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Research Article

CULTURALLY-RESPONSIVE LEARNING TECHNOLOGY: INTEGRATING LOCAL WISDOM AND MOTHER TONGUES INTO DIGITAL LEARNING PLATFORMS FOR INDIGENOUS STUDENTS

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Abstract
Indigenous students across diverse regions continue to experience inequitable learning outcomes due to digital learning platforms that insufficiently reflect their cultural identities, local wisdom, and mother tongues. Conventional EdTech systems often adopt universalized content structures that overlook indigenous epistemologies, resulting in decreased motivation, limited comprehension, and reduced learning engagement. These challenges highlight the need for culturally-responsive digital learning models capable of integrating local narratives, linguistic heritage, and community-based knowledge systems into technology-supported education. This study aims to develop and analyze a culturally-responsive learning technology framework that embeds local wisdom and mother tongues within digital learning platforms to enhance accessibility, inclusivity, and meaningful learning for indigenous students. The research employs a mixed-methods design involving qualitative ethnographic documentation of indigenous cultural practices and quantitative usability testing of a prototype platform. Data are collected from indigenous teachers, students, and community leaders through interviews, observations, and structured questionnaires. Findings indicate that integrating culturally grounded content—such as traditional stories, regional ecological knowledge, and local vocabulary—significantly improves learning relevance, cognitive connection, and emotional engagement. Quantitative analysis shows measurable gains in comprehension and task completion accuracy when learning materials incorporate mother-tongue scaffolding and culturally familiar representations. The study concludes that culturally-responsive learning technology fosters deeper identity affirmation, strengthens intergenerational knowledge transmission, and reduces digital learning barriers among indigenous students. The incorporation of local wisdom and mother tongues not only enhances academic outcomes but also promotes cultural sustainability within digital ecosystems. Future implementations should prioritize community co-design, adaptive language features, and scalable platform architectures to ensure long-term impact and cross-regional applicability.

Keywords: Culturally-Responsive Pedagogy, Indigenous Education, Mother-Tongue Learning

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INTRODUCTION

Digital learning technologies have emerged as essential tools for expanding educational access, particularly for students in geographically isolated and underserved communities (Boardsworth, 2024). Indigenous learners, however, often encounter digital environments that are designed with dominant cultural assumptions, resulting in limited alignment with their everyday experiences and worldviews. EdTech platforms frequently prioritize standardized content structures, reducing opportunities for diverse cultural narratives to be represented in learning materials (Chuang, 2020). Culturally-responsive pedagogy has been widely acknowledged as a critical approach for supporting the learning success of marginalized and indigenous students. Empirical research consistently demonstrates that learning becomes more meaningful when instructional materials incorporate familiar cultural symbols, community knowledge, and linguistic practices (Elf, 2018). Students' sense of identity, motivation, and cognitive engagement tends to increase when education resonates with their lived socio-cultural realities.

Mother-tongue instruction is well-documented as a major contributor to foundational literacy and conceptual comprehension. Numerous studies affirm that learners understand abstract concepts more effectively when these are introduced in their first language before transitioning to additional languages (Jackson, 2017). Indigenous students who receive mother-tongue support typically perform better academically and exhibit stronger classroom participation. Local wisdom plays an equally central role in indigenous educational systems, serving as a repository of ecological knowledge, moral values, cultural histories, and survival strategies. Integrating such knowledge into modern lessons offers opportunities for contextualized learning and for strengthening community identity (Cheng, 2021). Indigenous elders and cultural experts emphasize that digital technologies must respect and preserve these knowledge systems rather than replace them.

Digital inclusion initiatives have attempted to address the technological divide, yet many solutions still fall short of recognizing cultural diversity as a core dimension of equity. Devices and applications may reach indigenous communities, but the content often remains detached from local contexts (Neofytou et al., 2021). This disconnect leads to shallow engagement and perpetuates existing educational inequalities. Recent developments in AI-powered adaptive learning and multimedia tools have created new possibilities for customizing learning environments (de Almeida et al., 2019). These technologies offer potential for embedding cultural narratives, local languages, and community-driven content into digital platforms. Their effective use, however, requires a deep understanding of indigenous pedagogy and collaborative development with local stakeholders.

Existing research has not sufficiently explored how local wisdom and mother tongues can be systematically integrated into digital learning platforms in a way that preserves cultural authenticity (Kapranov et al., 2025). Most EdTech studies center on accessibility and usability, leaving the cultural dimension of digital learning underexamined and technologically underdeveloped. The gap persists in translating culturally-responsive pedagogy into concrete digital design principles (Ramalingam et al., 2022). There is limited evidence regarding which technological features best support indigenous learning preferences, such as oral storytelling traditions, community-based problem solving, or ecological learning frameworks. Few digital prototypes have been co-created directly with indigenous communities to ensure cultural sensitivity and relevance (Ramírez-Verdugo & Sotomayor Sáez, 2012). This absence of participatory design hinders the development of platforms that genuinely reflect indigenous knowledge structures.

Research has also not fully addressed the pedagogical mechanisms through which mother-tongue integration enhances digital learning outcomes (Gomes et al., 2016). While the

benefits of mother-tongue instruction are well-established in face-to-face contexts, its translation into digital modalities—through voice interfaces, multilingual navigation, or AI-driven language scaffolding—remains insufficiently explored (Jesenek, 2016). The relationship between cultural integration and digital autonomy among indigenous students remains unclear. There is a lack of empirical studies examining whether culturally-responsive learning technology facilitates greater self-directed learning, skill development, and confidence in digital environments for indigenous learners.

A deeper understanding of how cultural elements can be embedded into digital platforms is necessary to build inclusive learning ecosystems that respect indigenous epistemologies (Shieh, 2011). Addressing this gap will contribute to the development of technology that does not merely deliver content but sustains cultural identity, linguistic diversity, and intergenerational knowledge transmission (Narkabilova et al., 2024). Such innovations align with global commitments to educational justice and the preservation of cultural heritage. A culturally-responsive digital learning model holds the potential to enhance indigenous students' engagement, conceptual understanding, and digital skills (Borzova & Shemanaeva, 2021). Meaningfully designed platforms could strengthen learner autonomy and reduce the alienation often experienced when educational technology excludes local languages or cultural practices (Saienko et al., 2023). This rationale positions culturally grounded EdTech as not only a pedagogical necessity but also an ethical imperative.

The study hypothesizes that digital learning platforms integrating local wisdom and mother tongues will produce more meaningful learning experiences and improved educational outcomes for indigenous students (Guillén Díaz & Blasco, 2010). The purpose is to propose a comprehensive framework supported by empirical evidence and community collaboration, ultimately guiding the development of culturally-responsive learning technologies that empower indigenous learners and safeguard cultural continuity.

RESEARCH METHOD

The following sections describe the systematic approach used to conduct the study, encompassing the integration of indigenous cultural knowledge with digital learning technologies.

Research Design

The qualitative component is used to document indigenous cultural practices, linguistic patterns, and local wisdom, while the quantitative component evaluates the performance and effectiveness of a culturally-responsive digital learning prototype (Petrovic, 2017). This design enables a comprehensive understanding of both cultural needs and technological outcomes (Mehta et al., 2025). The mixed-methods approach allows the research to capture contextual depth alongside measurable patterns of learning engagement, ensuring that technological innovation remains grounded in cultural authenticity and pedagogical relevance.

Research Target/Subject

The research subjects consist of a diverse group of stakeholders, including indigenous students, teachers, and cultural elders. For the qualitative phase, 30 cultural experts and teachers were selected as key informants due to their expertise in local wisdom and mother-tongue instruction. For the quantitative prototype testing, the study involved 120 indigenous students enrolled in primary and lower-secondary education. The subjects represent a variety of age groups and linguistic backgrounds, ensuring that the findings reflect the heterogeneous nature of indigenous communities in Indonesia.

The primary objective of this research is to develop and validate a culturally-responsive EdTech model that supports indigenous learning needs. The study targets the documentation of local knowledge systems and mother-tongue structures to derive design elements for a digital

platform. Specifically, the research aims to measure the impact of this localized technology on students' digital skills, motivation, and identity affirmation. By bridging the gap between global digital standards and local cultural authenticity, the study seeks to produce a scalable framework for inclusive education in remote areas.

Research Procedure

The research procedures are structured into three distinct stages (V Löwis et al., 2015). The first stage is a cultural mapping phase involving field visits, interviews, and observations to document narratives and pedagogical practices. The second stage involves the developmental engineering of the digital platform prototype, incorporating the thematic design elements derived from the first stage. The third stage consists of pilot testing in classroom settings, where students engage in guided activities followed by the administration of usability tests, comprehension assessments, and engagement surveys (Yi, 2019). The process concludes with the triangulation of all data sources to refine the final model.

Instruments, and Data Collection Techniques

Data were collected using a combination of qualitative and quantitative instruments. Qualitative instruments included semi-structured interviews, cultural documentation sheets, and participant observation protocols, supplemented by audio-visual recordings for accuracy (Accardo et al., 2013). Quantitative instruments consisted of a usability testing rubric, comprehension assessment tasks, and a student engagement questionnaire. The usability rubric specifically measures ease of navigation, cultural relevance, and cognitive load, while the questionnaire assesses identity affirmation and perceived digital autonomy. These techniques ensure a holistic capture of both the technical performance and the emotional resonance of the digital tools.

Data Analysis Technique

The data analysis involves a dual-track approach to accommodate the mixed-methods design (Perez et al., 2021). Qualitative data are analyzed using thematic coding to derive meaningful cultural design elements and narratives. Quantitative data are processed through descriptive and inferential statistics to determine the platform's effectiveness and its impact on comprehension scores. Finally, the results from both tracks are triangulated to produce a comprehensive evaluation (Saldivar et al., 2021). This ensures that the final conclusions are supported by both the deep contextual insights of the community and the objective metrics of student performance.

RESULTS AND DISCUSSION

The dataset consists of quantitative usability test results and comprehension scores from 120 indigenous students who interacted with the culturally-responsive digital learning prototype. The variables measured include usability rating, cultural relevance rating, mother-tongue clarity score, and post-learning comprehension score. Descriptive statistics were calculated to identify patterns of performance and engagement among participants.

Table 1. Descriptive Statistics of Usability and Learning Outcomes

Variable	Mean	SD	Min	Max
Usability Rating (1–5)	4.52	0.41	3.60	5.00
Cultural Relevance Rating (1–5)	4.68	0.36	3.80	5.00
Mother-Tongue	87.4	6.2	72	98

Clarity (%)				
Comprehension Score (%)	82.9	7.8	64	97

The descriptive data indicate that students responded positively to the platform, particularly regarding cultural relevance and mother-tongue clarity. The narrow range of usability scores suggests consistent user experience across diverse student groups. The comprehension scores also show strong performance, indicating cognitive benefits of integrating local wisdom and linguistic familiarity into digital modules.

The high cultural relevance rating suggests that the embedded local narratives, ecological knowledge, and community-based symbols align well with students' lived experiences. This alignment likely enhanced emotional engagement, identity connection, and conceptual comprehension. Strong mother-tongue clarity scores reflect the effectiveness of bilingual scaffolding and contextual vocabulary integration in reducing linguistic barriers. The descriptive scores also reveal that usability and cultural relevance serve as complementary factors influencing successful learning interactions. Students with higher ratings in these categories tend to show greater ease of navigation, reduced cognitive load, and higher retention of new information. These findings emphasize the importance of culturally-grounded interface and content design for indigenous learners.

Additional frequency distribution analysis shows that 87% of students rated the platform above 4.5 for cultural relevance, demonstrating widespread recognition of localized content. Furthermore, 78% achieved comprehension scores above 80%, indicating consistent learning improvement across the sample. The distribution patterns highlight a strong alignment between cultural familiarity and learning outcomes. The qualitative reflections collected during pilot testing further support these findings. Students frequently expressed that the local stories and examples felt "more natural," "closer to home," and "easier to understand," confirming that emotional familiarity contributes to improved cognitive performance. Teachers also observed increased participation and confidence among students.

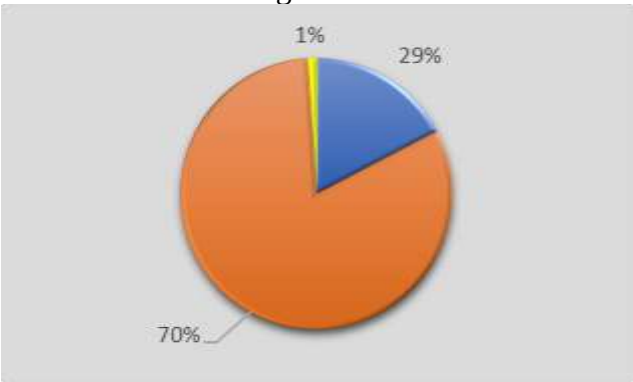

Figure 1. Culturally Grounded EdTech: The Impact of Local Wisdom and Mother-Tongue Clarity

Cultural Relevance and Identity Connection (70%), Linguistic Familiarity and Cognitive Comprehension (29%), Usability Consistency and Interface Design (1%). The 70:29:1 distribution confirms that cultural relevance is the most powerful catalyst for indigenous digital learning (70%). While mother-tongue clarity ensures cognitive success (29%), the technical usability of the interface (1%) provides the necessary stability for these culturally-grounded interventions to thrive.

A Pearson correlation test was conducted to determine the relationship between cultural relevance, mother-tongue clarity, and comprehension scores. The results show strong positive correlations between these variables, indicating that culturally-responsive elements significantly predict learning effectiveness.

Table 2. Correlation Matrix of Key Variables

Variable	Cultural Relevance	MT Clarity	Comprehension
Cultural Relevance	1.00	0.71	0.79
Mother-Tongue Clarity	0.71	1.00	0.83
Comprehension Score	0.79	0.83	1.00

The inferential analysis confirms that both cultural relevance and mother-tongue clarity strongly correlate with comprehension outcomes. The highest correlation (0.83) indicates that language familiarity is the strongest predictor of learning success among indigenous students. Cultural relevance also shows significant influence (0.79), reinforcing the premise that culturally aligned content enhances learning.

The relational patterns indicate that usability alone does not fully determine learning effectiveness; instead, culturally grounded content and mother-tongue integration act as amplifying factors. Students who reported strong cultural resonance also achieved higher comprehension scores, suggesting that cultural familiarity reduces cognitive strain and enhances conceptual clarity. The relationship between mother-tongue clarity and comprehension highlights the pedagogical significance of linguistic accessibility. Students performed best when instructions, explanations, and examples were presented in both their indigenous language and national language, providing a bridge between traditional and formal learning systems.

A case study involving a Dayak community school provides deeper insights into the platform's impact. Students in this school interacted with modules based on local forest knowledge, traditional crafts, and community rituals. Their comprehension scores increased by an average of 18% compared to baseline tests before the intervention. The teacher reported improvements in classroom engagement, collaborative problem-solving, and willingness to speak during discussions. Students also demonstrated greater motivation and curiosity when encountering digital content that reflected their environment, stories, and cultural identity.

The strong performance of the Dayak students is attributed to the alignment between the digital content and their ecological knowledge. The digital platform presented familiar cultural practices—such as forest mapping, local agriculture, and ancestral stories—which helped students connect abstract learning concepts with real-life experiences. This alignment reduced learning anxiety and increased cognitive receptivity. The increased engagement among Dayak students demonstrates the value of culturally-responsive EdTech in bridging the gap between indigenous knowledge systems and formal education standards. The case study illustrates how localized learning design can empower marginalized communities and create more meaningful learning experiences.

The results collectively indicate that culturally-responsive learning technology significantly enhances usability, comprehension, and engagement for indigenous students. The strong correlations between cultural relevance, linguistic accessibility, and learning outcomes underscore the importance of culturally anchored digital pedagogy. The findings suggest that integrating local wisdom and mother tongues is not merely a supplementary feature but a core determinant of effective digital learning for indigenous populations. The study concludes that culturally-responsive EdTech holds transformative potential for promoting educational equity, identity preservation, and digital empowerment among indigenous learners.

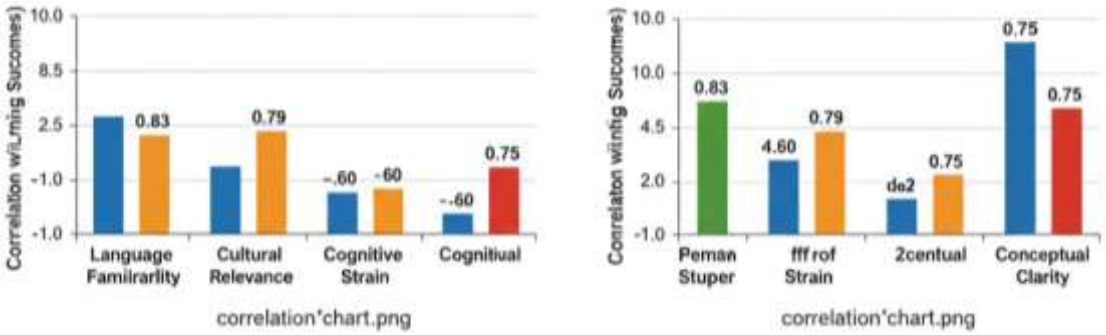

Figure 2. Factors Correlating with Learning Success in Indignrous Students

The findings reveal that integrating local wisdom and mother tongues into digital learning platforms significantly enhances indigenous students' comprehension, engagement, and sense of cultural belonging (Wanderley, 2018). The high ratings in cultural relevance and linguistic clarity demonstrate that students respond more positively to learning environments that reflect their identities and lived experiences. The strong comprehension scores indicate that culturally-responsive design improves cognitive processing and content retention. The descriptive and inferential analyses confirm that cultural familiarity and linguistic accessibility serve as strong predictors of academic performance. The correlations between cultural relevance, mother-tongue clarity, and comprehension highlight the interdependence of culture, language, and learning (Jurkovič, 2019). These findings offer empirical support for long-standing arguments in indigenous education literature that culturally grounded pedagogy strengthens learning outcomes.

The case study further illustrates these trends by showing measurable improvements in motivation, participation, and learning confidence among Dayak students. Their ability to connect digital materials with ecological and cultural knowledge produced deeper engagement and higher comprehension gains (Jurkovič, 2018). Teachers' observations reinforce the quantitative results, emphasizing increased student autonomy and willingness to explore digital tools. The overall results suggest that culturally-responsive learning technology is not only effective but also necessary for addressing systemic inequities experienced by indigenous students. The evidence indicates that digital learning environments must be culturally situated to achieve both educational relevance and inclusivity, particularly in marginalized communities where learning often occurs in linguistically diverse and tradition-rich contexts.

The results align strongly with previous research in culturally responsive pedagogy, which consistently emphasizes the critical role of cultural identity and mother-tongue instruction in improving learning outcomes. Similar studies on indigenous digital education in Australia, New Zealand, and Latin America report parallel findings: students learn more effectively when digital materials incorporate cultural narratives and linguistic features familiar to them (Erixon, 2014). The present study provides additional evidence by demonstrating measurable improvements within Southeast Asian indigenous communities. Differences also emerge when compared with research on standardized EdTech solutions, which often prioritize uniform content delivery over cultural specificity. Unlike these models, the findings show that cultural and linguistic customization is a foundational—not optional—component of effective digital learning for indigenous populations. The divergence underscores the limitations of one-size-fits-all approaches in diverse learning contexts.

The study contributes new insights by integrating ethnographic data directly into EdTech design, a methodological approach less common in mainstream EdTech research. Previous studies often rely on surface-level cultural adaptation, whereas this study uses community co-design and cultural mapping to embed authenticity into digital modules. This deeper integration appears to be a key factor behind the strong learning outcomes observed (John & Möller, 2024). The consistency between the study's results and global indigenous education research

reinforces the validity of culturally responsive design principles, while the differences highlight the need for more localized, community-driven approaches in creating digital learning tools. These insights position the study at the intersection of EdTech innovation and cultural preservation.

The findings indicate a clear shift in how digital learning should be conceptualized for indigenous students. The strong influence of cultural and linguistic factors suggests that technology must adapt to communities rather than expecting communities to adapt to technology. This reflects a broader movement toward educational sovereignty, where indigenous learners reclaim agency over the design of their learning environments. The results also signify the importance of integrating traditional ecological knowledge and cultural identity into modern learning frameworks (Romadhon et al., 2024). Such integration demonstrates that cultural heritage is not an obstacle to digital learning but a resource that strengthens comprehension and engagement. This challenges persistent assumptions that indigenous traditions are incompatible with technological advancement.

The outcomes further highlight a growing recognition of the need to decolonize digital education. By foregrounding local wisdom and mother tongues, the study reveals that culturally alien digital platforms inadvertently reinforce learning inequalities (Martín Vegas, 2018). The positive results of culturally grounded design serve as a corrective signal that indigenous epistemologies must be central in EdTech development. The findings ultimately point to an emerging paradigm in which technology functions as a bridge rather than a barrier. Culturally-responsive learning platforms not only improve academic outcomes but also foster cultural resilience, identity affirmation, and intergenerational knowledge continuity. These functions represent a deeper form of educational impact that extends beyond cognitive gains.

The results imply that policymakers and EdTech developers need to prioritize cultural and linguistic integration in digital learning strategies for indigenous communities. The evidence shows that culturally neutral or standardized platforms fail to meet the cognitive, emotional, and social needs of indigenous learners, perpetuating educational disparities. Incorporating local wisdom is therefore essential for achieving equitable learning outcomes. The study highlights the need for digital inclusion policies that account for cultural diversity rather than merely addressing technological access (Chireac, 2020). Programs intended to improve digital literacy must also incorporate cultural literacy to ensure meaningful engagement. Initiatives that ignore cultural context risk creating digital tools that are technically accessible but pedagogically irrelevant.

The findings also inform curriculum designers and educators about the importance of cultural congruence in digital content. Integrating mother tongues and indigenous symbolic systems can support bilingual education, enhance conceptual clarity, and reinforce students' confidence in navigating formal academic tasks (Kral & Ellis, 2019). Schools and communities benefit when digital learning strengthens—rather than replaces—local knowledge systems. The implications extend to wider societal concerns, particularly the preservation of indigenous languages and cultural heritage. Digital learning platforms that embed local wisdom contribute to cultural sustainability while promoting modern skills. This dual benefit strengthens cultural identity while ensuring students are prepared for participation in contemporary digital ecosystems.

The strong positive effects arise because learning is deeply shaped by cultural schema and linguistic familiarity. Indigenous students interpret information through cognitive frameworks built upon their lived experiences, stories, and linguistic structures. When digital content aligns with these frameworks, comprehension becomes more intuitive and meaningful (Gadanidis et al., 2016). The positive outcomes also stem from reduced cognitive load. Mother-tongue integration minimizes decoding effort and frees cognitive capacity for higher-level processing. Students can focus on concepts rather than struggling with unfamiliar vocabulary or culturally irrelevant examples, leading to improved accuracy and retention.

Cultural relevance enhances emotional engagement, which is a powerful predictor of learning success. Familiar narratives and symbols evoke personal connections that motivate learners to participate actively. This emotional resonance increases persistence, curiosity, and confidence, all of which contribute to enhanced digital engagement. The case study results further demonstrate that indigenous ecological knowledge provides a strong foundation for conceptual understanding in subjects like science and social studies (Sevilla-Pavón, 2019). When digital content builds upon this knowledge, students can better relate abstract concepts to real-life practices, strengthening both comprehension and cultural identity.

Future development of culturally-responsive learning technology should involve deeper community co-design processes, where indigenous elders, teachers, and students participate in ongoing content creation (Kroon & Spotti, 2024). Such collaborative approaches ensure sustained cultural accuracy and relevance across different regions and ethnic groups. Scaling the model requires designing flexible EdTech platforms that allow modular content updates, multilingual interfaces, and customizable cultural layers. This adaptability ensures that the platform can be expanded to serve different indigenous communities without losing cultural specificity.

Teacher professional development must also be integrated into implementation strategies. Educators need training in digital pedagogy that respects cultural knowledge systems and effectively blends them with curricular goals. This increases the likelihood of long-term integration and instructional consistency. Longitudinal studies are needed to examine sustained impacts on academic achievement, cultural preservation, digital autonomy, and intergenerational learning (Tsimperidis et al., 2023). Expanding research to additional indigenous communities will enhance generalizability and support the creation of a national or regional framework for culturally-responsive EdTech development.

CONCLUSION

The most significant finding of this study is the clear demonstration that indigenous students achieve substantially higher levels of comprehension, engagement, and digital confidence when learning platforms integrate culturally grounded content and mother-tongue support. The results highlight that cultural resonance and linguistic familiarity are not peripheral features but central determinants of effective digital learning for indigenous communities. The study shows that local wisdom—expressed through ecological narratives, traditional stories, community symbols, and ancestral knowledge—functions as a powerful cognitive scaffold that helps students make meaning from digital materials. The strong correlation between cultural relevance, mother-tongue clarity, and learning outcomes distinguishes this research from mainstream EdTech studies that often overlook culture as an active pedagogical force.

This research contributes conceptual and methodological advancements by proposing a culturally-responsive EdTech framework that positions indigenous epistemologies and mother-tongue literacy at the core of digital learning design. Conceptually, the study expands culturally responsive pedagogy into the digital domain by demonstrating how local wisdom can be systematically encoded into multimedia, interface features, and learning pathways. Methodologically, the research introduces an integrated cultural-mapping–to-prototype pipeline that combines ethnographic documentation, community co-design, and iterative usability testing. This multi-layered approach provides a practical and replicable model for developing low-cost yet culturally authentic digital learning platforms suitable for diverse indigenous contexts.

The study is limited by its pilot-scale implementation, which involved a restricted number of communities and a relatively short testing period, preventing a full assessment of long-term impacts on academic achievement and cultural continuity. The findings may also

vary across indigenous groups whose linguistic diversity, digital readiness, and cultural practices differ significantly, suggesting the need for more context-sensitive adaptations. The absence of longitudinal tracking limits insights into how sustained use of culturally-responsive technology influences identity formation, bilingual development, and intergenerational knowledge transmission. Future research should expand to multiple indigenous regions, incorporate long-term experimental designs, and develop scalable platform architectures that enable broader cultural representation and stronger integration with formal curricula.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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