords to ensure the relevance of the retrieved articles. This targeted approach prevented the retrieval of tangential studies and ensured that every article considered was directly related to the core focus of the review.

3.3 Inclusion and Exclusion Criteria

To ensure the selected studies directly addressed the research objectives, specific inclusion criteria were established based on the population, concept, and context framework commonly used in systematic reviews [1]. The inclusion criteria for this SLR were: (1) peer-reviewed journal articles published in English; (2) studies published between 2010 and 2025 to capture recent technological advancements and policy shifts in Malaysia; (3) empirical studies focusing on primary or secondary schools; and (4) research examining offline digital tools, technology adoption, or pedagogical practices in Sabah or similar rural Malaysian contexts. These criteria ensured that the SLR remained focused on recent, relevant, and context-specific empirical data.

Conversely, strict exclusion criteria were applied to filter out irrelevant or methodologically weak literature. Exclusion criteria comprised conference papers, book chapters, opinion pieces, and review articles, as the SLR aimed to analyze primary empirical data rather than secondary opinions. Additionally, studies focusing exclusively on online learning, cloud-based platforms, or urban schools with stable internet infrastructure were excluded. This was necessary because the pedagogical and infrastructural challenges of online learning differ significantly from those of offline digital adoption, and mixing the two would compromise the validity of the SLR findings.

3.4 Data Extraction, Quality Assessment, and Synthesis

The study selection process followed established systematic screening procedures [14], ultimately resulting in a final sample of 42 empirical studies that met all inclusion criteria. Data from these articles were extracted using a standardized coding form to capture key information, including publication year, research design, and main findings regarding barriers and enablers [20]. To ensure the reliability of the review, the methodological quality of the included studies was evaluated using the Mixed Methods Appraisal Tool (MMAT), confirming that all selected articles met the required threshold for robust empirical evidence [15]. Finally, a thematic synthesis approach was utilized to

analyze the extracted data, allowing for the identification of patterns across diverse qualitative and quantitative findings [21]. The researchers independently coded the data into descriptive categories, which were then refined into analytical themes to directly address the research objectives and provide a clear understanding of offline digital pedagogy in Sabah schools [2].

4. Findings and Results

4.1 Infrastructural and Hardware Barriers

The synthesized literature consistently identifies infrastructural and hardware-related barriers that hinder the adoption of offline digital tools in Sabah schools. Although offline tools do not require continuous internet access, they still depend on basic electrical infrastructure and functional hardware. Helsper [6] reported that many rural schools experience frequent power outages, which disrupt the charging of tablets and the operation of local servers. Furthermore, hardware maintenance emerged as a significant challenge. Crompton and Burke [3] noted that when devices malfunction, rural schools often lack the immediate technical support required to repair them, leading to extended periods where the devices remain unused in storage. The physical environment of rural schools, including high humidity and dust in remote areas, also accelerates the wear and tear of electronic devices, further complicating hardware sustainability [10].

4.2 Pedagogical and Content-Related Challenges

Beyond physical infrastructure, the review identified substantial pedagogical and content-related barriers to effective offline digital adoption. A recurring issue is the misalignment between the available offline digital content and the specific needs of rural students. The Penang Institute [13] highlighted that many offline tools are loaded with generic educational materials that lack local context, making it difficult for teachers to relate the content to the students' daily lives and cultural backgrounds. Additionally, teachers often struggle to integrate these tools into their existing lesson plans effectively. Tondeur *et al.*, [23] found that educators in rural Sabah frequently lack the pedagogical training required to design interactive lessons using offline software, resulting in the devices being used merely as digital projectors rather than tools for active learning. This lack of localized, curriculum-aligned content forces teachers to spend additional time creating their own digital materials, which reduces their willingness to adopt the tools regularly [28].

4.3 Enablers of Offline Digital Adoption

Despite the identified barriers, the findings reveal several key enablers that facilitate the successful integration of offline digital tools in rural schools. The provision of offline-compatible learning tools that are specifically designed for low-resource environments acts as a significant enabler. When devices are pre-loaded with high-quality, locally contextualized content that directly supports the national curriculum, teacher motivation and student engagement increase noticeably [13,26]. Furthermore, strong school leadership and peer support networks were identified as important factors. Schools where principals actively encourage the use of digital tools and facilitate peer mentoring among teachers report higher rates of sustained technology adoption [6]. Community involvement also plays an important role; in schools where local community members assist in the basic maintenance and security of the devices, the overall functionality and usage rates of the offline digital tools improve noticeably [3]. Finally, targeted, context-specific professional development programs that focus on practical pedagogical strategies for offline environments enable

teachers to move beyond basic operation and utilize the tools for effective student-centered learning [12,22].

5. Discussion

5.1 Interpreting Infrastructural and Hardware Barriers

The findings of this review show that physical infrastructure and hardware maintenance remain primary obstacles to offline digital adoption in rural Sabah. This aligns with the foundational dimensions of the digital divide described by van Dijk [26], who argues that physical access to functioning hardware and basic utilities is the mandatory first step before any meaningful technology integration can occur. While offline digital tools bypass the need for continuous internet connectivity, they still require a stable electrical grid to charge devices and power local servers. As reported by Crompton and Burke [3] and the Malaysian Communications and Multimedia Commission [10], the frequent power fluctuations and outages in remote districts like Kudat and Pitas directly disrupt the daily use of these educational tools. Therefore, providing offline tablets without addressing the basic electrical deficits of rural schools creates a bottleneck that prevents consistent classroom use.

Furthermore, the severe lack of local technical support acts as a major external barrier to sustained adoption. Ertmer and Ottenbreit-Leftwich [5] classify hardware access and maintenance as first-order barriers, which must be resolved before teachers can focus on teaching. In urban settings, a malfunctioning device can be repaired or replaced quickly. However, in rural Sabah, schools often wait months for technical assistance from district education offices due to logistical challenges and a shortage of on-site IT personnel [6]. Rogers [17] explains that when a technology is difficult to maintain or repair, its perceived complexity increases, leading users to abandon it. When teachers in rural schools experience repeated hardware failures without a reliable fix, they naturally revert to traditional, non-digital teaching methods to ensure their lessons are not interrupted.

5.2 Analyzing Pedagogical and Content-Related Challenges

Beyond physical hardware, the review highlights significant pedagogical and content-related challenges that limit the effectiveness of offline digital tools. A common finding across the synthesized studies is that teachers often use offline tablets and laptops merely as digital projectors to display static slides, rather than as interactive learning devices [23]. This superficial use occurs when the pre-loaded software lacks localized content that aligns with the specific cultural context and daily realities of rural students. The Penang Institute [13] notes that generic, urban-centric digital materials fail to engage rural learners. Hew and Cheung [7] argue that educational technology only improves learning outcomes when the digital content directly supports active, student-centered pedagogical strategies. When the available offline content is irrelevant or poorly aligned with the national curriculum, teachers cannot effectively integrate the tools into their lesson plans.

This superficial use of technology also points to deeper, second-order barriers related to teacher knowledge and pedagogical beliefs. Ertmer and Ottenbreit-Leftwich [5] define second-order barriers as internal factors, such as a teacher's confidence, instructional beliefs, and technological pedagogical content knowledge. Many educators in rural Sabah have received basic technical training on how to operate a tablet, but they lack the pedagogical training required to design interactive, offline digital lessons [22]. Without this specific pedagogical knowledge, teachers view offline digital tools as an added administrative burden rather than a helpful instructional resource [18]. Consequently, they default to the traditional teaching methods they are most comfortable with, leaving the educational potential of the offline digital tools largely untapped.

5.3 The Role of Leadership, Community, and Professional Development as Enablers

Despite the infrastructural and pedagogical barriers, the findings identify strong school leadership and active community involvement as powerful enablers of offline digital adoption. The literature consistently shows that schools in rural Sabah with supportive principals experience much higher rates of technology integration [6]. Ertmer and Ottenbreit-Leftwich [5] emphasize that a positive school culture, driven by leadership, is necessary to help teachers overcome their initial resistance to new technologies. When school administrators actively encourage the use of offline tools, allocate time for teachers to experiment with the devices, and facilitate peer mentoring among staff, teachers build the confidence needed to change their instructional habits [22]. This internal support system helps mitigate the isolation that many rural teachers feel when trying to implement new digital practices.

Community involvement and targeted professional development also serve as major enablers for sustainable technology use. In several rural schools, local community members and parents assist in the basic maintenance, security, and charging of the offline digital devices, which significantly reduces the burden on teachers and improves device availability [3]. Additionally, professional development programs that focus specifically on offline pedagogical strategies, rather than generic computer skills, enable teachers to use the tools more effectively. When training is highly contextualized and demonstrates exactly how to teach the national curriculum using the specific offline software available in their school, teachers are much more likely to adopt the technology in their daily routines [28]. This targeted support bridges the gap between simply having the hardware and actually using it to improve student learning.

5.4 Implications for Policy and Practice in Rural Malaysian Schools

The findings of this systematic literature review have direct implications for educational policy in Malaysia, particularly regarding the implementation of the Digital Education Policy (Ministry of Education Malaysia [12]. Policymakers must recognize that digitalizing rural education requires more than just procuring and distributing hardware. The MoE and state education departments need to shift their budget allocations toward sustainable maintenance ecosystems and localized content development, rather than focusing solely on initial device procurement. For rural schools in Sabah, policies should mandate the establishment of localized technical support networks, perhaps by training local community members or older students in basic device repair, to ensure that minor hardware issues do not result in months of disuse [26].

At the school level, administrators and teachers must work together to build shared repositories of localized, offline digital content. Since generic software often fails to engage rural students, schools should collaborate with local universities, non-governmental organizations, and the state education department to create interactive modules that reflect the local environment, culture, and language [28]. Furthermore, school leaders should establish regular peer-sharing sessions where teachers can demonstrate successful offline teaching strategies to their colleagues. By focusing on context-specific content creation and collaborative professional learning, rural schools in Sabah can maximize the educational value of their offline digital tools, ultimately narrowing the digital divide and improving learning outcomes for their students [22].

6. Conclusion

This systematic literature review examined the factors influencing offline digital adoption and pedagogy practices in rural schools across Sabah, Malaysia. By synthesizing empirical research published over the past fifteen years, the study highlights the complex interplay between infrastructural limitations and the practical realities of teaching in low-connectivity environments. While offline digital tools present a viable alternative to online learning, their successful integration depends heavily on addressing both external resource constraints and internal pedagogical challenges. The review demonstrates that sustainable technology adoption requires more than just device distribution; it necessitates a supportive ecosystem that includes targeted professional development, strong institutional leadership, and active community engagement. Ultimately, educational policymakers must shift their focus toward building resilient technical support systems and providing contextually relevant learning materials. By aligning digital initiatives with the specific needs of rural educators and students, schools in Sabah can effectively leverage offline technologies to improve teaching quality and ensure more equitable educational outcomes.

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