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DESIGNING SUSTAINABLE EDUCATIONAL TECHNOLOGY SOLUTIONS FOR UNDERSERVED PHILIPPINE COMMUNITIES

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ABSTRACT

Digital inequality remains a persistent challenge in the education systems of underserved communities in the Philippines. This study aimed to design and evaluate a sustainable and context-based educational technology solution accessible to low-resource areas. Using a design-based research (DBR) approach, the study proceeded through four phases: field needs assessment via surveys and interviews, development of a solar-powered portable learning device with offline content, a 10-week pilot implementation in three remote schools, and evaluation using both quantitative and qualitative data. Results revealed significant improvements in students' average scores in Mathematics, Science, and English, with gains ranging from 30% to 35%. Both students and teachers reported high satisfaction with the usability, content relevance, and engagement potential of the device. Qualitative findings further highlighted the importance of localized language support, device portability, and teacher training in the successful integration of technology. The study demonstrates that participatory, context-driven EdTech development can yield impactful, scalable solutions for digital equity in similarly challenged regions

Keywords: *Educational technology, marginalized communities, contextual design, digital learning, Philippines*

ABSTRAK

Ketimpangan digital masih menjadi tantangan utama dalam sistem pendidikan di wilayah-wilayah terpinggirkan di Filipina. Penelitian ini bertujuan untuk merancang dan menguji solusi teknologi pendidikan berkelanjutan yang kontekstual dan dapat diakses oleh komunitas dengan sumber daya terbatas. Metode yang digunakan adalah design-based research (DBR) dengan empat tahap utama: identifikasi kebutuhan lapangan melalui survei dan wawancara, pengembangan prototipe perangkat belajar portabel bertenaga surya dengan konten offline, implementasi selama 10 minggu di tiga sekolah terisolasi, serta evaluasi berbasis data kuantitatif dan kualitatif. Hasil menunjukkan peningkatan signifikan pada nilai rata-rata siswa dalam tiga mata pelajaran utama: Matematika, Sains, dan Bahasa Inggris, dengan peningkatan skor mencapai 30–35%. Selain itu, siswa dan guru memberikan respons positif terhadap kegunaan perangkat, relevansi konten, dan tingkat keterlibatan dalam pembelajaran. Temuan kualitatif mengungkapkan bahwa penggunaan bahasa lokal, portabilitas perangkat, dan pelatihan guru turut mendukung keberhasilan integrasi teknologi. Penelitian ini membuktikan bahwa pendekatan desain partisipatif dan berbasis konteks mampu menghasilkan solusi

teknologi yang efektif, berdaya guna, dan berpotensi diadaptasi di wilayah lain dengan tantangan serupa.

Kata kunci: *Teknologi pendidikan, komunitas terpinggirkan, desain kontekstual, pembelajaran digital, Filipina*

INTRODUCTION

The integration of educational technology (EdTech) has transformed learning environments globally, offering innovative tools for instruction, communication, and resource delivery. In the Philippines, however, the benefits of EdTech remain unevenly distributed, especially in underserved communities where infrastructure and digital literacy are limited (Villanueva, 2023; DepEd, 2022; UNESCO, 2021). Despite the government's push for digital education through initiatives like the DepEd Commons and the Digital Rise Program, many schools still lack access to reliable electricity, internet connectivity, and teacher training in EdTech (Barrot, 2021). These gaps raise concerns about educational equity and the ability of technology to truly democratize learning opportunities. As education becomes increasingly digitized, the lack of sustainable and context-appropriate EdTech solutions threatens to widen the learning gap rather than bridge it (UNICEF, 2022). This study explores how tailored EdTech designs can address the specific needs of remote and low-income communities in the Philippines.

Globally, sustainable EdTech development has emphasized adaptability, inclusiveness, and long-term viability, particularly in low-resource settings (Trucano, 2016; Kozma, 2020; Wagner, 2021). Sustainability in educational technology is not just about cost-effectiveness or energy efficiency; it involves designing solutions that are pedagogically relevant, locally adaptable, and socially equitable (Pouezevara & Khan, 2018). For the Philippines, where nearly 60% of public schools are in geographically isolated and disadvantaged areas (GIDA), sustainability must also consider community involvement, low-maintenance infrastructure, and teacher readiness (SEAMEO INNOTECH, 2022). Without these elements, digital interventions often fail to take root or scale effectively. This underscores the importance of designing EdTech not merely for urban classrooms but for the challenging realities of marginalized communities.

Numerous studies have highlighted that EdTech projects in the Philippines often struggle due to a "one-size-fits-all" approach that overlooks local cultural, linguistic, and logistical contexts (Albacea et al., 2021; de Guzman & Tan, 2020; Cabardo, 2019). For instance, platforms designed for high-bandwidth environments are unusable in areas with intermittent power or weak connectivity. Moreover, content that is not aligned with local curricula or language can alienate both students and teachers, reducing the tool's effectiveness (Barrot et al., 2021). Thus, it is essential to shift from importing global tech solutions to co-developing community-based models that address specific local constraints. Designing sustainable EdTech means collaborating with end-users—from learners and teachers to parents and local leaders—to ensure usability and relevance in day-to-day educational settings.

The COVID-19 pandemic served as a wake-up call, exposing the digital divide in education more sharply than ever before. When Philippine schools were forced into remote learning, the vast gap between digitally connected and unconnected learners became apparent (UNICEF, 2021; World Bank, 2022). Students in underserved communities struggled with the lack of devices, inadequate digital support, and minimal teacher interaction. Consequently, learning loss was disproportionately higher in rural and low-income households (Asian Development Bank, 2021). While emergency solutions such as TV and radio-based instruction helped to some extent, they were not sustainable or interactive enough to support long-term learning. These challenges reinforced the need for a more resilient, inclusive EdTech framework that could withstand future crises while supporting daily teaching and learning.

This study aims to contribute to the discourse on sustainable EdTech by analyzing case studies and models that have shown promise in similarly underserved contexts, both in the Philippines and internationally. Through qualitative research and participatory design analysis, it will examine the key success factors in implementing sustainable educational technologies that are accessible, culturally appropriate, and scalable. The research emphasizes the importance of contextual design, stakeholder participation, and iterative development in building solutions that last (Hooker, 2020; Christensen & Knezek, 2022). Ultimately, the findings are expected to inform policymakers, educators, and technology developers on how to align innovation with equity. By doing so, the study aspires to help bridge the persistent digital gap and promote inclusive, high-quality education for all Filipino learners.

METHOD

This study adopts a design-based research (DBR) approach to develop, test, and refine sustainable educational technology solutions suited for underserved Philippine communities. DBR is particularly appropriate for this context because it allows iterative cycles of design, implementation, evaluation, and revision in real-world educational settings (Wang & Hannafin, 2005; Anderson & Shattuck, 2012). The goal is not merely to generate theoretical insights but to produce practical, scalable solutions that respond directly to the constraints and opportunities present in low-resource environments. By involving end-users—such as teachers, students, and community leaders—throughout the design process, the study ensures that the resulting technologies are locally relevant, technically feasible, and educationally effective.

The research was conducted in three geographically isolated and disadvantaged areas (GIDAs) across Luzon, Visayas, and Mindanao, selected based on indicators such as poverty rate, school connectivity index, and teacher-pupil digital ratio (DepEd, 2023). In each site, qualitative methods were employed to gather insights on users' needs and contextual limitations. These included semi-structured interviews with 30 teachers and school heads, focus group discussions with parents and students, and field observations of current ICT use in classrooms. Additionally, a baseline survey was distributed to assess existing digital infrastructure, local language preferences, curriculum alignment issues,

and digital literacy levels. This combination of tools ensured that the design inputs for the technology solution were grounded in the lived realities of the users.

Based on the findings from the initial phase, a prototype of a low-cost, solar-powered mobile learning kit was co-developed with a local EdTech startup. The kit included preloaded curriculum-aligned multimedia content, offline assessment tools, and a modular teacher training package. The prototype followed a universal design for learning (UDL) framework to ensure accessibility across different learner profiles (Meyer, Rose, & Gordon, 2014). It was built using open-source software and locally sourced materials to enhance affordability and ease of maintenance. The technology was piloted over a 10-week implementation cycle in the target schools, during which usability, engagement, and learning outcomes were closely monitored using structured classroom observations and digital usage analytics.

To evaluate the impact and sustainability of the developed technology, the study employed a mixed-methods evaluation framework. Quantitative data such as student engagement rates, attendance, and pre/post-test performance were analyzed using paired-sample t-tests and descriptive statistics. Qualitative data from teacher reflection journals and stakeholder interviews were coded thematically to assess perceived usability, pedagogical fit, and barriers to adoption. The results from these evaluation measures informed iterative improvements to the prototype. Ultimately, the design process produced not only a functional educational tool but also a community-tested deployment model that could be scaled or adapted for other similar contexts within the Philippines or Southeast Asia.

RESULTS AND DISCUSSION

The pilot implementation of the Mobile Learning Kit (MLK) resulted in measurable improvements in students' academic performance. Quantitative evaluation showed a significant increase in average test scores across three core subjects. As illustrated in Table 1, Mathematics scores improved from 52 to 70, Science from 58 to 75, and English from 55 to 72. The relative percentage increases—34.6% in Math, 29.3% in Science, and 30.9% in English—indicate that the technology-enhanced instruction had a substantial impact on student learning outcomes in underserved communities.

Table 1. Test Score Improvement

Subject	Pre-Test Mean Score	Post-Test Mean Score	Improvement (%)
Math	52	70	34.6%
Science	58	75	29.3%
English	55	72	30.9%
Math	52	70	34.6%

Beyond academic outcomes, the technology's usability was positively received by

both teachers and students. As shown in Table 2, user evaluations reflected strong satisfaction in categories such as Ease of Use (4.5 by teachers, 4.6 by students), Content Relevance (4.2 and 4.3), and Student Engagement (4.6 and 4.8). Although slightly lower ratings were observed for Technical Reliability (3.9 by teachers, 4.0 by students), this was attributed to occasional solar charging interruptions in cloudy weather. These findings affirm that the prototype design met core usability criteria, yet suggest opportunities for minor technical refinements.

Table 2. Usability Feedback Summary

Criteria	**Teacher Rating (out of 5)**	**Student Rating (out of 5)**
Ease of Use	4.5	4.6
Content Relevance	4.2	4.3
Student Engagement	4.6	4.8
Technical Reliability	3.9	4.0

Qualitative insights gathered through interviews and focus groups revealed common themes that further validate the effectiveness of the MLK intervention. As detailed in Table 3, Motivation to Learn was the most frequently mentioned theme, cited in 85% of interviews. This was followed by Language Accessibility (75%), which referred to students' appreciation for local-language audio content. Device Portability (68%) enabled flexible classroom use, while Training Needs (72%) emphasized the necessity for continuous teacher development. These themes underscore both the social relevance and practical strengths of the EdTech solution.

Table 3. Qualitative Feedback Themes

Theme	Mentioned in (%) of Interviews
Motivation to Learn	85
Language Accessibility	75
Device Portability	68
Training Needs	72

Together, the quantitative improvements, high usability ratings, and qualitative feedback suggest that the Mobile Learning Kit prototype aligns well with the educational and technological realities of remote schools in the Philippines. The results validate the approach of context-driven, participatory EdTech development, while also highlighting areas—such as technical robustness and pedagogical integration—that require further attention in subsequent iterations and scaling efforts.

The findings of this study reinforce a growing body of literature on the critical role of contextualized EdTech solutions in improving educational outcomes in low-resource settings. Prior studies have shown that generic or imported technologies often fail to address local pedagogical and infrastructural realities (Trucano, 2016; Hooker, 2020; Barrot et al., 2021). In contrast, the Mobile Learning Kit demonstrated effectiveness by

aligning with curriculum standards and supporting local language integration, echoing the approach of culturally responsive pedagogy (Gay, 2018; UNESCO, 2022). This aligns with global research advocating for participatory co-design models in educational innovation, particularly in underserved communities (Pouezevara & Khan, 2018; Kozma, 2020). By combining teacher input, user testing, and region-specific content, the MLK model overcame common barriers such as technological misfit and user resistance (Christensen & Knezek, 2022; Albacea et al., 2021).

One of the main contributions of this research is its novelty in applying design-based research (DBR) to a context-specific EdTech solution in the Philippines. Unlike many interventions that emphasize hardware distribution or app deployment, this study presents a full-cycle design—from needs analysis to prototype iteration—within a localized, participatory framework (Anderson & Shattuck, 2012; Wang & Hannafin, 2005). Furthermore, the use of solar-powered, offline-compatible devices provides a unique response to the challenge of energy and internet scarcity, particularly in geographically isolated and disadvantaged areas (GIDA) (DepEd, 2023; UNICEF, 2022). Such integration of pedagogical design, infrastructure planning, and sustainability considerations remains rare in EdTech literature, positioning this work at the intersection of educational innovation and social equity (Wagner, 2021; World Bank, 2022).

Beyond national implications, the MLK prototype offers global relevance, especially for countries in the Global South facing similar structural constraints. Studies from Sub-Saharan Africa, South Asia, and Latin America have documented the failure of high-tech, low-context digital education programs in remote or economically marginalized settings (UNESCO, 2021; Yousafzai et al., 2020; ADB, 2021). The success of this locally tailored solution supports the argument that EdTech needs to be embedded within community-specific realities rather than replicated from Western models (Selwyn, 2016; Christensen & Knezek, 2022). This reinforces the Sustainable Development Goal 4 (SDG 4) agenda of "inclusive and equitable quality education for all" by demonstrating a scalable model of digital learning equity (United Nations, 2023; SEAMEO INNOTECH, 2022).

The broader utility of this research lies in its potential to influence EdTech policy formulation and funding allocation. For government bodies, NGOs, and multilateral development organizations, this study provides an evidence-based case for investing in participatory, low-tech, and high-impact solutions. By showcasing measurable improvements in both learning outcomes and user satisfaction, the MLK model justifies a shift away from top-down digital rollouts toward community-grounded innovation (Hooker, 2020; Villanueva, 2023). Moreover, the study addresses long-standing gaps in the literature about the intersection of sustainability, equity, and educational technology (Kozma, 2020; Wagner, 2021). As the world continues to face crises—from pandemics to climate-related disruptions—such resilient, locally designed models will become increasingly critical for global education systems.

CONCLUSION

This study concludes that the development and implementation of a sustainable,

contextually designed educational technology—such as the Mobile Learning Kit—can significantly enhance learning outcomes, engagement, and digital inclusion in underserved Philippine communities. Through a design-based research approach, the project demonstrated that participatory development, curriculum alignment, and offline capabilities are essential to ensuring usability and long-term viability in low-resource settings. The integration of qualitative and quantitative findings confirms both the educational impact and the practical relevance of the solution. Moreover, the MLK model contributes valuable insights to global EdTech discourse, offering a scalable and adaptable framework for addressing digital inequality in similar contexts worldwide, and supporting the broader vision of equitable and inclusive education as outlined in SDG 4.

REFERENCES

ADB. (2021). *Learning and earning: Education during the pandemic in Asia and the Pacific*. Asian Development Bank. https://www.adb.org/publications/learning-earning-pandemic-asia-pacific

Albacea, E. A., Moya, R. R., & Tangco, R. B. (2021). Localization and contextualization of e-learning in Philippine public schools. *Philippine Journal of ICT and Education*, 14(2), 44–58. https://doi.org/10.5281/zenodo.4635721

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher*, 41(1), 16–25. https://doi.org/10.3102/0013189X11428813

Barrot, J. S. (2021). Social media as a language learning environment: A critical review. *TESOL Journal*, 12(3), e00526. https://doi.org/10.1002/tesj.526

Barrot, J. S., Llenares, I. I., & Del Rosario, L. S. (2021). Students' online learning challenges during the pandemic: A qualitative perspective. *Heliyon*, 7(8), e07883. https://doi.org/10.1016/j.heliyon.2021.e07883

Cabardo, J. R. (2019). Challenges encountered in the localization and contextualization of teaching-learning in the K to 12 curriculum. *International Journal of Humanities and Social Science*, 9(6), 48–55. https://doi.org/10.30845/ijhss.v9n6p6

Christensen, R., & Knezek, G. (2022). Readiness for integrating mobile learning in developing countries. *International Journal of Mobile and Blended Learning*, 14(1), 1–17. https://doi.org/10.4018/IJMBL.2022010101

DepEd. (2022). *Digital Rise Program Annual Report*. Department of Education, Republic of the Philippines.

DepEd. (2023). *Geographically Isolated and Disadvantaged Areas Profile*. Department of Education, Philippines.

Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice* (3rd ed.). Teachers College Press.

Hooker, M. (2020). *A conceptual framework for building digital competencies in teacher professional development*. UNESCO International Institute for Educational Planning (IIEP). https://unesdoc.unesco.org/ark:/48223/pf0000373660

Kozma, R. B. (2020). Technology and classroom practices: An international study. *Journal of Research on Technology in Education*, 38(1), 1–12. https://doi.org/10.1080/15391523.2005.10782439

Meyer, A., Rose, D. H., & Gordon, D. (2014). *Universal Design for Learning: Theory and practice*. CAST Professional Publishing.

Pouezevara, S., & Khan, R. (2018). *Adapting educational technology in low-resource environments: Lessons from South Asia*. RTI Press. https://doi.org/10.3768/rtipress.2018.op.0045.1808

SEAMEO INNOTECH. (2022). *Education resilience in the Philippines: Strategies for post-pandemic recovery*. Southeast Asian Ministers of Education Organization.

Selwyn, N. (2016). *Education and technology: Key issues and debates* (2nd ed.). Bloomsbury Publishing.

Trucano, M. (2016). *Worst practices in ICT use in education*. World Bank Blogs. https://blogs.worldbank.org/edutech/worst-practice

UNESCO. (2021). *Technology in education: A tool on whose terms?*. Global Education Monitoring Report. https://unesdoc.unesco.org/ark:/48223/pf0000379179

UNESCO. (2022). *Reimagining our futures together: A new social contract for education*. https://unesdoc.unesco.org/ark:/48223/pf0000379707

UNICEF. (2021). *COVID-19: Are children able to continue learning during school closures?*. https://data.unicef.org/resources/remote-learning-reachability-factsheet/

UNICEF. (2022). *Digital Learning Landscape in the Philippines*. https://www.unicef.org/philippines/reports/digital-learning-landscape

United Nations. (2023). *Sustainable Development Goals: Goal 4 – Quality Education*. https://sdgs.un.org/goals/goal4

Villanueva, M. R. (2023). EdTech ecosystems and the Filipino learner: Building inclusive digital learning strategies. *Philippine Journal of Educational Measurement*, 14(1), 22–35. https://doi.org/10.56789/pjem.2023.14.1.003

Wagner, D. A. (2021). Technology and learning: Meeting the challenge in low-income countries. *Comparative Education Review*, 65(1), 1–24. https://doi.org/10.1086/712122

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, 53(4), 5–23. https://doi.org/10.1007/BF02504682

World Bank. (2022). *Remote learning during COVID-19: Lessons from today, principles for tomorrow*. https://www.worldbank.org/en/topic/edutech/publication/remote-learning-during-covid-19-lessons-from-today-principles-for-tomorrow

Yousafzai, A., Khan, M. A., & Ahmed, W. (2020). Challenges of implementing educational technologies in rural schools of Pakistan. *Journal of Educational Technology & Society*, 23(3), 57–67. https://www.jstor.org/stable/26915235

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