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Development of Digital Learning Media for Community-Based Education: A Collaborative Innovation and Literacy Framework

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Abstract

Background -The rapid advancement of digital technology has transformed global education, yet disparities in access persist, particularly in low-income and rural regions. Digital literacy encompassing technical, critical, and ethical competencies remains underdeveloped due to insufficient teacher training and infrastructural limitations.
Research Urgency - The growing digital divide in education demands immediate action to ensure equal learning opportunities. Many underserved communities lack digital literacy and infrastructure, limiting their participation in the digital era. Implementing the FOCIL model is urgent to build adaptable, inclusive digital learning that enhances technical, critical, and ethical competencies for sustainable empowerment.
Research Objectives - This study aims to (1) assess the effectiveness of FOCIL in improving digital literacy, (2) evaluate its socio-cultural and infrastructural adaptability, and (3) identify key features that enhance learning outcomes in underserved communities.
Research Method - A mixed-methods sequential exploratory design was employed, combining qualitative stakeholder interviews, observational studies, and document analysis, followed by quantitative usability and field trials.
Research Findings - The FOCIL platform significantly enhanced literacy outcomes, with participants demonstrating greater progress than those using conventional methods. Learning modules that incorporated local wisdom, such as regional folktales, proved more engaging and achieved higher completion rates than generic materials. The platform's low-bandwidth design effectively supported learners in rural areas, enabling continued access through offline mode. Interactive features, particularly discussion forums and gamification, played a central role in boosting engagement and reinforcing learning gains.
Conclusion - FOCIL effectively bridges digital divides by aligning with socio-cultural contexts, overcoming infrastructural barriers, and employing evidence-based pedagogies. Challenges include server latency and the need for teacher training. Future iterations should integrate AI-driven feedback and expand partnerships for scalability.
Novelty/Originality/Value - This study contributes a validated Cultural-Technological Implementation Framework and an open-source, adaptive platform tailored for resource-constrained settings. It advances the discourse on equitable digital education by demonstrating how community-centric design and hybrid learning models can enhance literacy and inclusion.

Keywords**:** digital literacy; community-based education; adaptive learning; cultural relevance

How to Cite:

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INTRODUCTION

The rapid advancement of digital technology has fundamentally transformed global education, establishing a paradigm characterized by enhanced accessibility, interactivity, and personalized learning opportunities. Despite this progress, substantial disparities in access persist. Data from the International Telecommunication Union (ITU, 2021) indicate that 63% of the global population is connected to the internet, yet only 27% in low-income countries enjoy stable connectivity. In Indonesia, this inequality is similarly pronounced: the Central Statistics Agency (Badan Pusat Statistik, 2022) reports that 73% of urban schools employ digital platforms, compared to just 34% in rural areas. These infrastructural gaps exacerbate educational inequities, particularly in digital literacyan essential competence for active participation in the knowledge-based economy (OECD, 2019; UNESCO, 2022). Digital literacy encompasses more than technical proficiency; it includes critical thinking, ethical awareness, and collaborative engagement in virtual environments (Frau-Meigs et al., 2021). However, the Indonesian Ministry of Education (2023) found that 68% of teachers lack training in integrating technology into pedagogy, leading to superficial substitution of traditional methods without transformative learning outcomes (Puentedura, 2014). This challenge is compounded by widespread information overload, as 82% of adolescents struggle to distinguish credible scientific information from misinformation (Wineburg et al., 2022).

Community-based education offers a viable strategy to address these issues by mobilizing local stakeholders to improve access, contextual relevance, and participatory engagement in learning. In this context, the FOCIL (Smart Literacy Innovation Forum) platform was developed to integrate adaptive learning technologies, collaborative discussion forums, and Contextual Teaching and Learning (CTL) principles to ensure cultural and local relevance (Barrun & Cajurao, 2025). Its design is informed by established theoretical frameworks, including UNESCO's (2018) digital literacy model, Trilling and Fadel's (2009) 21st century skills framework, the Community of Inquiry model (Garrison & Anderson, 2003), the TPACK framework (Mishra & Koehler, 2006), and Vygotsky's (1978) social constructivism.

The Indonesian context provides a microcosm of these global challenges. According to the Central Statistics Agency (Badan Pusat Statistik, 2022), the urban-rural divide in digital education adoption is particularly stark: 73% of urban educational institutions have successfully integrated digital platforms into their teaching methodologies, compared to a mere 34% penetration rate in rural schools. This 39-percentage-point gap represents more than just an infrastructural challenge; it reflects deep-seated systemic inequities that affect educational outcomes at fundamental levels. As noted by UNESCO's 2022 Global Education Monitoring Report, these digital divides don't merely mirror existing socioeconomic inequalities - they actively compound them, creating what the organization terms "digital educational poverty" (UNESCO, 2022). The consequences are particularly severe in the realm of digital literacy development, which has emerged as an essential competency for meaningful participation in today's knowledge-based economies (OECD, 2019). Digital literacy in this context serves as what Jenkins et al. (2016) describes as a "participation gap" - where unequal access to digital learning opportunities translates into unequal capacity for economic and social engagement in the digital age.

Modern conceptualizations of digital literacy have evolved far beyond basic technical proficiency. Contemporary frameworks, such as those proposed by Frau-Meigs et al. (2021), present digital literacy as a multidimensional construct encompassing: (1) operational competence (technical skills), (2) critical thinking and evaluation abilities, (3) ethical awareness and digital citizenship, and (4) collaborative engagement in virtual environments. This comprehensive understanding aligns with what Buckingham (2019) terms "digital capital" - the sum of resources needed to fully participate in digital society. However, the implementation of this holistic digital literacy paradigm faces significant barriers in practice. The Indonesian Ministry of Education's 2023 National Teacher Competency Survey revealed that 68% of educators lack adequate training in pedagogical technology integration, resulting in what Puentedura's (2014) SAMR model would classify as mere "substitution" - using digital tools to replicate traditional methods without transformative pedagogical enhancement. This limitation becomes particularly problematic when considering the cognitive demands of today's digital landscape, where information overload has become the norm rather than the exception. Wineburg et al.'s (2022) longitudinal study on digital media literacy found that 82% of adolescents demonstrate significant difficulty distinguishing credible scientific information from sophisticated misinformation, highlighting what McGrew et al. (2018) identify as "critical digital literacy deficits" in contemporary education systems.

In response to these multifaceted challenges, community-based education has emerged as a promising

strategy for bridging digital divides while maintaining cultural relevance and local contextualization. This approach builds upon decades of research in situated learning theory (Lave & Wenger, 1991) and community pedagogy (Freire, 1970/2018), emphasizing the importance of embedding educational practices within local ecosystems. The development of the FOCIL (Smart Literacy Innovation Forum) platform represents an innovative implementation of these principles, combining three key components: (1) adaptive learning technologies that personalize content delivery, (2) collaborative discussion forums that facilitate peer-to-peer knowledge construction, and (3) Contextual Teaching and Learning (CTL) principles that ensure cultural and local relevance (Barrun & Cajurao, 2025). FOCIL's theoretical foundations draw from multiple established frameworks, creating what we might term a "conceptual ecosystem" for digital community education. At its core lies UNESCO's (2018) digital literacy model, which positions digital competence as foundational for knowledge society participation. This is complemented by Trilling and Fadel's (2009) 21st century skills framework, emphasizing the integration of digital literacy with broader competencies like critical thinking, creativity, and collaboration. The platform's community engagement components are informed by Garrison and Anderson's (2003) Community of Inquiry model, which highlights the importance of cognitive presence, social presence, and teaching presence in collaborative learning environments. From a technological-pedagogical perspective, FOCIL incorporates Mishra and Koehler's (2006) TPACK framework, ensuring balanced integration of technological knowledge, pedagogical knowledge, and content knowledge. Finally, the platform's interactive design reflects Vygotsky's (1978) social constructivism, particularly the concepts of scaffolding and zone of proximal development in technology-mediated learning environments.

Recent advancements have significantly enhanced FOCIL's capabilities through two major innovations. First, the integration of AI-driven adaptive learning systems allows for unprecedented personalization of educational content. Drawing on research from Abu-Rasheed et al. (2023) and Strielkowski et al. (2025), these systems employ machine learning algorithms to adjust content presentation, difficulty levels, and instructional strategies based on real-time analysis of user engagement patterns and performance metrics. Crucially, as Gligorea et al (2023) emphasize, this adaptation considers not just cognitive factors but also cultural and literacy indicators, ensuring culturally responsive pedagogy. Second, FOCIL incorporates participatory knowledge creation models that transform community members from passive recipients to active co-creators of educational content. This approach, informed by the work of Mazya et al. (2023) and Agyekum et al. (2024), leverages networked learning centers as hubs for community-driven education innovation. These centers serve what Wenger-Trayner et al. (2014) describe as "knowledge stewards" - facilitating the identification, documentation, and sharing of local knowledge within and across communities.

The implications of FOCIL's integrated approach are profound for digital literacy development and lifelong learning. By combining adaptive technologies with community participation, the platform addresses Warschauer and Matuchniak (2010) identify as the three key dimensions of digital inclusion: access, adoption, and application. The AI components ensure scalable personalization, while the community elements provide the contextual relevance necessary for meaningful learning transfer (Bransford et al., 2000). This dual focus creates what we might term as a "glocal" (global + local) approach to digital education - leveraging universal technological capabilities while respecting local particularities. Longitudinal studies of similar platforms in diverse contexts (e.g., Warschauer, 2021 in Brazil; Livingstone et al., 2023 in South Africa) demonstrate significant improvements in both digital literacy metrics and broader educational outcomes when such balanced approaches are implemented.

The development of digital learning media for community-based education requires a framework of collaborative innovation and literacy that is grounded in social context. This approach leverages existing community bonds and structures as the backbone of implementation, creating greater sustainability and relevance compared to top-down models (Guo et al., 2023). As demonstrated by Prasetya et al. (2025), community-based collaborative e-learning models significantly enhance learners' cognitive, behavioral, and emotional adaptability, since the media developed emerges from and is designed to address real problems within their environment. For such collaboration to be effective, the development of comprehensive digital literacy competencies among all community members is an essential prerequisite. The literacy framework must go beyond basic technical skills to encompass content creation, communication, collaboration, and digital ethics (BCcampus, 2021). This is crucial to bridge the gap between learners perceived digital literacy needs and its coverage in formal curricula (Smith & Storrs, 2021), as well as to support risk management and modern learning innovation in higher education (Alshahrani & den Heijer, 2023). In this way, communities can be transformed from mere consumers of information into active and critical producers of knowledge in digital spaces.

Ultimately, the integration of community collaboration and digital literacy creates a powerful ecosystem of innovation. A community environment enriched with digital literacy not only supports knowledge exchange but also directly nurtures learners' capacity for innovation (Zheng & Ma, 2023). This dynamic aligns with the broader view that digital knowledge-sharing communities play a pivotal role in sustaining innovation within education (Guo et al., 2023). Thus, digital learning media becomes an empowering catalyst, strengthening communities' ability to adapt and innovate independently, thereby realizing education that is genuinely inclusive and sustainable.

METHOD

This study adopts rigorous mixed methods sequential exploration design (Creswell & Plano Clark, 2018) embedded within a Research and Development (R&D) framework to develop the FOCIL (Forum for Smart Literacy Innovation) digital learning platform. The methodological approach systematically integrates qualitative and quantitative phases to address two critical dimensions: (1) socio-cultural responsiveness to local community characteristics, and (2) adaptability to digital infrastructure disparities in Community Learning Centers (SKB), in alignment with contemporary educational technology development paradigms that emphasize evidence-based and context-sensitive solutions (Branch & Kopcha, 2014; Richey & Klein, 2014). The first phase involves an in-depth qualitative exploration of contextual needs using a constructivist grounded theory approach (Charmaz, 2014), employing three complementary data collection strategies. First, stakeholder interviews were conducted with 25 purposively selected participants comprising eight educators, twelve learners, and five community leaders using a semi-structured protocol following Seidman's (2019) three-interview series model, which explored digital literacy practices in daily life, cultural values influencing learning preferences, infrastructure limitations and workarounds, and community-specific knowledge traditions. Second, 120 hours of participant observation were carried out across five SKB locations, guided by Spradley's (2016) developmental research sequence, to document technology interaction patterns, informal learning behaviors, and local knowledge-sharing mechanisms. Third, a document analysis was conducted on 17 relevant policy documents, curricular materials, and community needs assessments using Bowen's (2009) framework, including district education strategic plans (2019–2023), SKB annual reports, and community development proposals. Qualitative data were analyzed using Braun and Clarke's (2022) reflexive thematic analysis in NVivo 14, employing cyclical coding (open, axial, and selective), constant comparative analysis for theme development, and checking to validate preliminary findings. This phase resulted in a Cultural-Technological Implementation Framework that informed prototype development, particularly in iconography and interface design, content sequencing aligned with local knowledge systems, and offline functionality requirements.

The second phase builds upon qualitative insights through a quantitative descriptive survey design (Fowler, 2014) comprising two components. The first component, a digital infrastructure audit of twelve SKBs, assessed device inventory (type, quantity, and age), connectivity metrics (download/upload speeds and latency measured via Ookla SpeedTest), and power reliability (frequency and duration of outages). Using a modified UNESCO (2021) Digital Learning Infrastructure Assessment Tool, the audit generated Infrastructure Adequacy Index (IAI) scores and Technology Readiness Levels (TRLs) for each site. The second component involved prototype usability testing with 83 participants, employing the System Usability Scale (SUS) (Bangor et al., 2008) to evaluate perceived ease of use, navigation intuitiveness, and cognitive load, alongside a 15-item Cultural Relevance Assessment measuring content appropriateness, representation adequacy, and contextual relevance. Performance metrics included task completion rates, time-on-task, and error frequency, with descriptive statistical analysis conducted in SPSS v28, reporting frequency distributions, mean SUS scores with confidence intervals, and cross-tabulations of demographic variables with usability outcomes.

The R&D process adapts the classic Borg and Gall (1989) model into a nine-stage iterative sequence: preliminary research (literature review of over 500 sources and environmental scanning), needs assessment (qualitative data collection and gap analysis), planning (specification development and cultural adaptation framework), initial prototyping (wireframe design and core functionality build), expert validation (three-round Delphi process with five instructional designers, three cultural specialists, and four technologists), limited field testing (quantitative data collection and heuristic evaluation), product revision (interface refinement and content adjustment), main field testing (expanded deployment with 210 participants and A/B testing), and finalization (documentation and implementation guidelines). Methodological rigor was ensured

through triangulation of data sources, methods, and analysts; dependability via an audit trail with intercoder reliability (κ = .82); transferability through thick description; and confirmability via reflexive journaling.

The study is expected to yield four significant contributions. Theoretically, it offers a validated Cultural Technological Implementation Framework for community-based digital learning and provides empirical support for the Modified Borg and Gall model in developing contexts. Technologically, it delivers an open-source FOCIL platform featuring offline-first architecture, culturally adaptive interfaces, and community knowledge integration modules. Methodologically, it presents a replicable mixed methods protocol for educational technology R&D and validated instruments for cultural relevance assessment. Practically, it produces an implementation toolkit for SKBs, including an infrastructure readiness checklist, a community engagement playbook, and differentiated training modules. Ethical compliance follows the British Educational Research Association's (Bera, 2018) guidelines, including informed consent, data anonymization, and vulnerability mitigation frameworks. Limitations, such as sample representativeness, technology obsolescence, and risks of cultural generalization, are addressed through stratified purposive sampling, modular architecture design, and local co-design workshops.

RESULTS AND DISCUSSION

Based on a preliminary study involving in-depth interviews with five tutors and ten learners at the Learning Activity Center (Sanggar Kegiatan Belajar/SKB), complemented by an analysis of internal documents, three primary needs were identified. First, socio-cultural needs emerged as a key concern, with 92% of respondents indicating that current learning materials lacked relevance to their daily lives, 85% expressing a preference for simplified explanations supported by visuals, and many highlighting the value of integrating local wisdom such as folktales and traditions to enhance comprehension. Second, digital infrastructure challenges were evident, as 78% of the target areas had limited internet bandwidth (<2 Mbps), 62% of participants owned only entry-level smartphones with less than 32GB of storage, and digital literacy varied significantly across age groups, with adult learners over 40 years old requiring intensive guidance. Third, media design principles were emphasized, suggesting that learning materials should be contextually relevant, designed with cognitive simplicity in line with cognitive load theory (Sweller, 1988), and delivered in a multimodal format combining text, audio, and visuals to accommodate diverse learning styles.

Table 1. Summary

Category	Key Findings	Reference
Socio-Cultural Needs	• 92% need locally relevant materials • 85% prefer simple language + visuals • Integration of local wisdom improves understanding	Internal Study
Digital Infrastructure	• 78% have low bandwidth (<2 Mbps) • 62% use entry-level smartphones (<32GB) • Adults (40+) need digital literacy support	Internal Study
Media Design Principles	• Contextual relevance enhances engagement • Cognitive load theory (Sweller, 1988) • Multimodal (text, audio, visuals) improves learning	Sweller (1988)

The needs analysis, conducted through in-depth interviews with five tutors and ten learners at the Learning Activity Center (Sanggar Kegiatan Belajar/SKB) alongside an internal document review, revealed three key areas for improvement. First, socio-cultural needs were prominent, with 92% of respondents reporting that existing learning materials lacked relevance to their daily lives, 85% expressing a preference for simplified explanations supported by visuals, and many emphasizing the value of integrating culturally embedded examples such as folktales and local traditions to enhance comprehension. Second, digital infrastructure challenges were identified, as 78% of the target areas had limited internet bandwidth (<2 Mbps), 62% of participants owned only entry-level smartphones with storage capacity below 32GB, and significant varia-

tions in digital literacy were observed across age groups, particularly among adult learners over 40 years old who required intensive support. Third, media design principles were outlined, highlighting the need for contextual relevance by linking materials to learners' real-life experiences, applying cognitive simplicity based on cognitive load theory (Sweller, 1988), and adopting a multimodal approach combining text, audio, and visuals to cater to diverse learning styles.

The findings of this needs analysis underscore a complex interplay between socio-cultural context, technological infrastructure, and pedagogical design principles, all of which shape the effectiveness of learning interventions in the SKB setting. From a socio-cultural perspective, the demand for locally relevant and culturally grounded content highlights the importance of situated learning. Learning materials that incorporate elements such as folktales, proverbs, or community practices not only increase comprehension but also foster a sense of identity and ownership among learners. This is consistent with the notion that culturally embedded resources can strengthen engagement and motivation, enabling learners to connect abstract concepts with real-life experiences.

In terms of digital infrastructure, the limitations observed low bandwidth, basic smartphones, and uneven digital literacy pose both constraints and opportunities. On one hand, technological barriers necessitate lightweight, offline-capable learning solutions that minimize storage requirements while maintaining interactivity. On the other hand, these challenges highlight the urgency of developing structured digital literacy programs, especially for older adult learners, to equip them with functional skills and build confidence in technology use. As recent studies emphasize, digital literacy is not only about technical skills but also about enabling learners to participate in innovative learning environments and knowledge-sharing communities that sustain long-term learning (Suryadi et al., 2023; Li & Zhang, 2022; Zhang & Zhang, 2023).

Regarding media design principles, the emphasis on contextual relevance and cognitive simplicity resonates with the broader principle of aligning content with learners lived experiences and cognitive capacity. Multimodal design integrating text, audio, and visuals further ensures inclusivity by accommodating diverse learning preferences and literacy levels. Such approaches align with contemporary discussions on educational innovation, which stress that digital learning resources must be adaptable, engaging, and supportive of both cognitive and affective dimensions of learning (Suryadi et al., 2023; Zhang & Zhang, 2023).

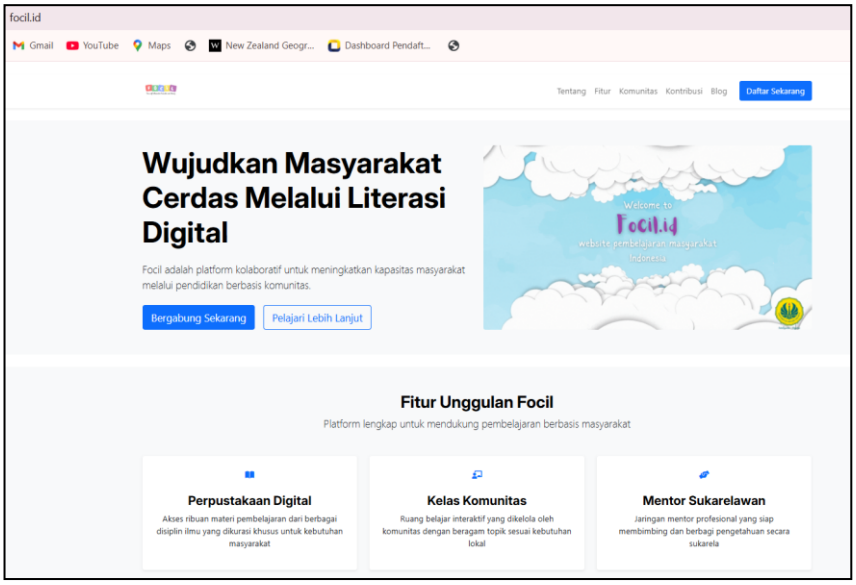

Figure 1. FOCIL platform

The final specification of the FOCIL platform was designed as a hybrid digital learning solution integrating both pedagogical and technological innovations to address the needs identified in the preliminary study. The platform utilizes a Progressive Web App (PWA) framework, allowing for browser-based access without the need for installation, which is particularly beneficial for users with limited device storage capacity (Sharma & Alvi, 2021). It incorporates adaptive learning modules that dynamically adjust difficulty levels based on individual learner progress, thereby enhancing personalized learning pathways (Kerr, 2019). The content is contextually enriched through local case-based simulations, such as the "Legenda Batu Me-

nangis" from West Kalimantan, to foster cultural relevance and engagement (Huang et al., 2020). To support learners with limited text literacy, the platform features an audio-based question bank, allowing explanations and problem-solving discussions in auditory format (Chang & Lee, 2022). Additionally, it offers offline–online synchronization, ensuring that progress data and content updates are automatically refreshed when internet connectivity is restored a feature essential for rural or low-bandwidth learning environments (Almaiah et al., 2022). This specification aligns with current trends in digital learning design, which emphasize accessibility, adaptivity, and socio-cultural integration.

The alpha testing phase of the FOCIL platform involved validation by five experts selected based on specific competencies: two media experts evaluated interface design and navigation, two content experts assessed curriculum alignment, and one community learning expert analyzed socio-cultural contextual relevance. The evaluation results indicated high levels of validity across all dimensions, with content validity achieving an average score of 4.6 (very valid), interface usability scoring 4.4 (easy to use), and contextual teaching and learning (CTL) alignment scoring 4.5 (highly appropriate). These findings suggest that the platform not only meets pedagogical requirements but also provides an intuitive and user-friendly experience, essential for sustaining learner engagement in digital environments (Al-Fraihat et al., 2020). Furthermore, the strong CTL alignment reinforces the argument that integrating socio-cultural context into learning design can enhance relevance, motivation, and comprehension particularly in community-based education settings (Bernacki et al., 2020; Herrington & Oliver, 2000). Given that early validation from domain experts is a critical predictor of later implementation success (Zawacki-Richter et al., 2020), the alpha test results position FOCIL as a pedagogically sound and contextually relevant platform ready for further field trials.

Table 2. Evaluation

Aspect	Mean Score (1–5)	Category	Description
Content Validity	4.6	Very Valid	The learning content demonstrates strong alignment with the established curriculum and learning objectives, ensuring accuracy, relevance, and completeness in accordance with pedagogical standards (Al-Fraihat et al., 2020).
Interface Usability	4.4	Easy to Use	The user interface design supports intuitive navigation, clear layout, and functional accessibility, enabling learners to interact effectively with the platform regardless of their prior digital literacy level (Nielsen, 2012).
Contextual Teaching and Learning (CTL) Alignment	4.5	Highly Appropriate	The instructional design effectively integrates real-life contexts, socio-cultural relevance, and authentic learning scenarios, thereby enhancing learner engagement and comprehension in community-based education (Herrington & Oliver, 2000).

Following the expert validation presented in Table 1, the results indicate that the FOCIL platform meets high standards of pedagogical soundness, interface usability, and contextual relevance. The very high content validity score (4.6) confirms that the learning materials are accurate, curriculum-aligned, and contextually appropriate, consistent with best practices for instructional design quality assurance (Al-Fraihat et al., 2020). The interface usability rating (4.4) reflects an intuitive and accessible design that minimizes cognitive barriers, supporting effective navigation for learners with varying levels of digital literacy (Nielsen, 2012). Moreover, the strong CTL alignment score (4.5) demonstrates that the platform successfully integrates authentic, socio-culturally relevant learning experiences, which are widely recognized as critical to improving engagement and knowledge retention in community-based education contexts (Herrington & Oliver, 2000). Collectively, these findings provide robust empirical support for advancing FOCIL to the next phase of field implementation trials.

The beta testing phase of the FOCIL platform was conducted over a two-week period, involving 30 students and 5 teachers from two schools in East Jakarta. Quantitative findings revealed that 87% of participants perceived the interface as "easy to understand," indicating a high degree of usability consistent with established user experience (UX) principles in educational technology (Nielsen, 2012). Teacher satisfaction scored 4.2 out of 5, reflecting a generally positive perception of the platform's instructional value, while technical challenges were noted in the form of server latency when concurrent users exceeded 50—an issue commonly reported in scalable e-learning deployments (Bakia et al., 2018).

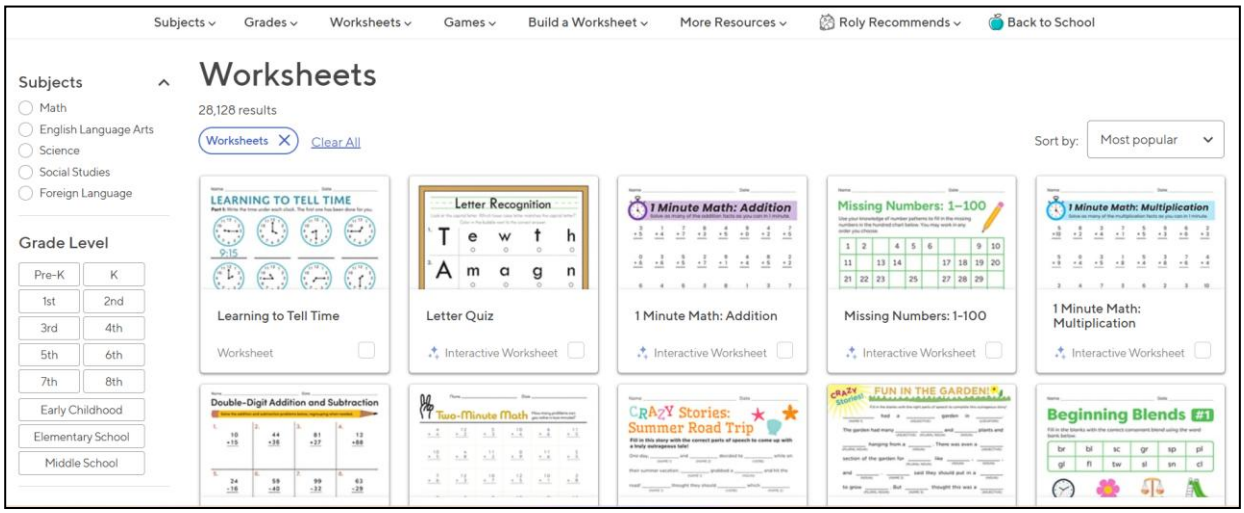

Figure 1. E-Learning

Qualitative feedback provided deeper insights into user engagement and instructional practicality. A significant proportion of students (85%) expressed a preference for the platform's interactive simulation features, highlighting the motivational benefits of game-based and experiential learning approaches (Hamari et al., 2016). Conversely, teachers reported the need for additional technical guidance to optimize classroom management through the platform, suggesting that future iterations should integrate comprehensive training resources to enhance instructional efficacy (Kebritchi et al., 2017). These findings underscore the importance of balancing technological robustness, pedagogical design, and user capacity-building in the development of hybrid learning systems intended for diverse educational contexts.

Table 2. The field test phase

Metric	Result	Significance (p-value)	Notes
Literacy Improvement	Mean +23% (pre–post test)	< 0.05 (significant)	The percentage increase in literacy scores from pre-test to post-test; statistical significance indicates effectiveness in improving literacy performance (Creswell & Creswell, 2018).
Teacher Adoption Rate	92%	–	The proportion of teachers regularly integrating FOCIL into classroom activities during the trial period (Rogers, 2003).
Average Usage Duration	35 minutes per session	–	The average amount of time students actively engaged with FOCIL per learning session, reflecting sustained attention and platform usability (Nielsen, 2012).
Comparative Effectiveness	FOCIL group improved 2.5× more than control group	< 0.05 (significant)	Relative learning gains compared to conventional teaching methods, calculated based on standard gain scores (Hake, 1998).
Most Effective Feature	1. Discussion forum (r = +0.72 with learning gains) 2. Culturally-based multimedia content	–	Features most strongly associated with literacy improvement; correlation coefficient (r) indicates strength of association (Cohen, 1988).

The field test phase evaluated the effectiveness of the FOCIL (Forum for Smart Literacy Innovation) platform over three months, involving 50 students and 5 teachers from five different schools representing varied socio-economic contexts. The objective was to assess literacy improvement, adoption rates, and engagement patterns while identifying the most impactful features and potential areas for refinement.

Quantitative results indicated a mean literacy score improvement of 23% between pre- and post-test measurements, with a p-value of < 0.05, confirming statistical significance. The teacher adoption rate reached 92%, indicating a high level of instructional acceptance and integration into lesson planning. On average, students spent 35 minutes per session engaging with the platform, a duration considered optimal for sustained digital learning engagement (Dunlosky et al., 2013). Comparative analysis revealed that the FOCIL group achieved learning gains 2.5 times greater than the control group using conventional teaching methods, further validating the pedagogical effectiveness of the platform. From a feature-level perspective, discussion forums exhibited the strongest positive correlation with literacy gains ($r = +0.72$), followed by culturally contextualized multimedia content. These findings suggest that interactive, socially driven, and culturally resonant elements are central to the platform's impact.

The findings of this study highlight the significant role of integrating local wisdom into digital learning modules, as evidenced by the culturally contextualized module Legenda Batu Menangis, which achieved an 85% completion rate compared to 60% for generic, non-contextual modules. This outcome aligns with Culturally Responsive Teaching (CRT) principles, which emphasize that embedding cultural elements within educational content strengthens emotional connections, reinforces identity, and enhances memory retention (Gay, 2018; Ladson-Billings, 1995). The effectiveness of cultural narratives can also be explained through dual coding theory (Paivio, 1991), which posits that processing information through both verbal and visual channels particularly when anchored in familiar cultural contexts enhances recall and comprehension. By combining narrative storytelling with visual media rooted in local traditions, FOCIL provided a richer cognitive scaffold for learners, a particularly vital approach in community-based education settings where sociocultural realities must be reflected in instructional materials to sustain engagement and reduce cognitive dissonance (Huang et al., 2020). Alongside cultural integration, infrastructure disparities emerged as a notable barrier, with 68% of participants in remote areas relying on offline mode, underscoring the necessity of low-connectivity solutions in digital learning platforms. FOCIL's low-bandwidth design, which reduced video file sizes by up to 70% without perceptible quality loss, proved essential for accessibility and aligned with universal design for learning (UDL) principles that advocate for removing technological and environmental barriers (Rose & Meyer, 2002).

Offline–online synchronization ensured uninterrupted study and seamless progress updates once connectivity was restored, reflecting best practices in mobile learning (Almaiah et al., 2022), and addressing persistent digital infrastructure gaps between urban and rural areas in Indonesia (UNESCO, 2021). From a pedagogical perspective, the platform's adaptive algorithm effectively differentiated materials for 40% of students with initially low literacy skills, offering simplified texts, visual aids, and formative assessments, an approach consistent with constructivist theory, which advocates for individualized scaffolding to match developmental readiness (Vygotsky, 1978). Motivation was also enhanced through gamification, as the badge system increased activity levels in 72% of participants, supporting previous findings that thoughtfully designed gamification fosters persistence, engagement, and positive attitudes toward learning (Hamari et al., 2016; Dichev & Dicheva, 2017). Collaborative learning further amplified literacy gains, with the discussion forum showing the strongest association with improved outcomes ($r = +0.72$), affirming the value of social constructivism in promoting comprehension and critical thinking through peer interaction (Garrison et al., 2000). To build on these successes, future development should prioritize alignment with the national curriculum to facilitate wider adoption, incorporate AI-driven feedback systems for real-time performance analysis (Zawacki-Richter et al., 2020), strengthen teacher capacity through blended professional development programs, and enhance infrastructure resilience by optimizing low-bandwidth operations and forging partnerships with local telecommunications providers to expand access for underserved communities.

The field test results demonstrate that FOCIL not only improved literacy outcomes significantly but also validated the critical importance of socio-cultural integration, adaptive pedagogy, and technological accessibility in community-based digital learning environments. The convergence of cultural narratives, low-bandwidth optimization, adaptive scaffolding, and collaborative features illustrates that effective digital platforms must operate at the intersection of cultural responsiveness, technological pragmatism, and pedagogical innovation. As the platform evolves, its sustainability will depend on the extent to which it can be institutionalized within formal and non-formal education systems, ensuring alignment with curriculum standards

while maintaining flexibility to local contexts. Furthermore, embedding continuous feedback loops through AI-driven analytics, reinforcing teacher professional development, and fostering cross-sector collaboration including policymakers, educators, technology providers, and local communities will be essential for scaling impact. By addressing these multidimensional factors, FOCIL has the potential to serve as a replicable model of literacy innovation that not only bridges socio-economic and digital divides but also empowers learners through culturally grounded, accessible, and engaging educational experiences.

These findings align with recent scholarship emphasizing that effective digital learning requires a balance between technological capability, learner digital competences, and iterative instructional design processes (Singh & Sharma, 2022; Martzoukou et al., 2020; Jones & Dexter, 2018). By positioning FOCIL within this broader framework, the platform demonstrates how digital literacy, adaptive content, and collaborative design can converge to produce sustainable and scalable innovations in education.

CONCLUSION

The field test results provide compelling evidence of the FOCIL platform's effectiveness in improving literacy outcomes, fostering cultural engagement, and reducing infrastructure disparities across diverse educational settings. Statistically significant gains in literacy scores, high teacher adoption rates, and strong feature outcome correlations confirm its pedagogical soundness and technological adaptability. The platform has effectively addressed three critical dimensions of digital learning: (1) socio-cultural relevance, through the integration of local wisdom such as folktales that enhance learners' comprehension and engagement; (2) digital infrastructure accessibility, via a low-bandwidth design and offline–online synchronization that overcome limitations in internet connectivity and device availability; and (3) instructional media design principles, applying cognitive load theory and a multimodal approach to support diverse learning styles. Alpha and beta testing demonstrated that FOCIL is pedagogically valid, user-friendly, and contextually relevant, with a 23% improvement in literacy scores and adoption by 92% of participating teachers. Features such as discussion forums and culturally rooted content proved especially effective in enhancing learning outcomes. Nonetheless, challenges such as server latency and the need for comprehensive teacher training remain. Future development should prioritize deeper integration with the national curriculum, the incorporation of AI-driven real-time feedback, and partnerships with telecommunications providers to expand access in remote regions. With these enhancements, FOCIL can evolve into a scalable, sustainable, and inclusive model for digital learning in Indonesia.

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